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Potential Ozone Depleting Substances

Uses and Alternatives in the Nordic Countries

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Nordic Environmental Co-operation

The Nordic Environmental Action Plan 2005-2008 forms the framework for the Nordic countries' environmental co-operation both within the Nordic region and in relation to the adjacent areas, the Arctic, the EU and other international forums. The programme aims for results that will consolidate the position of the Nordic region as the leader in the environmental field. One of the overall goals is to create a healthier living environment for the Nordic people.

Nordic co-operation

Nordic co-operation, one of the oldest and most wide-ranging regional partnerships in the world, involves Denmark, Finland, Iceland, Norway, Sweden, the Faroe Islands, Greenland and Åland. Co-operation reinforces the sense of Nordic community while respecting national differences and similarities, makes it possible to uphold Nordic interests in the world at large and promotes positive relations between neighbouring peoples.

Co-operation was formalised in 1952 when *the Nordic Council* was set up as a forum for parliamentarians and governments. The Helsinki Treaty of 1962 has formed the framework for Nordic partnership ever since. The *Nordic Council of Ministers* was set up in 1971 as the formal forum for co-operation between the governments of the Nordic countries and the political leadership of the autonomous areas, i.e. the Faroe Islands, Greenland and Åland.

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Preface

The Montreal Protocol has had great success in reducing the production and use of a number of known ozone depleting substances. As a result many alternatives to the banned substances have been developed. Some of these substances have, however, themselves ozone depleting properties or can be hazardous to the environment in other ways.

As the procedure for including new ozone depleting substances under the regulation of the Montreal protocol is rather time consuming the tenth meeting of the parties to the Montreal Protocol decided in DEC. X/8 *inter alia* 'to encourage parties in the light of reports from the Technology and Economic Assessment Panel, to take measures to actively, as appropriate, discourage the production and marketing of new ozone depleting substances'. Further it was decided in DEC IX/24 and X/8 to request parties to report to the ozone secretariat on new substances.

EU has taken the effort to elaborate a table of 'New substances with ozone depletion potential'. Based on this list a shorter list of 7 substances of concern has been prepared by the Nordic Ozone Group for assessment in this study. Besides information on one substance assessed in another study is summarised. The substances were selected on the basis of information on ozone depletion potential and the amounts produced and used in the Nordic countries.

The overall objective of the study is to contribute to the work on the protection of the ozone layer eventually by providing information which would facilitate the inclusion of new substances under the Montreal Protocol or by otherwise reducing the use of these substances if appropriate.

It is beyond the scope of this study to review the ozone depletion potential of the substances. This evaluation of the substances takes place in other fora.

The study has been followed by a Steering Committee consisting of the members of the Nordic Ozone Group under the Nordic Chemicals Group:

- Heiðrún Guðmundsdóttir, Environment and Food Agency, Iceland (chairman)
- Mikkel Aaman Sørensen, Danish Environmental Protection Agency, Denmark
- Sophia Mylona, The Norwegian Pollution Control Authority, Norway
- Eliisa Irpola, Finnish Environment Institute, Finland
- Maria Ufjalusi, Swedish Environmental Agency, Sweden
- Carsten Lassen, COWI A/S, Denmark

The following team has contributed to the solving of this assignment: Carsten Lassen (Project Manager), Erik Hansen and Jakob Maag, COWI A/S.

Summary

This report presents the findings of the project "Potential ozone depleting substances - uses and alternatives in the Nordic Countries" prepared by COWI A/S for the Ozone Group under Nordic Council of Ministers.

A part of the obtained information, in particularly on consumption figures, is considered confidential, and this report contains only a part of the information that has been available for the Nordic Ozone Group.

The objective of the study is to identify current uses of seven substances of concern as ozone depleting substances. During the study one substance, tetrachlorohexafluorobutane, has been added to the list. Besides, the study summarises available information for dibromodifluoromethane (Halon-1202).

The assessed substances and identified uses are listed in table 1.

Table 1 Uses and estimated consumption of the substances in the Nordic Countries in 2003

Substance	CAS No	ODP*	Uses identified in this study	Estimated consumption in the Nordic countries in 2003 Tonnes/year
1-Bromopropane	106-94-5	0.003 -0.1	Degreaser (solvent); Process raw material; Laboratory chemical	8-15
2-Bromopropane	75-26-3	0.018	Intermediate for pharmaceuticals; Laboratory chemical	Confidential
Bromoethane	74-96-4	No data	Laboratory chemical	<0.010
Dibromoethane	106-93-4	No data	Laboratory chemical; gasoline additive	8-12
1-Bromo-3-chloropropane	109-70-6	0.05	Intermediate for pharmaceuticals	Confidential
1,1,1-Trichloro-2,2,2-trifluoroethane	354-58-5	0.65	Degreaser (use has ceased)	0
2,2,3,3- Tetrachlorohexafluorobutane	375-34-8	No data	No uses identified	0
Tetrachlorohexafluorobutane	28107-59-9	No data	Solvent in oil-in-water analysis	Confidential
Dibromodifluoromethane	75-61-6	1.25	No uses identified	0

* ODP = Ozone depletion potential

Based on an initial survey of uses in the Nordic Countries, four of the substances were selected for further evaluation of applications and alternatives: 1-bromopropane, dibromoethane, 1,1,1-trichloro-2,2,2-trifluoroethane and tetrachlorohexafluorobutane. The substances were selected on the basis of information on their ozone depletion potential and/or on the respective production and consumption patterns.

Production

None of the substances are produced in the Nordic Countries.

Product register data

Data has been obtained from the product registers in Denmark, Sweden, Norway and Finland on a confidential basis. Iceland does not hold any product register and it has consequently not been possible to obtain any recorded data on the use of the substances in Iceland.

Six of the substances are registered in one or more of the product registers of Denmark, Sweden and Finland. 1-Bromopropane and dibromoethane are registered in Denmark, Sweden and Finland. For these two compounds several products and applications are reported. For most of the compounds the number of registered products is so low that the information is considered confidential. For none of the substances any consumption is registered in the Norwegian product register.

Information from suppliers

A number of producers and suppliers of chemical substances (listed in Annex 2) has been contacted in order to supplement the information obtained from the product registers. In general very little specific information has been obtained by the direct contact to producers/suppliers. Most of the contacted companies do not supply any of the substances to the Nordic market. One of the main producers, which probably supply some of the substances to the Nordic market, Albemarle Europe has refused providing market information for the study.

Laboratory chemicals

According to information from suppliers most of the compounds are used as laboratory chemical in the Nordic countries. Based on information from suppliers the substances are each used in quantities of a few kilograms per year.

1-Bromopropane

The total consumption of 1-bromopropane in the Nordic Countries is estimated at 8-15 t/year.

1-Bromopropane is among other applications used as solvent for cleaning of electronics and metal parts. The total amount used for this application is confidential. For solvent application the compound is typically used in mixtures consisting of about 90% 1-bromopropane in combination with stabilizers and other additives. 1-Bromopropane based solvents are used in different ways with vapour degreasing as the preferred method. By the application, the substances may be released to the atmosphere.

The solvents entered the market as substitutes for the now banned trichloroethane (TCA) based degreasing agents, and 1-bromopropane

based degreaser solvents can be applied directly in degreaser units designed for TCA and TCE (trichloroethylene) use. TCE and 1-bromopropane are today used for the same applications, and the solvents are applied by use of the same degreaser units. A number of alternative degreasers exist including alcohols and alkaline degreasing. The alternatives are in many cases cheaper, but imply higher investment costs or more cleaning steps.

The substance is in one or more of the Nordic product registers registered as process raw material for production of pharmaceuticals.

2-Bromopropane and 1-bromo-3-chloropropane

2-Bromopropane and 1-bromo-3-chloropropane is in one or more of the product registers registered as intermediate. Except for the consumption as laboratory chemicals, no other uses of the substances in the Nordic countries have been identified.

Bromoethane

According to data from the product registers and suppliers, the total consumption of bromoethane in the Nordic countries as laboratory chemical is in the order of magnitude of 1-10 kg per year. This is the only identified use of the substance in the Nordic countries.

Dibromoethane

Dibromoethane is used as scavenger in leaded aviation gasoline (AVGAS) used in the Nordic countries for piston engine powered propeller-driven aircraft. The scavenger reacts with lead oxide formed in the motor from tetraethyl lead and converts it to a mixture of volatile lead bromide and lead oxybromide. Based on information on the use of lead for AVGAS in Denmark, Norway and Sweden and the typical content of dibromoethane, the total use of dibromoethane for AVGAS is estimated at 8-12 t/year.

Dibromoethane may be lost to the atmosphere by spill of gasoline or as unreacted compounds in the exhaust gas. In one study (the only identified) organobromine compounds accounted for 22-44% of the total bromine in the exhaust gas of engines using dibromoethane containing leaded gasoline.

Today no alternatives to dibromoethane in lead-containing AVGAS exist, and the alternative to the use of dibromoethane is to use lead-free AVGAS. A Swedish produced alternative exists for the AVGAS type AVGAS 91/96, whereas no alternatives exist to the higher octane type AVGAS 100/130. The lead-free AVGAS 91/96 is widely used in Sweden, where the company has its own distribution net, but it is not supplied in the other Nordic countries. The price of the lead-free AVGAS is approximately the same as of the lead-containing. Apart from the aircraft designed for AVGAS 92/96, 70% of the AVGAS 100 fleet can, according

to information from the manufacturer of lead-free AVGAS, use the lead-free AVGAS 91/96, if they use the correct motor oil.

More widespread use of lead-free AVGAS may significantly reduce the releases of both lead and dibromoethane from aircrafts in the Nordic countries.

1,1,1-trichloro-2,2,2-trifluoroethane

According to the Danish product register 1,1,1-trichloro-2,2,2-trifluoroethane was used as degreaser in Denmark (one product only), but according to the company the substance has not been used the last 2-3 years. No other uses of the substance in the Nordic countries have been identified.

2,2,3,3- tetrachloro hexafluorobutane

No applications of the substance 2,2,3,3- tetrachloro hexafluorobutane in the Nordic countries have been identified, and most probably the substance is not used. In the reporting to UNEP the substance has been confused with other congeners of tetrachloro hexafluorobutane included in the solvent, S-316 mentioned below.

Tetrachloro hexafluorobutane

Different congeners of tetrachloro hexafluorobutane are included in the solvent S-316, which is used in equipment for on-site water-in-oil analysis produced by the Japanese company Horiba. According to suppliers, S-316 may generally be used for oil-in-water analysis in many sectors, including the oil and refinery industry, airports, and industries which monitor oil contents of their wastewater discharges. In the Nordic countries however, the use seem to be rather limited today. It has not been possible to obtain overview information from suppliers on the use of S-316 in the Nordic countries.

A number of alternatives exist, but most of them have different drawbacks compared to S-316. The most promising alternative seems to be supercritical extraction by CO_2 and IR (infrared) detection. The process has recently become commercially available, and the practical experience with it is still rather limited.

Dibromodifluoromethane

A recent inventory of the use of halons in the Nordic countries did not identify any use of dibromodifluoromethane (halon 1202), and the substance is most probably not used in the Nordic countries.

Waste management

Waste containing any of the substances is classified "hazardous" and must be treated accordingly.

Dansk sammenfatning

Denne rapport præsenterer resultaterne af projektet "Potential ozone depleting substances - uses of and alternatives in the Nordic Countries" [Potentielle ozonnedbrydende stoffer - anvendelser og alternativer i de nordiske lande], som er gennemført af COWI A/S for Ozon Gruppen under Nordisk Ministerråd.

En væsentlig del af den indhentede information - især mængdeoplysninger - er fortrolig, og denne rapport indeholder derfor kun en begrænset del af den viden, der har været til rådighed for Ozon Gruppen.

Formålet med undersøgelsen har været at finde ud af, hvad syv stoffer, der er under mistanke for at have ozonnedbrydende effekt, bruges til i de nordiske lande. I løbet af undersøgelsen er tetrachlorhexafluorbutan føjet til listen over stoffer, som skulle undersøges. Herudover er viden om brugen af dibromdifluormethane (Halon-1202) sammenfattet fra en anden undersøgelse.

Den indsamlede, offentligt tilgængelige viden om de otte stoffer er sammenfattet i tabel 1.

Baseret på en indledende undersøgelse af anvendelserne i de nordiske lande, udvalgte Ozon Gruppen følgende fire stoffer for hvilke anvendelser og alternativer skulle undersøges nærmere: 1-brompropan, dibromethan, 1,1,1-trichlor-2,2,2-trifluorethan og tetrachlorhexafluorbutan. Stofferne var udvalgt på det grundlag, at der ved anvendelse af stofferne var mulighed for et væsentligt tab til atmosfæren.

Produktion

Ingen af stofferne produceres i de nordiske lande.

Produktregister data

På fortrolig basis er der indsamlet data fra produktregistrene i Danmark, Sverige, Norge og Finland. Island har ikke noget produktregister, og det har derfor ikke været muligt at indhente data om det registrerede forbrug i Island.

Seks af stofferne er registreret i mindst et af registrene i Danmark, Sverige og Finland, mens ingen af stofferne er registreret i det norske produktregister. 1-brompropan og dibromethan er registreret i både Danmark, Sverige og Finland. For disse to stoffer er der registreret flere forskellige produkter og anvendelser. For flere af stofferne er antallet af registreringer så lille, at de detaljerede oplysninger skal behandles fortroligt.

Information fra leverandører

Et større antal producenter og leverandører af stofferne (opgjort i Annex 2) er blevet kontakter for at supplere den information, der har kunnet indhentes fra produkt registrene. Alt i alt har det kun været muligt at få meget lidt specifikke oplysninger gennem kontakt til producenter og leverandører. Hovedparten af de kontaktede virksomheder har ikke noget salg af de pågældende stoffer på det nordiske marked. En af de vigtigste producenter af bromerede forbindelser, Albemarle Europe, har ikke ønsket at bidrage med markedsoplysninger til nærværende undersøgelse.

Tabel 1 Anvendelser og skønnet forbrug af stofferne i de nordiske lande i 2003

Stof	**CAS**	**ODP**	**Anvendelser fundet i denne undersøgelse**	**Skønnet forbrug i de nordiske lande i 2003** **Tons/år**
1-Brompropan	106-94-5	0,0033 - 0,11	Affedtningsmiddel; mellemprodukt ved fremstilling af farmaceutiske produkter; laboratoriekemikalie	8-15
2-Brompropan	75-26-3	0,018	Mellemprodukt ved fremstilling af farmaceutiske produkter; laboratoriekemikalie	Fortroligt
Bromethan	74-96-4	Ingen data	Laboratoriekemikalie	<0.010
Dibromethan	106-93-4	Ingen data	Laboratoriekemikalie; proces råvare; additiv til flybenzin	8-13
1-Brom-3-chlorpropan	109-70-6	0,05	Mellemprodukt ved fremstilling af farmaceutiske produkter	Fortroligt
1,1,1-Trichlor-2,2,2-trifluorethan	354-58-5	0,65	Affedtningsmiddel (forbruget er ophørt)	0
2,2,3,3- Tetrachlor-hexafluorbutan	375-34-8	Ingen data	Ingen anvendelser fundet	0
Tetrachlorhexafluorbutan	28107-59-9	Ingen data	Opløsningsmiddel til analyse af olie i vand	Fortroligt
Dibromdifluormethan	75-61-6	1,25	Ingen anvendelser fundet	0

* ODP = Ozone depletion potential = potentiale for ozonnedbrydning

Laboratoriekemikalier

Ifølge oplysninger fra leverandører anvendes de fleste af stofferne som laboratoriekemikalier i de nordiske lande. Forbruget er for hvert af stofferne i størrelsesordenen nogle få kilogram.

1-Brompropan

Det samlede forbrug af 1-brompropan til alle formål er skønnet til 8-15 tons/år.

1-Brompropan anvendes bl.a. som opløsningsmiddel til rensning af elektronik og metaldele. Den samlede mængde, der anvendes til dette formål, er fortrolig.

Som opløsningsmiddel anvendes stoffet typisk i blandinger med omkring 90% 1-brompropan sammen med stabilisatorer og andre additiver. Damp-affedtning er den mest anvendte metode.

I forbindelse med brugen vil en væsentlig del af affedtningsmidlerne fordampe fra udstyret.

Opløsningsmidlet kom på markedet som alternativ til affedtningsmidler baseret på det nu regulerede trichlorethan (TCA), og affedtningsmidler baseret på 1-brompropan kan direkte anvendes i udstyr designet til brug af TCA og TCE (trichloretylen). TCE og 1-brompropan bruges således i dag til de samme typer af anvendelser med brug af det samme udstyr.

Der findes en række alternativer, heriblandt alkoholer og vandbaserede alkaliske affedtningsmidler. Mange af alternativerne er billigere end 1-brompropan, men brugen indebærer større investeringsomkostninger i afrensningsudstyr eller flere afrensningstrin.

Stoffet er i et eller flere af de nordiske produktregistre registreret anvendt som mellemprodukt ved produktionen af farmaceutiske produkter.

2-brompropan og 1-brom-3-chlorpropan

Stofferne er i et eller flere af de nordiske produktregistre registreret anvendt som mellemprodukt ved produktionen af farmaceutiske produkter og bruges i øvrigt som laboratoriekemikalie.

Bromethan

Ifølge oplysninger fra leverandører anvendes bromethan i de nordiske lande som laboratoriekemikalie i mængder på 1-10 kg per år. Dette er den eneste fundne anvendelse af stoffet i de nordiske lande.

Dibromethan

Dibromethan bruges som såkaldt "scavenger" (stof, der fjerner et andet stof) i blyholdig flybenzin (AVGAS), som i de nordiske lande i dag kun anvendes i stempelmotordrevne propelfly. Dibromethan reager med blyoxid, som i motoren dannes ud fra tetraethylbly, og omdanner blyoxidet til blybromid og blyoxybromider, som er flygtige og dermed forsvinder sammen med udstødningsgassen. Baseret på oplysninger om brugen af bly med AVGAS i Danmark, Sverige og Norge og det typiske forhold mellem bly og dibromethan anslås det, at der årligt bruges 8-12 tons dibromethan med AVGAS i de nordiske lande.

Dibromethan kan afgives til atmosfæren i forbindelse med spild af AVGAS eller i form af ureagerede forbindelser i udstødningsgassen. I en enkelt undersøgelse (den eneste fundet) udgjorde organiske bromforbindelser 22-44% af det totale bromindhold i udstødningsgas fra motorer, som anvendte dibromethanholdig benzin.

Der findes i dag ikke nogen alternativer til dibromethan i blyholdig AVGAS, og hvis man vil undgå at bruge dibromethan, skal man bruge blyfri AVGAS.

Et svenskproduceret alternativ findes til AVGAS med lavt oktantal, AVGAS 91/96, mens der ikke findes blyfri alternativer til AVGAS med højere oktantal, AVGAS 100/130. Den blyfri AVGAS 91/96 er vidt anvendt i Sverige, hvor producenten har eget distributionsnet, men leveres

ikke i de øvrige nordiske lande. Den blyfri AVGAS koster ca. det samme som den blyholdige, men udbredelsen begrænses af investeringerne i distributionsnet. Udover fly beregnet til AVGAS 91/96 kan ca. 70% af AVGAS 100 flåden, ifølge oplysninger fra producenten af blyfri AVGAS, anvende den blyfri AVGAS 91/96, forudsat at den rigtige motorolie anvendes.

Mere udbredt brug af den bly-fri AVGAS kan reducere udledningerne af såvel bly som dibromethan i de nordiske lande betydeligt.

1,1,1-trichlor-2,2,2-trifluoroethan

Ifølge det danske produktregister har 1,1,1-trichlor-2,2,2-trifluorethan været brugt som affedtningsmiddel i Danmark, men ifølge den registrerede bruger har stoffet ikke været anvendt de seneste 2-3 år. Der er ikke fundet andre anvendelser af stoffet i de nordiske lande.

2,2,3,3- tetrachlor-hexafluorbutan

Der er ikke fundet nogen anvendelser af 2,2,3,3- tetrachlorhexafluorbutan i de nordiske lande, og stoffet anvendes sandsynligvis ikke. I en tidligere rapportering til FNs Miljøprogram, UNEP er stoffet blevet forvekslet med andre congenere af tetrachlorhexafluorbutan, som indgår i opløsningsmidlet S-316, som omtales nedenfor.

Tetrachlorhexafluorbutan

Forskellige congenere af tetrachlorhexafluorbutan indgår i opløsningsmidlet S-316, som anvendes i udstyr til analyse af olie i vand, som leveres af det japanske firma Horiba. Ifølge leverandører anvendes S-316 generelt til analyse af olie i vand inden for mange sektorer, bl.a. olieudvinding og raffinaderier, lufthavne og virksomheder, der undersøger for olie i spildevandet. Det har ikke været muligt at etablere et overblik over anvendelserne og forbruget i de nordiske lande på baggrund af leverandøroplysninger.

Der findes en række alternativer som alle har forskellige ulemper i forhold til S-316. Det mest lovende alternativ er kritisk ekstraktion med CO_2 og IR (infrarød) bestemmelse. Processer er for nylig blevet kommercielt tilgængelige, men den praktiske erfaring med metoden er endnu begrænset.

Dibromdifluormethan

I en nyligt gennemført undersøgelse af brugen af haloner i de nordiske lande blev der ikke fundet nogen brug af dibromdifluormethan (halon 1202), og stoffet anvendes højst sandsynligt ikke i de nordiske lande.

Affaldsbehandling

Affald, som indeholder et eller flere af de omhandlede stoffer, skal klassificeres og behandles som "farligt affald".

1 Methodology

Initial information on the use of the substances and the sale on the Nordic market was retrieved by direct inquiries to the European producers registered in the International Uniform Chemical Information Database (IUCLID) database and their agents in the Nordic Countries. In addition agents in the Nordic Countries for non-European producers have been contacted. The producers were identified by the use of IUCLID, the Chemfinder database of suppliers of chemical products and Internet searches. Contacted companies are listed in Annex 2.

Concurrently data were retrieved from the databases of the products registers in Denmark, Norway, Sweden and Finland. Iceland does not hold any product register. Information on the product registers and the results of the retrievals are described in chapter 2.

The use of dibromodifluoromethane (halon-1202) has recently been assessed as part of another study for the Nordic Chemicals Group. Information on dibromodifluoromethane has been extracted from this study, and no additional information has been retrieved as part of the present study.

Based on an initial survey of uses in the Nordic Countries, four of the substances were selected for further evaluation of applications and alternatives: 1-bromopropane, dibromoethane, 1,1,1-trichloro-2,2,2-trifluoroethane and tetrachlorohexafluorobutane. The substances were selected on the basis of information on their ozone depletion potential and/or on the respective production and consumption patterns. The other substances are either consumed in small amounts or used as intermediate in chemical or pharmaceutical industry. The use as intermediate takes place by one company only for each substance and the releases from the use as intermediate are presumed to be relatively small.

Information on applications and alternatives has been obtained by direct inquiries to producers and suppliers.

It has been beyond the limits of this study to investigate a possible import of the substances in solid processed articles, e.g. equipment for air-conditioning equipment.

Material Safety Data Sheets for each substance obtained from producers are attached in Annex 4.

2 Data from Nordic product registers

Data from the Nordic product registers were retrieved as part of the initial data collection. Product registers exist in Norway, Denmark, Sweden and Finland. Iceland does not hold any product register.

2.1 Substances in the product registers

Substances covered by the product registers

In **Sweden** the declaration requirements are based on the customs tariff codes, so that as a general rule they apply to all chemical products (substances and preparations). The Swedish register therefore contains more products than those that are classified as dangerous according to EU legislation. In Sweden, substances that are not classified as dangerous and that make up less than 5 per cent of a product may be omitted from the declaration.

In **Norway**, declaration is mandatory for all products to which the Regulations relating to the classification, labeling, etc. of dangerous chemicals (the Chemical Labeling Regulations) apply. These regulations implement EU directives on the classification, labeling, etc. of chemicals in Norwegian legislation. It means that declaration is only mandatory for products in which one of the substances is included in the list of dangerous substances. For declared products all constituents of the product is registered, whether or not the substances are included in the list of dangerous substances

In **Denmark**, like in Norway, the declaration is mandatory for product including dangerous substances, but the requirements also apply to all solvents, pesticides, biocides and cosmetics. Information on all constituents is required for products for which declaration is mandatory. Denmark has complete information on composition for the majority of products. Until 2004 declaration was not mandatory for products marketed before April 1, 1983, and for this reason e.g. fuels were generally not declared (Andersen, 2005).

In **Finland**, like in Norway and Denmark, the declaration is mandatory for product including dangerous substances. Additional requirements apply to pesticides and chemicals that cause danger, although they are not classified. The information on the composition of products is registered from the safety data sheets. Complete information on the exact composi-

tion is consequently not necessarily given. The volumes are contrary to the other countries registered as intervals of ten: 1-10 t, 10-100 t, etc.

Exemptions

All four countries exempt products that come under legislation on foodstuffs and medicinal products from mandatory declaration. Furthermore, the duty to declare products to the product registers does not apply to cosmetic products in Sweden, Norway and Finland.

There is also a general exemption from the duty to declare chemicals in Sweden, Finland and Norway, if the quantity produced or imported is less than 100 kg per year. This means that small volumes of chemicals (e.g. laboratory chemicals or products for dental services) may escape registration.

In addition, there is no requirement to declare solid processed articles (e.g. air-conditioning equipment) to any of the registers. Thus, the duty to declare products to the registers does not include chemicals in textiles, chipboard, etc. Based on the available information it is expected that the substances covered by this study will mainly be traded in chemical products, but it cannot be excluded that some of the substances are imported in e.g. industrial air-conditioning equipment.

Update of product register data

In Sweden and Norway the quantities, the classification, the codes for areas of use and the codes for product types of products are updated every year, and trends can therefore be followed for both substances and products. Updating of the other information given by the company at registration, like composition and physical properties is supposed to take place whenever these conditions are altered.

In Finland the quantitative data are quite up-to-date as the Finnish product register has only been collecting information on quantities since year 2001.

In Denmark, there is no systematic updating of quantities of products. The companies are obliged to send in any new information regarding their products whenever changes occur. If companies fail to fulfill their obligations, a result might be that products that have been discontinued still remain on the lists. For the present analysis the Danish product register has contacted companies who have declared the use of the substances and updated the declared quantities on this basis.

2.2 Registered consumption

The registered consumption of the substances in the Nordic product registers is shown in table 2.1.

The registers in Norway, Denmark and Finland mainly include products containing dangerous substances. Five of the new ozone depleting substances are included in the EU list of dangerous substances and should thus be declared to the product registers in all four countries. The remaining three may be declared if they make part of chemical products which contain dangerous substances, but the product register data for these substances cannot be considered comprehensive.

Many of the data from the product registers are considered confidential due to a low number of registered products/declaring companies and it has thus been necessary to aggregate all data across the Nordic countries.

1,1,1-trichloro-2,2,2-trifluoroethane and dibromodifluoromethane, not included in the list of dangerous substances, are only declared in DK, but may be traded in at least Norway and Finland without being declared.

2,2,3,3- Tetrachloro hexafluorobutane is not registered in any of the registers and not included in the list of dangerous substances.

2-Bromopropane and 1-Bromo-3-chloropropane are registered as used as intermediate in Finland only. The substances are most probably used by one company only (Fermion Oy).

Only 1-bromopropane and dibromoethane are registered in all countries. For these two compounds several different applications are reported.

Bromoethane is registered in Finland only in small quantities for laboratory use.

For none of the substances any consumption was registered in Norwegian product register.

Table 2.1 Reported consumption of registered substances in the Nordic product registers in 2003

Substance	Included in the list of dangerous substances	Total registered consumption in the Nordic countries	Reported use categories	Registered in following registers
1-Bromopropane	+	8	Degreaser; Stabiliser (use has ceased), Process raw material; Laboratory chemical (with a recorded consumption of 0 t)	DK, SE, FI
2-Bromopropane	+	Confidential	Intermediate for pharmaceuticals	Confidential
Bromoethane	+	Confidential	Laboratory chemical	Confidential
Dibromoethane	+	0.6	Laboratory chemical; gasoline additive *	DK, SE, FI
1-Bromo-3-chloropropane	+	Confidential	Intermediate for pharmaceuticals	Confidential
1,1,1-trichloro-2,2,2-trifluoroethane		Confidential	Degreaser (use has ceased)	Confidential
2,2,3,3-Tetrachloro hexafluorobutane		0		
Dibromodifluoromethane		0		

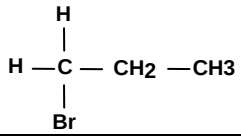
* In Sweden the application as gasoline additive was indicated as "process raw material".

3 Uses and alternatives

In the following chapter uses of the substances and alternatives to the substances are described. For each substance the chapter includes the following information:

- A table listing names, identification numbers, molecular formula, ozone depletion potential, classification and registered producers in Europe.
- A description of identified uses and consumption of the substances. The consumption figures are based on information obtained from the Nordic product registers combined with information from supplies. In some cases information on consumption figures is confidential because less than three companies have notified the consumption of the substance to the product registers.
- A description of alternatives to the substances for the identified applications. The description is based on information obtained from suppliers and users of the substances and suppliers of alternatives. Alternatives are addressed for the four substances 1-bromopropane, dibromoethane, 1,1,1-trichloro-2,2,2-trifluoroethane and tetrachlorohexafluorobutane only. The remaining substances are either not used in significant amounts or used only as intermediate in the chemical or pharmaceutical industry.

3.1 1-Bromopropane

Name	1-Bromopropane
Synonyms	n-Propyl bromide nPB
CAS No	106-94-5
EINECS No	203-445-0
Molecular formula	C_3H_7Br 
Appearance	Clear colourless to slightly yellow liquid
ODP	0,003-0,1 (UNEP 2003)
Classification	F; R11 - Rep. Cat. 2; R60 - Rep. Cat. 3; R63 - Xn; R48/20 - Xi; R36/37/38 - R67
Risk Phrases	R60 : May impair fertility. R11 : Highly flammable. R36/37/38 : Irritating to eyes, respiratory system and skin. R48/20 : Harmful: danger of serious damage to health by prolonged exposure through inhalation. R63 : Possible risk of harm to the unborn child. R67 : Vapours may cause drowsiness and dizziness.
Safety Phrases	S53 : Avoid exposure - obtain special instructions before use. S45 : In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible)
Producers in Europe (according to IUCLID)	Albemarle PPC, FR CHEMIMPO BV , NL ELF ATOCHEM , FR (now ATOFINA) Eurobrom B.V., NL

3.1.1 Application and consumption

According to producers' information the substances are used as organic solvent for the preparation of formulations used for precision cleaning of electronics, metal parts, coatings and inks (Dead Sea Bromine Group 2004a and Albemarle 2004a). 1-Bromopropane is also used as an organic intermediate for pharmaceuticals and agrochemicals (Dead Sea Bromine Group 2004a).

Further the compound is in literature reported to be used in spray adhesives and as an intermediate in the synthesis of pharmaceuticals, insecticides, quaternary ammonium compounds, flavours, or fragrances (CERHR 2003a).

As the substance is included in the list of dangerous substances, chemical products containing the substance shall be declared to the products registers in the Nordic countries (if the total is above the triviality limit).

The total recorded consumption of 1-Bromopropane in the Nordic product registers is 8 tonnes. The total consumption in the Nordic countries is estimated at 8-15 t/year.

Solvents, use and characteristics

Pure1-bromopropane is unusable as a solvent. It is therefore sold as a mixture containing stabilizers or additives for solvent applications. The compositions of the solvents typically include 1-bromopropane at 70-95% with 1-bromopropane levels exceeding 90% in the majority of products (CERHR 2003a). Other ingredients listed in these MSDS included butylene oxide, 1,3-Dioxolane, nitromethane, dimethoxymethane, t-butanol, 1,1,1-2-tetrafluoroethane, and a terpene blend (CERHR 2003a).

Trade names for 1-bromopropane solvent mixtures traded in the Nordic countries include Ensolv (Enviro Tech International Inc.). Other trade names on the US market include Abzol (Albemarle),Hypersolve, Lenium, Contact Cleaner–NPB Heavy Duty, Leksol, Teksol, Solvon, Vapor Edge 1100, X-Cel, VDS-3000, Cobar-Clean NPB, No Flash Nu Electro Cleaner, Heavy Duty Degreaser II, and 1640 Bulk (CERHR 2003a).

According to industry sources, 1-bromopropane based degreaser solvents are broadly applicable to all kinds of organic solvent degreasing. These substances were chosen as substitutes for the now banned trichloroethane (TCA) based degreasing agents, and 1-bromopropane based degreaser solvents can be applied directly in degreaser units designed for TCA and TCE (trichloroethylene) use. 1-bromopropane is however significantly more expensive than TCA/TCE and may therefore have a higher application for smaller items, which do not require so large solvent volumes in the degreaser unit.

The solvents are applied in different ways. Vapour degreasing is according to information of suppliers the most effective method of washing, rinsing and drying contaminated substrates in one step. Vapour degreasing has become the preferred method of cleaning since the introduction of halogenated solvents. The solvent is used in a vapour degreaser, in which a part of the solvent is heated to the boiling point and vapours rise above the liquid level into the work zone. The items which are degreased are introduced in the degreaser manually or automatically on a conveyer. Because solvent vapour is heavier than air, it can be contained in the degreaser. Periodical replenishment of the solvent is however necessary and losses to the air do take place. Periodically, the dirt rinsed off the cleaned items (oils, fat etc.) reach concentrations in the solvent necessitating cleanups (is monitored via measurements of the boiling point of the solvent/dirt mixture). The dirt is either pumped out of the solvent sump or removed manually by opening the degreaser unit and scraping out the

dirt. Both the dirt/solvent mixture and disposed pure solvent must be collected and disposed of as hazardous waste.

Another method, cold cleaning, generally takes place in a tank filled with solvent. The parts are dipped into the solvent, which dissolves and removes contaminates.

Solvents, consumption and releases

Industry sources contacted for this study hesitate to give consumption data, but state however that an absolute maximum for the total consumption of 1-bromopropane based degreasers in the Nordic countries is 50 tonnes/year. Based on other indicative information, this should however likely be considered a high-end estimate.

The reason for the higher consumption figures in Denmark compared to the other countries appears to be that other solvents are used in degreasers in the other countries for the same processes. According to suppliers, TCE is the major degreasing agent for comparable processes in Norway and Sweden. In Norway dichloromethylene (DCM) and perchloroethylene (PCE) are apparently still in use for degreasing purposes. Degreasing with modified alcohols is an up-coming alternative in Sweden, but this requires more expensive degreasing units (see below about alternatives).

According to suppliers, 1-bromopropane-based degreasing agents are relatively expensive, and this should in itself promote the limitation of atmospheric releases for economical reasons. Based on information from suppliers on the approximate number of 1-bromopropane using degreasing installations and a rough estimate of likely ranges for hourly atmospheric releases per installation, an impression of the annual releases in can be formed.

Stabiliser

The Danish product register holds information on a minor use of the substance as stabiliser, but according to the company, which has declared the use, the substance is not used for this purpose any more.

Chemical raw material

The substance is registered as process raw material in one or more of the Nordic product registers. .No information on alternatives has been available.

Adhesives

Trade names of adhesives containing 1-bromopropane on the US market include Whisper Spray (Imperial Adhesive) and Fire Retardant Soft Seam 640 (Mid South Adhesive) (16). (CERHR 2003a). It has not been possible to obtain any information on the use of 1-bromopropane in adhesives in the Nordic countries.

Laboratory chemical

According to information from suppliers the consumption of dibromoethane as laboratory chemical is in the order of magnitude of a few kilograms. For laboratory use, the substance is applied in research and biotech industry, among others, in the Nordic countries.

3.1.2 Alternatives

Alternatives to 1-bromopropane solvent use (degreasing)

1-bromopropane degreasers are competing with TCE degreasers on the market. TCE is however classified as dangerous and is therefore not considered an environmentally better alternative.

Degreasing can be performed with several other processes and substances. Some examples are alcohol degreasing and alkalic (water-based) degreasing. According to industry sources degreasing with alcohol requires vacuumized degreasing units, which are large in size and require higher investments.

Alkaline, water-based degreasing is another generally applied method. According to industry sources, the used substance is cheaper than 1-bromopropane, but the process as such may not necessarily be cheaper, because more process steps are involved, and the rinsed items must be dried, and the process thereby requires more energy.

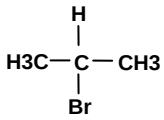
A relatively new alternative degreasing agent is liquid CO_2, which has favourable environmental characteristics, but must operate under pressure in closed systems and does therefore require higher installation requirements. According to suppliers of competing degreasing systems, CO_2's solvency is limited, which makes its (current) use restricted to certain specialised applications. CO_2-based degreasing systems are commercially available in Denmark now.

Product information material on a 1-bromopropane based solvent "Abzol cleaner" from the producer Albemarle (2004a), mentions the following alternatives to TCA, and summarises their view of the applicability:

Hydrocarbons and oxygenated hydrocarbons:	Low cost, but "tend to be readily flammable"
HCFCs:	HCFC-141b has been restricted to non-cleaning applications. "Other examples tend to be too expensive, too volatile, or have only moderate cleaning ability."
Fluorocarbons:	Non-toxic, non-flammable and safe to use. Expensive and have "poor solvency for some soils" (Eds.: soils may mean "dirt" here).
Hydrofluorocarbons (HFCs):	Moderate solvency, and tend to be expensive, but are applicable "for niche applications that can accept the high price".
Hydrofluorethers (HFEs):	HFEs are similar to HFCs in solvency and costs.
Volatile methyl siloxanes (VMSs):	"VMSs, such as hexamethyldisiloxane, are low in toxicity, contain no halogen atoms and are chemically stable. On the other hand, they have flash points and only offer moderate solvency". (Authors comments: Certain low weight siloxanes are of concern having toxic effects)

Aqueous systems	Low cost, but not suitable for all applications. "Slow drying, residues on cleaned parts and corrosion of metals are issues to consider. Electrical or electronic applications usually cannot tolerate the presence of any remaining traces of water."
Semi-aqueous systems	Not disposable with wastewater. "Separation and recycle of the organic phase are usually difficult and is not cost-efficient. Slow drying and potential corrosion problems may also come into play".

3.2 2-Bromopropane

Name	2-Bromopropane
Synonyms	Isopropyl bromide
CAS No	75-26-3
EINECS No	200-855-1
Molecular formula	C_3H_7Br 
ODP	0.018 (Huie et al. 2002)
Classification	Rep1;R60 F;R11 Xn;R48/20 R66
Risk Phrases	R60 : May impair fertility. R11 : Highly flammable. R48/20 : Harmful: danger of serious damage to health by prolonged exposure through inhalation. R66 : Repeated exposure may cause skin dryness or cracking.
Safety Phrases	S16 : Keep away from sources of ignition - No smoking. S53 : Avoid exposure - obtain special instructions before use. -S45 : In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible).
Producers in Europe (according to IUCLID)	Albemarle PPC, FR ELF ATOCHEM, FR (now ATOFINA) Great Lakes Chemical (Europe) Limited ', UK Riedel-de Haën AG, DE (Sigma Aldrich Group)

3.2.1 Application and consumption

2-bromopropane may - according to producers' information - be used as intermediate in organic synthesis and as a solvent (Albemarle 2004 b).

Further 2-bromopropane is formed as a contaminant by synthesis of 1-bromopropane. In the USA the Occupational Safety and Health Administration (OSHA) has analyzed several samples of commercial 1-bromopropane in the past year and found 2-bromopropane present in each of them, in concentrations ranging from 0.1 to 0.2 % (CERHR. 2003b).

Intermediate

2-bromopropane is registered as feedstock for synthesis of pharmaceuticals in one or more of the Nordic product registers.

Solvent use

There is no evidence of the use of 2-bromopropane as solvent in the Nordic countries.

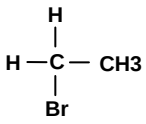
Laboratory chemical

According to information from suppliers the consumption of 2-bromopropane as laboratory chemical is in the order of magnitude of a few kilograms.

Contaminant

If it is assumed that 2-bromopropane is present as contaminant in 1-bromopropane at a level of 0.1-0.2 % and the consumption of 1-bromopropane in the Nordic countries is approximately 9 t/year (see section 3.1) the total content of 2-bromopropane as contaminant can be estimated at 9-18 kg/year.

3.3 Bromoethane

Name	Bromoethane
Synonyms	Ethylene bromide Ethyl bromide
CAS No	74-96-4
EINECS No	200-825-8
Molecular formula	C_2H_5Br 
ODP	no data
Classification	F;R11 Xn;R20/22 Carc3;R40
Risk Phrases	R11 : Highly flammable. R20/22 : Harmful by inhalation and if swallowed. R40 : Limited evidence of a carcinogenic effect.
Safety Phrases	S2 : Keep out of the reach of children. S36/37 : Wear suitable protective clothing and gloves.
Producers in Europe (according to IUCLID)	Albemarle PPC, FR BASF AG , DE ELF ATOCHEM , FR (now ATOFINA) Great Lakes Chemical (Europe) Limited, UK

3.3.1 Application and consumption

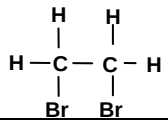
The substance is by producers reported to be used as intermediate in organic synthesis (Albemarle). There is no indication of the use of the substance for this purpose in the Nordic countries.

Laboratory chemical

According to data from the product registers 1-10 kg/year bromoethane is used as laboratory chemical. A supplier has reported that the substance is used in marginal amounts (few kg) in the Nordic countries for the synthesis of an intermediate for asymmetric catalytic reactions.

Information from suppliers confirms that the consumption of 2-bromopropane as laboratory chemical is in the order of magnitude of a few kilograms per year.

3.4 Dibromoethane

Name	Dibromoethane
Synonyms	Ethylene dibromide DBE 1,2 dibromoethane
CAS No	106-93-4
EINECS No	203-444-5
Molecular formula	$C_2H_4Br_2$ 
ODP	no data
Classification	Carc. Cat. 2; R45 T; R23/24/25 Xi; R36/37/38 N; R51-53
Risk Phrases	R45 : May cause cancer R23/24/25 : Toxic by inhalation, in contact with skin and if swallowed R36/37/38 : Irritating to eyes, respiratory system and skin. R51/53 : Toxic to aquatic organisms, may cause long-term adverse effects in the aquatic environment.
Safety Phrases	S53 : Avoid exposure - obtain special instructions before use. S45 : In case of accident or if you feel unwell, seek medical advice immediately (show the label where possible). S61 : Avoid release to the environment. Refer to special instructions/Safety data sheets.
Producers in Europe (according to IUCLID)	Associated Octel , UK * Associated Octel Company Ltd, UK. * Atochem, FR (now ATOFINA) Eurobrom B.V., NL (ICL Industrial Products) S.I.A.C. S.R.L., IT

* According to information from the company it has ceased the production

3.4.1 Application and consumption

Dibromoethane is according to producers used as a scavenger additive in leaded gasoline and widely used as a solvent and as intermediate in the chemical and pharmaceutical industry (Dead Sea Bromine Group 2004b).

By the US Occupational Safety and Health Administration the substance is reported to be used as a pesticide (fumigant); used in production of waterproofing agents, fire extinguishing agents, and gauge fluids during manufacture of measuring instruments; used in organic synthesis in production of dyes, pharmaceuticals, perfumes, vinyl bromide, and ethylene oxide; used as a specialty solvent for resins, gums, waxes, celluloid, fats, and oils (OSHA 2004).

Leaded gasoline

Dibromoethane is used as scavenger for tetraethyl lead added as anti-knock agent to gasoline. Leaded gasoline is in the Nordic countries today used for piston engine powered propeller-driven aircrafts.

When the gasoline (so-called AVGAS) is burned in an engine, the lead in tetraethyl lead is converted to lead oxide. Without a scavenger, lead oxide deposits would quickly accumulate on the valves and spark plugs. Dibromoethane reacts with the formed lead oxide and converts it to a mixture of lead bromide and lead oxybromides. As these compounds are volatile, they are exhausted from the engine along with the rest of the combustion products (Chevron 2004).

According to information from Octel Corp., the world's major producer of tetraethyl lead, dibromoethane is the only scavenger used for AVGAS, whereas leaded motor gasoline for cars (not used in the Nordic countries) usually contains a mixture of ethylene dibromide and ethylene dichloride (17.86% w/w DBE and 18.81% w/w DCE). Octel supplies the product "TEL- B" for exclusive use in aviation gasoline. The product contains 61.49% w/w tetraethyl lead (with a lead content of 64%) and 35.72% w/w ethylene dibromide. The Pb/dibromoethane ratio is consequently 1.1. It is in the most used fuel, AVGAS 100 LL (LL for low lead) dosed to achieve a maximum lead content in the fuel of 0.56 g Pb/l corresponding to 0.51 g dibromoethane per l. MSDSs for different AVGAS products indicate a dibromoethane content at < 4 ml/g al (Chevron Texaco) and 0.02% (Engen).

According to the available information lead-containing AVGAS is not produced by any of the refineries in the Nordic countries, but is imported from abroad.

In Denmark the consumption of AVGAS in 2000 was 4,000-5,000 tons (Lassen et al. 2002). With an average lead content of 0.52 g Pb/l the total lead content is estimated at 2-2.5 t Pb (Lassen et al. 2002). If, for a first estimate, the ratio between lead and dibromoethane of TEL-B is used, the consumption of dibromoethane can be estimated at 1.8-2.3 t.

In Norway 2.5 t lead was released to the air from aviation activities in 2002 (SFT 2004), and in Sweden the release is estimated at about 5 tonnes (Ny Teknik 2005), which is well in accordance with the per-capita consumption in Denmark. Hjelmeberg (2005) estimates, however, that the consumption of leaded AVGAS in Sweden has decreased in recent years to a level of about 3 tonnes/year.

If it is assumed that the per capita consumption of AVGAS in Finland corresponds to the consumption in Norway, Sweden and Denmark, the total consumption of dibromoethane with AVGAS in 2003 can be estimated at 9-11 t/year. Considering the uncertainty on the estimates the actual consumption is estimated to be within the range of 8-12 t/year.

A consumption of dibromoethane at this level is not confirmed by the data from the Nordic product registers. In Finland the product register has recorded the consumption in 2002 and 2003 of 1.2 and 0.2 tonnes respectively. In Sweden 0.42 tonnes in 2003 was indicated in the product register as used as "process raw material", but the actual application was as additive in leaded gasoline. The product register in Denmark have no record on the use of dibromoethane as gasoline additive.

In Denmark the use of leaded aviation gasoline is prohibited by Statutory Order No. 1012 of 13. November 2000 (the Lead Statutory Order), but exemptions have been granted.

According to the Toxicological Profile from OSHA (2002) 1,2-Dibromoethane releases to the atmosphere historically have been due to releases from production and fugitive emissions from leaded gasoline and automobile exhaust. The report does not quantify the fugitive emissions. The Environmental Health Criteria on dibromoethane (WHO 1996) quote a number of studies demonstrating the significance of dibromoethane in exhaust gas from vehicles and chain saws, but do not provide any information on specific emission factors.

An analysis of organobromine compounds and HBr in exhaust gases from motor cars using dibromoethane-containing fuel demonstrated that organobromine compounds accounted for 22-44% of the total bromine in the exhaust gas (Baumann and Heaumann 1987). The concentration of methyl bromide, dibromoethane, and vinyl bromide in the exhaust gas was in the range of 90–190 $\mu g/m^3$, 15–85 $\mu g/m^3$, and 5–20 $\mu g/m^3$, respectively. The concentration of the organobromine compounds decreased with increasing motor temperature.

Laboratory chemical

According to information from suppliers, the consumption of dibromoethane as laboratory chemical is in the order of magnitude of a few kilograms. Uses include reference standards for analysis, solvent uses, chemical synthesis and production of pharmaceuticals.

Pesticide

Dibromoethane has formerly been used as pesticide (and is still used as such in some parts of the world). The use of dibromoethane as pesticide is prohibited in the EU. (Council Directive 79/117/EEC with amendments).

3.4.2 Alternatives

Alternatives to dibromoethane in AVGAS

According to producer's information no alternatives to dibromoethane are available for use in leaded AVGAS. Chlorinated substances cannot be used because of corrosion problems. The alternative is to use unleaded gasoline.

Lead-free AVGAS has been developed by the Swedish company Hjelmco AB, which probably is the only supplier of lead-free AVGAS in the world. The AVGAS consists of pure hydrocarbon and is a so-called alcylate aviation gasoline. Today only lead-free AVGAS 91/96 UL is supplied. (Hjelmberg 2005). The lead-free types are widely used in Sweden, where Hjelmco AB has their own distribution net for distribution of the gasoline. The price of the lead-free AVGAS is the same as for lead-containing AVGAS in Sweden.

According to Hjelmberg (2005) the lead-free AVGAS cannot oust lead-containing AVGAS in other countries without environmentally differentiated tax on AVGAS. The obstacle for the use of the lead-free AVGAS is the development of the distribution system (filling stations, etc.)

Today no alternatives are available for the AVGAS 100/130 octane. The main AVGAS used for this octane is AVGAS 100 LL. Approximately 30% of the piston engine powered aircraft fleet is certified for 100/130 and consumes approximately 70% of the AVGAS (Hjelmberg 2002; 2005). According to Hjelmberg (2005), however, approximately 70% of the 100LL fleet can use the lower octane lead-free substitute, just by changing to another type of motor oil.

The currently most promising 100/130 octane replacement candidates are (Hjelmberg 2005):

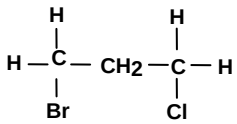
- MTBE (methyl tertiary butyl ether) + hydrocarbon gas;
- MTBE/ETBE (methyl tertiary butyl ether/ethyl tertiary butyl ether) + alkylate + amines.

The MTBE is of environmental concern as a groundwater pollutant (Harrekilde et al. 2003). ETBE is today used in smaller quantities and is less investigated. The solubility of ETBE is about one third of the solubility of MTBE (US EPA 1998) indicating that the risk of groundwater pollution may be less for this substance, but it has not been possible to identify any

evidence for this. Both MTBE and ETBE are degraded to tert-butyl alcohol (TBA). Besides, the amines may also be of concern.

The development of lead-free 100/130 octane has been going on for about 10 years, and still no useful formula exists. Once a formula has been found, certification would take another 3-5 years.

3.5 1-Bromo-3-chloropropane

Name	1-Bromo-3-chloropropane
Synonyms	Bromochloropropane Trimethylene chlorobromide 1,3 BCP
CAS No	109-70-6
EINECS No	203-697-1
Molecular formula	C_3H_6BrCl 
ODP	0,05 (UNEP 2003)
Classification	Not classified in the Annex I of Directive 67/548/EEC
Risk Phrases	-
Safety Phrases	-
Producers in Europe (according to IUCLID)	Albemarle PPC, FR Orion-Yhtymä Oy, Fermion, FI *

* According to the company the substance has never been produced by Fermion.

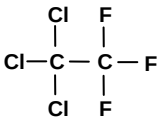
3.5.1 Application and consumption

1-Bromo-3-chloropropane is by producers reported to be used as intermediate for organic synthesis (Albemarle 2004c).

Organic synthesis

The substance is registered as intermediate for synthesis of pharmaceutical ingredients in one or more of the Nordic product registers.

3.6 1,1,1-Trichloro-2,2,2-trifluoroethane

Name	1,1,1-trichloro-2,2,2-trifluoroethane
Synonyms	R. 113a CFC-113a FREON FT Trichlorotrifluoroethane (also used for CFC 113)
CAS No	354-58-5
EINECS No	206-564-6
Molecular formula	$C_2Cl_3F_3$ 
Appearence	Colourless liquid with a slight ethereal odour
ODP	0,65 (UNEP 2003)
Classification	Not classified in the Annex I of Directive 67/548/EEC
Risk Phrases	-
Safety Phrases	-
Producers in Europe (according to IUCLID)	Solvay Fluor und Derivate GmbH, DE *

* According to the company, Solvay has ceased the production of the substance[1]

The substance 1,1,1-trichloro-2,2,2-trifluoroethane is an isomer of CFC-113 which is included in the Annex A, Group 1 to the Montreal Protocol. The coding, 113 is derived from the number of atoms in the substance: $C_2Cl_3F_3$. According to Article 1 of the Protocol the definition of a controlled substance includes isomers of the substances listed in the annexes (except otherwise specified in the relevant annex) and therefore CFC-113a should already be considered a controlled substance itself as pointed out in the report of the Executive Director to the thirteenth meeting of the parties to the Montreal Protocol, October 2001 (UNEP 2001). The name CFC 113 is mostly used for the substance 1,1,2-trichloro-1,2,2-trifluoroethane (CAS No 76-13-1).

According to IUCLID the substance is in Europe produced by Solvay Fluor und Derivate GmbH, but the production has, according to information from the company, ceased.

The substance has previously been traded by Fluorochem, UK, but they have removed it from their catalogue.

The substance is included in the catalogue of Apollo Scientific Ltd., UK, a company supplying chemicals for research and development pur-

[1]

poses. According to information from the company they do no longer sell the substance.

3.6.1 Application and consumption

The substance is by a US supplier reported to be used as an intermediate to manufacture of specialty chemicals (Halocarbon Products Corporation 2004).

According to (UNEP 2001) 1,1,1-trichloro-2,2,2-trifluoroethane has been reported to UNEP by India. The substance was being synthesized by an Indian chemical company for use as an agrochemical intermediate.

The compound is together with other CFC 113 isomers in the EU trade statistics included in the Combined Nomenclature commodity group 2903 43 00: Trichlorotrifluoroethanes.

The substance can be found in web-based catalogues from the companies Apollo Scientific Ltd. and Fluorochem (both UK); however, according to information from the companies there is no sale of the compound.

Degreaser

According to the Danish product register 1,1,1-trichloro-2,2,2-trifluoroethane was used as degreaser in the electronics industry. According to recent information the product has not been used for the last 2-3 years.

This application is not included in the Danish reporting on the use of ozone depleting substances (Poulsen 2004). According to the report 0.95 t CFC-113 is used for laboratory purposes.

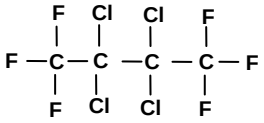
Laboratory chemical

There is no evidence of the use of the compound as laboratory chemical in the Nordic countries.

3.6.2 Alternatives

For degreasing, the general alternatives are described in section 3.1.2 on alternatives to 1-bromopropane.

3.7 2,2,3,3-Tetrachlorohexafluorobutane

Name	2,2,3,3- Tetrachlorohexafluorobutane
Synonyms	Hexafluoro-2,2,3,3-tetrachlorobutane
CAS No	375-34-8
EINECS No	
Molecular formula	$C_4Cl_4F_6$ 
ODP	no data
Classification	Not classified in the Annex I of Directive 67/548/EEC
Risk Phrases	-
Safety Phrases	-
Producers in Europe (according to IUCLID)	No producers

The substance has previously been traded by Fluorochem (UK), but they have recently removed it from their catalogue.

The substance is included in the catalogue of Apollo Scientific Ltd., UK, a company supplying chemicals for research and development purposes. The company lists small pack sizes (5 g and 25 g). According to information from the company there is no sale of the compound.

3.7.1 Application and consumption

Flon-s-316

2,2,3,3-Tetrachlorohexafluorobutane has according to UNEP (2001) been used as Flon-s-316, a substitute for CFC 113. Asahi (Japan) is indicated as producer.

On request, Asahi Glass Company Ltd. has informed that Asahi does not produce or use the substance. Among other chemical products, Asahi produces the solvent ASAHIKLIN AK-225 which is a mixture of 3,3-dichloro-1,1,1,2,2-pentafluoropropane (HCFC-225ca) and 1,3-dichloro-1,1,2,2,3-pentafluoropropane (HCFC-225cb).

By an Internet search for flon-S-316, only one application of flon-S-316 was identified. The product is reported to be used as extraction agent in analyses of drainage water from off-shore oil drilling rigs (Statoil 2003).

The mentioned flon-S-316 is a solvent produced by the Japanese company Daikin and marketed in Europe by another Japanese company, Horiba. The solvent is widely used for analysis of oil in water and has the type number S-316 (but without "flon"). The solvent does not contain

2,2,3,3-tetrachlorohexafluorobutane, but other congeners of tetrachlorohexafluorobutane. The solvent is further described in the next chapter.

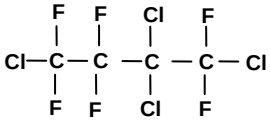
Laboratory chemical

It has not been possible to obtain any information indicating that 2,2,3,3-tetrachlorohexafluorobutane is used as laboratory chemical in the Nordic countries.

Conclusion

Most probably 2,2,3,3-tetrachlorohexafluorobutane is not used in the Nordic countries.

3.8 Tetrachlorohexafluorobutane

Name	Tetrachlorohexafluorobutane
Synonyms	Hexafluorotetrachlorobutane
CAS No	28107-59-7
EINECS No	248-847-7
Molecular formula	$C_4Cl_4F_6$  The substance is a mixture of congeners - only one example shown

ODP	no data
Classification	Not classified in the Annex I of Directive 67/548/EEC
Risk Phrases	-
Safety Phrases	-
Producers in Europe (according to IUCLID)	No producers

3.8.1 Application and consumption

Solvent use

Tetrachlorohexafluorobutane makes part of a solvent, S-316 produced by the Japanese company Daikin, and marketed in Europe by another Japanese company, Horiba. The solvent is widely used for analysis of oil in water by infrared (IR) detection.

According to the MSDS for S-316 obtained from Horiba the solvent contains CAS No. 9002-83-9 (chlorotrifluoroethylene telomere/polychlorotrifluoroethylene) and CAS No 28107-59-9 (tetrachlorohexafluorobutane). The Tetrachlorohexafluorobutane is a product of polymerisation of trifluorochloroethylene (CF2=CFCl), and according to information from Horiba the polymerization yields only ClCF2-CFCl-CF2-

CFCl2 (1,2,4,4 tetrachlorohexafluorobutane), CFCl2-CF2-CF2-CFCl2 (1,1,4,4, tetrachlorohexafluorobutane) and CF2Cl-CFCl-CFCl-CF2Cl (1,2,3,4-tetrachlorohexafluorobutane). The principle is that at least one Cl is in the 1st and the 4th position, respectively. The congener 2,2,3,3-tetrachlorohexafluorobutane should not be present in S-316.

According to Hayakawa et al. (1999), S-316 contains the substance 1,2,3,4-tetrachlorohexafluorobutane (CAS 375-45-1).

Horiba's S-316

Horiba sells S-316 exclusively for the use as an extraction solvent in Horiba's on-site IR measurement analysers for analysis of oil in water and soil. According to Horiba, other techniques for analysis of oil in water and soil are not equally quick and handy for in-the-field use. Alternatives for S-316 use in Horiba's IR analysis units are being sought. Most currently available alternatives are however ozone depleting substances (ODS) themselves. The qualities that make S-316 suitable for the application are high density, high boiling point, low miscibility with water and an absorption spectre that does not interfere in the measurements (Horiba, 2005).

According to suppliers, S-316 may generally be used for oil-in-water analysis in many sectors, including the oil and refinery industry, airports (for analysis of surface water), and industries which monitor oil contents of their waste water discharges to fulfil environmental requirements. In the Nordic countries however, the use seem to be rather limited currently and no overview information on sectors where it used is available for these countries. No information on consumption in the Nordic countries is available from suppliers.

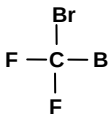
3.8.2 Alternatives

Alternatives for S-316 in oil-in-water analysis

Statoil in Norway, who is a user of oil-in-water analyses, has summarised their experiences with possible alternatives for S-316 in oil-in water analysis (Statoil, 2004). Alternatives include other solvents and other technologies. They defined the main characteristics of suitable alternative solvents as follows: In-solubility in water, good solvency for oil, must not have carbon-hydrogen bonds, must not be ozone-depleting, and must not induce a health risk. Statoil considered the following alternatives:

Super critical extraction with CO_2 and IR detection	The method is new and appears promising. An asset is that results can be compared with results produced with S-316 and Freon extraction. The process has recently become commercially available, the practical experience with it is however still limited.
Infracal, pentane extract analysed with IR "flat cell" detection	Volatile hydrocarbons vaporise and leave too little material for detection on the flat cell.
Arjay Fluorocheck, pentane extract analysed with UV-fluorescence detection	Low concentrations in the samples of PAHs, which are the substances that can be detected with this technology, make the method unreliable for this use.
IR on extracts with perchloroethylene	Good method, but the substance is carcinogenic, and was therefore ruled out.
IR on extracts with "Ikon-P" solvent	Ikon-P was developed for this specific use, but the substance decomposes during analysis, giving short analysis time. The possible toxicity of decomposition substances may pose a health risk.
GC-FID headspace analysis of volatile hydrocarbons	This method only detects the volatile part of the oil in the samples, and does therefore not provide an adequate alternative to S-316/IR analysis.

3.9 Dibromodifluoromethane

Name	Dibromodifluoromethane
Synonyms	Halon-1202 Difluorodibromomethane Freon 12-B2 R12B2 UN1941
CAS No	75-61-6
EINECS No	200-885-5
Molecular formula	$CBr_2 F_2$ 
ODP	1,25 (UNEP 2003)
Classification	Not classified in the Annex I of Directive 67/548/EEC
Risk Phrases	-
Safety Phrases	-
Producers in Europe (according to IUCLID)	No producers listed

3.9.1 Application and consumption

Halon-1202 is according to a summary of the recommendations of the Technology and Economic Assessment Panel, a working group of the parties to the Montreal Protocol, used as fire extinguisher in three types of military aircraft (UNEP 2000). It is according to the document estima-

ted that about 2 tonnes are used annually, out of 110 tonnes installed. The reported increases in atmospheric concentrations of halon-1202 cannot be explained by its use as a fire extinguisher. Halon-1202 is also used as a feedstock for the production of halon-1211. Emissions of halon-1202 are according to the summary mostly due to the use as feedstock during the production of halon-1211.

The areas of current halon usage in the Nordic countries have recently been assessed in a study for the Nordic Council of Ministers (DIFT 2004). In the study halons used in the Nordic countries are identified and described, and detailed country estimates for quantities of halons used are prepared. According to the study only halon-1211 and halon-1301 are still in use in the Nordic countries. The main areas of use are in all three branches of the armed forces, small vessels, such as fishing boats and ferries, and in civil aircraft.

The study does not identify any use of halon-1202 in the Nordic countries. As the study includes those areas, for which the use of halon-1202 has been reported in other countries, it can be concluded that halon-1202 most probably is not used in the Nordic countries today. This conclusion is confirmed by the author of the report (Westerman 2004).

4. Management of waste of addressed substances

Based on the implementation of the EU Waste Directive (1975), the Hazardous Waste Directive (1991) and the European Waste Catalogue (2001) in the national waste regula-tion in Denmark, Sweden, Finland and Norway waste containing the addressed sub-stances will fall into the category of "Hazardous waste".

In the Nordic countries, the waste in these categories must be collected and treated sepa-rately from ordinary domestic waste.

The question is, however, to what extent the waste is actually disposed of in accordance with the regulations. It has been beyond the scope of this study to prepare a survey of the actual waste disposal practice. Based on the authors' background knowledge, in Den-mark the majority of the waste with these substances is expected to actually be collected separately and disposed of as hazardous waste via public or private collection schemes. The same is deemed to be true for the other Nordic countries as well. No Danish EPA reports were identified which could directly document this statement, however. Contact to the environment supervision unit for industries of a major Danish municipality con-firm this assumption; adequate containment and disposal of hazardous waste is a priority issue in the control visits to industrial companies. Even most waste amounts of dibro-moethane used as additive in aviation fuel - the only application sector where less awareness of separate collection requirements could perhaps be expected - is most likely treated as hazardous waste; in this case perhaps to some degree in the form of waste oil from oil separators.

Normally, the waste of the relevant categories is incinerated in hazardous waste incin-erators in the Nordic countries, either in specialised hazardous waste incinerators, or in cement kilns configured to destruct organic hazardous wastes under safe environmental conditions.

According to the European Waste Catalogue, the waste of the addressed substances would fall under one or more of the following main EWC categories (based on a survey of the detailed categories):

EWC-no.	Description
07 00 00	WASTES FROM ORGANIC CHEMICAL PROCESSES
08 00 00	WASTES FROM THE MANUFACTURE, FORMULATION, SUPPLY AND USE (MFSU) OF COATINGS (PAINTS, VARNISHES AND VITREOUS ENAMELS), ADHESIVES, SEALANTS AND PRINTING INKS
13 00 00	OIL WASTES AND WASTES OF LIQUID FUELS
14 00 00	WASTE ORGANIC SOLVENTS, REFRIGERANTS AND PROPEL-LANTS
- 14 06 00	- 14 06 waste organic solvents, refrigerants and foam/aerosol propel-lants
- 14 06 00	- Chlorofluorocarbons, HCFC, HFC
- 14 06 02	- Other halogenated solvents and solvent mixtures
- 14 06 04	- Sludges or solid wastes containing halogenated solvents

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Annex 1 Summary tables

Please find summary tables overleaf

Substance	CAS	Synonyms	Formula	ODP [1]	Producers in Europe (according to IUCLID) [2]	IUCLID Data sheet [2]
1-Bromopropane	106-94-5	n-propyl bromide nPB	1-C_3H_7Br or $CH_2BrCH_2CH_3$	0.003-0.1	Albemarle PPC, FR CHEMIMPO BV , NL ELF ATOCHEM , FR Eurobrom B.V., NL	
2-Bromopropane	75-26-3	Isopropyl bromide	C_3H_7Br	0.018 (Huie et al. 2002)	Albemarle PPC, FR ELF ATOCHEM, FR Great Lakes Chemical (Europe) Limited ', UK Riedel-de Haën AG, DE	
Bromoethane	74-96-4	Ethylene bromide	C_2H_5Br		Albemarle PPC, FR BASF AG , DE ELF ATOCHEM , FR Great Lakes Chemical (Europe) Limited, UK	
Dibromoethane	106-93-4	Ethylene dibromide DBE 1,2 dibromoethane	$C_2H_4Br_2$		Associated Octel , UK Associated Octel Company Ltd, UK. Atochem, FR Eurobrom B.V., NL S.I.A.C. S.R.L., IT	+
1-Bromo-3-chloropropane	109-70-6	Bromochloropropane Trimethylene chlorobromide 1,3 BCP	C_3H_6BrCl	0.05	Albemarle PPC, FR Orion-Yhtymä Oy, Fermion, FI (Author:	+
1,1,1-Trichloro-2,2,2-trifluoroethane	354-58-5	R.113a CFC-113a		0.65	Solvay Fluor und Derivate GmbH, DE	
2,2,3,3- Tetrachlorohexafluorobutane	375-34-8	Hexafluoro-2,2,3,3-tetrachlorobutane	$C_4Cl_4F_6$		No producers listed	
Tetrachlorohexafluorobutane	28107-59-9	Hexafluorotetrachlorobutane	$C_4Cl_4F_6$		No producers listed	
Dibromodifluoromethane	75-61-6	Halon-1202 Difluorodibromomethane Freon 12-B2 R12B2 UN1941	CBr2 F2	1.25	No producers listed	

1) Source: Decision XIII/5, X/8 & IX/24. ***New ozone depleting substances that have been reported by Parties***. UNEP Ozone Secretariat, August 2003

2) Source: IUCLID, European Chemicals Bureau, May 2004. Some of the producers have actually never produced the substances; see the sections for each substance.

Substance	Classification	Uses identified in this study	Other uses mentioned in literature and adverti-sements	Estimated consumption in the Nordic countries Tonnes/year	Amount registered in Nordic product registers Tonnes/year
1-Bromopropane	F; R11 Rep. Cat. 2; R60 Rep. Cat. 3; R63 Xn; R48/20 - Xi; R36/37/38 R67	Degreaser (solvent); Process raw material; Laboratory chemical	Spray adhesives	8-15	8
2-Bromopropane	Rep1;R60 F;R11 Xn;R48/20 R66	Intermediate for pharmaceuticals; Laboratory chemical	Contaminant of 1 bromopropane Solvent	Confidential	Confidential
Bromoethane	F;R11 Xn;R20/22 Carc3;R40	Laboratory chemical	Intermediate for organic synthesis	Confidential	Confidential
Dibromoethane	Carc. Cat. 2; R45 T; R23/24/25 Xi; R36/37/38 N; R51-53	Laboratory chemical; Process raw material; Gasoline additive	Pesticide. Gauge fluid component; Solvent for resins, gums and waxes	8-12	0.6
1-Bromo-3-chloropropane	Xn;R22 Carc3;R40	Intermediate for pharmaceuticals		Confidential	Confidential
1,1,1-Trichloro-2,2,2-trifluoroethane	No classification	Degreaser		Confidential	Confidential
2,2,3,3- Tetrachloro hexafluorobu-tane	No classification	No uses identified	Solvent (probably a mistake)	0	0
Tetrachloro hexafluorobutane	No classification	Solvent		>0.065	Not determined
Dibromodifluoromethane	No classification	No uses identified	Fire extinguisher in some types of military aircraft	0	0

Annex 2 Contacted companies

ABC Hansen Engineering A/S, Denmark

Albemarle Europe, Leuvain-La-Neuve, Belgium

Apollo Scientific Ltd, Stockport, Cheshire, UK

Atofina Norden, Herlev, Denmark

Asahi Glass Company Ltd., AGC Chemicals Fluorochemicals Div., Japan

Bang & Bonsomer Oy, Helsinki, Finland (agent for Eurobrom)

BASF Nordic A/S, Copenhagen, Denmark

BP, Copenhagen, Denmark

Bycosin AB, Karlstad, Sweden (agent for Octel Corp.)

Chemimpo B.V., Den Bosch, the Netherlands

Chemimpo S.A., Johannesburg, South Africa

Clarén Kemi, Hadsund, Denmark

Eurobrom B.V., Rijswijk, the Netherlands (Regional office of Dead Sea Bromine Group)

Fermion Oy, Espoo, Finland (Orion Pharma subsidiary)

Fluorochem, Derbyshire, UK

Great Lakes Chemicals, Bergish Gladbach, Germany

Hjelmco AB, Sollentuna, Sweden

Horiba Ltd., Japan

Horiba Europe GmbH, Germany

Larodan Fine Chemicals AB, Malmö, Sweden (agent for Fluorochem)

Octel Corporation, Newark, USA

Rode & Rode A/S, Hedensted, Denmark (agent for Solvay Fluor und Derivate GmbH.)

S.I.A.C. S.R.L., Bussi Officine, Italy (closed)

Sigma-Aldrich Denmark, Copenhagen

Statoil, Stavanger, Norway

Annex 3 Abbreviations and acronyms

AVGAS	Aviation gasoline (formulated for use in piston-driven airplanes)
CFC	Chlorofluorocarbons
DCM	Dichloromethylene
ETBE	Ethyl tertiary butyl ether
EU	European Union
GC-FID	Gas chromatograph with flame ionization detector
HCFCs	Hydrochlorofluorocarbons
HFCs	Hydrofluorocarbons
HFEs	Hydrofluoroethers
IR	Infrared (light)
IUCLID	International Uniform Chemical Information Database (The basic tool for the data collection and evaluation in the frame of the European Risk Assessment Programme on Existing Substances)
MSDS	Material Safety Data Sheet
MTBE	Methyl tertiary butyl ether
ODP	Ozone depletion potential. (ODP of a substance indicates its capacity for depleting the ozone layer relative to CFC 11)
ODS	Ozone depleting substance
OSHA	United States Occupational Safety and Health Administration
PAHs	Polyaromatic hydrocarbons
PCE	Perchloroethylene
SPIN	Substances in Preparations in Nordic Countries (Data base with information from the Nordic product registers)
TCA	Trichloroethane
TCE	Tetrachloroethylene
UK	United Kingdom
UL	Underwriters Laboratories (developer of standards)
UNEP	United Nations Environment Programme
UV	Ultra violet
VMSs	Volatile methyl siloxanes