Halon Critical Uses and Alternatives

A Nordic perspective

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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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Sammenfatning

Rapporten "Halon Critical Uses and Alternatives" blev udarbejdet i 2003 og 2004 af Dansk Brand- og Sikringsteknisk Institut, DBI, for Nordisk Kemikaliegruppe under Nordisk Ministerråd. Rapporten giver en oversigt over den aktuelle anvendelse af haloner til brandslukning i de nordiske lande Danmark, Færøerne, Finland, Grønland, Island, Norge og Sverige.

Rapporten præsenterer og sammenfatter lovgivningen i EU og de nordiske lande, herunder de anvendelsesområder, som defineres som henholdsvis kritiske og ikke-kritiske. Områder, hvor halon er i almindelig brug, identificeres, og mængden af halon skønnes for hvert af de berørte lande. Brugen af halon analyseres i forhold til kritisk brug, ikke-kritisk brug, samt for sektorer, hvor halon anvendes. For Norden som helhed skønnes det, at der stadig er 65 tons halon 1211 og 168 tons halon 1301 i brug. De vigtigste anvendelsesområder er alle tre forsvarsværn, mindre fartøjer, f.eks. fiskekuttere og færger, og inden for civil luftfart. En tredjedel af al aktuel brug af halon 1211 ligger uden for de kritiske anvendelser. Det samme gælder for over halvdelen af brugen af halon 1301.

Rapporten giver en beskrivelse af bestemmelserne vedr. substitution for hvert anvendelsesområde, som er identificeret i de mange kommercielt anvendelige alternative brandslukningssystemer eller –midler. Rapporten opregner såvel tekniske hindringer som økonomiske hindringer (for så vidt sådanne tal findes) for substitution. Eksisterende metoder til behandling af genvunden halon beskrives, f.eks. halonbanker og destruktionsanlæg. Rapporten giver desuden en oversigt over nuværende alternative brandslukningssystemer og –midler, samt de igangværende programmer for forskning i fremtidige alternative slukningssystemer og –midler. Planerne for yderligere udfasning af brugen af halon i de nordiske lande præsenteres.

Rapporten konkluderer, at fjernelse af al halon for ikke-kritiske anvendelser, med skrappe kontrol af lovregulerede anvendelser, og mere målrettet begrænsning af militære anvendelser, kan føre til et fald fra de nuværende 233 tons halon til ca. 60 tons inden for de kommende 3-5 år. En sådan reduktion kan opnås med de nuværende alternativer, medens substitution af de resterende mængder, især inden for luftfarten, afventer resultaterne af den langsigtede internationale forskningsindsats.

1 Summary

This report, *Halon Critical Uses and Alternatives*, has been prepared in 2003 and 2004 by DIFT, the Danish Institute of Fire and Security Technology, for the Nordic Chemicals Group under the Nordic Council of Ministers. It contains information on current uses of halons used as fire extinguishing agents in the Nordic countries, Denmark, Faroe Islands, Finland, Greenland, Iceland, Norway and Sweden.

It lists and summarises EU and Nordic legislation, including the areas of use defined as critical and non-critical. The areas of current halon usage in the Nordic countries are identified and described and detailed country estimates for quantities of halon used are prepared. Usage is further analysed in terms of critical and non-critical usage as well as in sector of use. For the whole Nordic region, it is estimated that 65 tons halon 1211 and 168 tons halon 1301 are still in use. 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. One third of all current halon 1211 usage is outside the critical use areas, as is over half the usage of halon 1301.

Restrictions to substitution of halons for each sector of use identified by the many commercially available alternative extinguishing systems or agents are described. Both technical and, where figures are available, economical hindrances to substitution are noted. Existing ways of dealing with recovered halons, such as halon banks and destruction facilities, are identified. An overview of currently existing alternative extinguishing agents and systems is provided and the research programmes under way for future alternative extinguishing systems and agents are described. Plans for further phasing out of halons in the Nordic area are noted.

The report concludes that removal of all halons used in non-critical areas, with more stringent control of areas currently under legislation, together with a more aggressive reduction in military usage, could result in reductions from the present usage of 233 tons halons to a level around 60 tons, within the next 3-5 years. This reduction could be achieved with currently available alternatives, while substitution of the remaining quantities, predominantly in the aviation sector, await the results of long-term international research efforts.

2 Background

Halons are the substances which are most harmful to the ozone layer, their potential to destroy ozone being three to ten times higher than that of CFC's (chlorofluorocarbons). Halon 1211, 1301 and, to a more limited extent, 2402 were widely used as fire extinguishing agents in both portable extinguishers and fixed systems from their introduction in the 1950's until restrictions on use and production were introduced in the 1990's.

Under the Montreal Protocol, halon production in the developed countries was banned from 1st. January 1994, since technically and economically feasible alternatives for the majority of uses of halons were available.

EU Regulation (EC) No 2037/2000 on substances that deplete the ozone layer controlled marketing and use of halons (1211, 1301 and 2402). Exceptions were made for a list of uses of halons in areas defined in annex 7 as critical uses. This list is under review, as the possibilities of finding alternatives for different sectors and uses improve. The European Commission has established a working group to assess if critical uses can be restricted and if phase-out dates could be found for the remaining exemptions.

For most non-critical uses of halon, studies have been carried out on possibilities for transition. Individual Nordic countries have also similar national lists and halons have generally been phased out in Nordic Countries as fire-extinguishing agents, except for specific listed critical uses.

A requirement for decommissioning of halon extinguishing systems entered into force in the EU on 31st. December 2003.

A number of alternative extinguishing systems are available. However, there have been technical, procedural and economical difficulties for some sectors in changing over their extinguishing or inerting systems to alternative substances. Cargo and fishing vessels and underground power plants have been among those sectors in the Nordic Countries that appear to have faced difficulties with installing alternatives. Additionally, there are remaining critical halon uses in the defence forces, as well as in civil aircraft.

This report contains information on current areas of use of halon in the Nordic countries, Denmark, the Faroe Islands, Greenland, Finland, Iceland, Norway and Sweden. The information was gathered by using contacts in the fire, security and defence fields, together with communications by mail and e-mail to other contacts and potential contacts as well as extensive Internet searching. The initial study in Denmark was carried out in more detail than for the other Nordic countries and was used to create a framework for finding information and information sources in the other countries. It also provided a basis for extrapolation purposes, if

only limited information was available elsewhere. The Danish contacts were also sources for further contacts in the other Nordic countries.

Based on the so-called critical areas of use, identification and quantification of halon utilisation in the Nordic countries is reported. Actual use, where use is defined as the utilisation of halons in the production or maintenance, hereunder refilling, of products or equipment, is not quantified but is reported where information was available. Where possible, potential and existing halon alternatives to the identified uses are indicated. Insofar as costs are available, the availability of the alternatives in terms of their financial viability is also assessed. Identification and description of existing systems for dealing with recovered halon in the Nordic countries, such as halon banks and destruction facilities are covered. Current usage of alternative extinguishants with climatic effects, such as HFC's (hydrochlorofluorocarbons) and PFC's (perfluorocarbons), is not covered.

This 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

The consultant in the project has been David Westerman.

3 Legislation

This chapter describes EU legislation and compares it with the legislation current as per 1st January 2004 in each Nordic country. Any differences between EU and national legislation are noted below.

The Nordic countries in general adopted a much more restrictive timetable for reduction in halon usage than that laid down by EU regulations. In some countries, however, dispensations as to the areas of use or those being defined as being critical was expanded to allow for national interpretations, based either on security or economic considerations or both.

All countries introduced regulations for control of halon emissions during maintenance and testing and for initial allowance of use of recycled halons. Regulations allowed for use of halons in the same areas of usage described in EU legislation but only if approved alternatives were not available.

Annex C contains a chronological overview of the halon controlling legislation introduced in each country. It contains titles and links to relevant national legislation in which use of halons is named, together with a summary in English for each legislation of the parts of the legislation that are considered relevant to this report.

3.1 European Union

Regulation No 2037/200 controls marketing and use of halons (1211, 1301 and 2402), effective from 1st October 2000. Exceptions are use of halons for critical uses.

Use of HCFC's as replacements for halons in critical use applications is permitted, under certain conditions.

The critical uses listed in this legislation were later modified slightly to include a specific military area of use not covered in the initial list. The amended list now reads:

Use of halon 1301:

- in aircraft for the protection of crew compartments, engine nacelles, cargo bays and dry bays, and fuel tank inerting,
- in military land vehicles and naval vessels for the protection of spaces occupied by personnel and engine compartments,
- for the making inert of occupied spaces where flammable liquid and/or gas release could occur in the military and oil, gas and petrochemical sector, and in existing cargo ships,

- for the making inert of existing manned communication and command centres of the armed forces or others, essential for national security,
- for the making inert of spaces where there may be a risk of dispersion of radioactive matter,
- in the Channel Tunnel and associated installations and rolling stock.

Use of halon 1211:

- in military land vehicles and naval vessels for the protection of spaces occupied by personnel and engine compartments,
- in hand-held fire extinguishers and fixed extinguisher equipment for engines for use on board aircraft,
- in aircraft for the protection of crew compartments, engine nacelles, cargo bays and dry bays,
- in fire extinguishers essential to personal safety used for initial extinguishing by fire brigades,
- in military and police fire extinguishers for use on persons.

3.2 Denmark

Use is not allowed but the Danish Environmental Protection Agency can issue dispensations for the use of halons in areas of critical use, as defined in the current EU regulations. Possession of fire fighting equipment containing halon is illegal unless installed in an aircraft.

3.3 Faroe Islands

No differences from EU legislation.

3.4 Finland

Halons had to be decommissioned from portable extinguishers from 1997 and from fixed systems from 2000

The allowed critical uses of halon in Finland are restricted to:

- portable extinguishers or fixed extinguishing installations used in aircraft and submarine vessels;
- portable extinguishers essential to personal safety used for initial extinguishing by fire brigades; and
- the use of halons in manned command, communications and computer centres essential for the country's government and security,

or in manned communications and command centres, combat vehicles and warships of the Defence Forces.

Halons that are taken out of use shall be treated as hazardous waste.

3.5 Greenland

Mobile and fixed systems to be removed, except for life-saving use of recycled material in ships, aircraft and airport control towers and defence forces, unless approved alternatives are available.

3.6 Iceland

Regulation no. 586/2002 on ozone depleting substances follows up on the EU legislation.

Use of halon 1211 in portable extinguishers not allowed. Use of halon 1301 in small vessel engine rooms was only allowed until 31st. December 2003 but a letter from the Ministry for the Environment extends this dispensation until 2007/2008. Re-filling of flooding systems is not allowed.

Halons that are taken out of use shall be treated as hazardous waste.

3.7 Norway

No differences from EU legislation. However, understanding the annex in the EU regulation on critical uses of halon had initially been unclear both to Norway and several EU Countries. When this issue was clarified with EU in 2003, Norway chose, out of consideration to shipping companies, to grant in individual cases dispensation for a limited time to cargo ships and mobile installations in the oil, gas and petrochemical sector built before 1 October 1994.

Exemptions are given only in cases where replacement of halon requires an extraordinary docking with subsequent financial losses and possible contractual liability for the shipping company in question. The exemption period should not extend any longer than 31 December 2004. Passenger and fishing vessels are not given any dispensation, but should instead decommission halon by 31 December 2003.

Halons that are taken out of use shall be treated as hazardous waste.

3.8 Sweden

The Swedish Regulation 2002:187 on substances that deplete the ozone layer is a complement to the EU Regulation 2037/2000, which prohibits the use of halon 1211, 1301 and 2402 since 1998.

Use of halons in aeroplanes and submarines and in military vehicles and combat command centres which are located on ships or underground is still allowed, if the halons cannot be substituted by an alternative substance, technique or otherwise.

Halons, which are not re-used within the exempted areas, are classified as hazardous waste and must be delivered for destruction to an authorised body.

4 Current areas of halon use in the Nordic countries

Use of halon 1211 and halon 1301 in portable extinguishers and of halon 1301 in flooding systems in buildings is considered almost completely eliminated. However, it is estimated that 5-10 installations and a limited number of portable extinguishers remain in each country.

Over and above these, the following areas of use of halons in the Nordic countries, both critical uses and non-critical uses, have been identified. Usage areas are only described in general terms since it is likely that the list is not complete and single uses or small groupings have not been identified in this survey.

4.1 Civil aircraft

The owner of every registered aircraft is required by the national air authority to hold an airworthiness safety certificate for the aircraft, as a condition of being allowed to operate. Safety certificates are based on the original type approval. All engine-powered aircraft are required to have a fire extinguisher available. These can be for use by the pilot or crew or for automatic extinguishing in unmanned areas or in motors or auxiliaries. Nearly all aircraft manufacturers have originally used halon as fire extinguishant and to re-certify an aircraft to obtain the same level of safety with another form or type of extinguishant is a long-term, costly affair.

Halon 1211 and 1301 are used in portable extinguishers, and in flooding systems. On civilian aircraft, cargo bays are protected by halon 1301 systems and aircraft lavatories may have small fixed systems with halon 1301 to extinguish fires in waste receptacles.

4.2 Airports (civil and military)

Large, portable (wheeled) extinguishers with halon 1211 are used in motor-start areas for both civil and military airports. Airport fire brigades use portable extinguishers with halon 1211 as well as special equipment on crash rescue vehicles with lances for penetrating aircraft cabins. Flooding systems with halon 1301 are used in flight controller rooms.

4.3 Fire brigades

Fire brigades are permitted to use halon 1211 in portable fire extinguishers if essential for personal safety and for use on persons.

4.4 Merchant Shipping

Smaller cargo vessels and ferries use flooding systems with halon 1301 in engine rooms.

4.5 Fishing vessels

Fishing vessels use halon 1301 in flooding systems for engine rooms. Small boats use halon 1211 in fire fighting for engine rooms.

4.6 Power stations

Hydroelectric power stations and power stations in isolated communities use flooding systems with halon 1301.

4.7 Offshore installations

None reported, although it is thought that some drilling rigs and platforms operating in Danish owned by foreign (US) operators still use halon 1301.

4.8 National Communications centres

Underground defence action information rooms and civilian communications centres, including critical television and radio, data and telecommunication centres have flooding systems with halon 1301.

4.9 Army Vehicles

In military armoured fighting and personnel vehicles, engine compartments are protected by fixed, total flooding, halon 1211 systems designed to extinguish any fires caused by the ignition of leaked fuel, lubricant or hydraulic fluids. The crew compartments of many vehicle types are also fitted with halon 1301 systems intended to prevent explosions and fires

that may be caused by hostile action. The crew compartment systems are designed to discharge the halon in a few tens of milliseconds to prevent or suppress the ignition of any fuel vapourised by an incoming round that has penetrated a fuel tank on its way to the compartment. Vehicles may also be equipped with portable halon 1211 or 1301 extinguishers for crew use. Vehicles without halon 1301 in crew compartments will have halon 1211 portable extinguishers.

4.10 Naval Vessels

Halon 1301 is used in flooding systems for engine rooms and control centres and some areas in submarines.

4.11 Military Aircraft

In aeroplanes and helicopters, portable extinguishers using halon 1211 and 1301 in cockpit, passenger and cargo areas, flooding systems using halon 1301 in auxiliary power units (APU), engines and cargo bays.

Halons are used to protect the engine nacelles and, on larger aircraft, auxiliary power units, from fires caused by fuel leaks or other engine failures. Larger aircraft with more than one occupant are also fitted with portable halon 1211 or 1301 extinguishers. On transport aircraft, cargo bays are protected by halon 1301 systems and aircraft lavatories may have small fixed systems to extinguish fires in waste receptacles. On aircraft and helicopters, dry bays (the compartments surrounding fuel tanks) are protected by rapid response automatic explosion suppression halon 1301 systems. On some US-designed aircraft types, halon 1301 systems are installed to prevent explosions from whatever cause by the pre-emptive inerting of the empty space in fuel tanks.

5 Halon quantities in the Nordic countries

This chapter contains a description of the quantities of halons considered present in the Nordic countries. Halons can be present in equipment, ready for use, and as such is described as in use. Halon can also be present as a stock, which is kept available for refilling of emptied equipment. Where reported, the amount of halon stock used for re-filling in 2003 is noted. Halons are also present as stocks awaiting destruction or export.

Several sectors in different countries have not reported within the time frame of the present project. For these sectors, estimates have been made, based on usage in similar sectors in other Nordic countries.

The figures reflect quantities installed and in some cases in stock in 2003. Various suppliers of figures for halon quantities in stock and installed have requested that exact figures are not used, on the grounds of commercial or national confidentiality. This has led in several instances to approximate or averaged figures being used.

Some sectors of use of halons are very fragmented, in some cases having thousands of separate users. A more detailed analysis, outside the scope of the present survey, could provide more accurate information about halon quantities for each sector group.

The reliability of the reports showing the amounts of halons are categorised as reported, probable and possible.

Reported amounts are from reliable sources or sources that are cross-checked. Information received is often in writing and quantities can be based on physical stocktaking. An example here is a completed phase-out schedule reporting form on use of halon for critical uses. Usage is confirmed and accuracy of quantities reported here is high.

Probable amounts are based on information from sources judged as reliable but where no physical stocktaking has taken place. An example here is information from a contact commercially active in installing alternative systems in a market sector in one country. Through his knowledge of market size and size of typical installation, an estimate of the remaining size of this specific market can be prepared. There is thus a high degree of certainty of use in the sector but the accuracy of the actual quantities involved is less certain.

Possible amounts are based on reasonable, informed opinions from correspondents judged as reliable but where no confirmation was available. If the survey has revealed information about halon use in a specific sector in one or two of the Nordic countries but not in other countries, then it is assumed that the halons are in use but that the survey has not

been able to confirm this directly. There is a possibility that halons are used in the sector reported but any quantities noted are based on informed estimates, with a large margin of error.

The reported, probable and possible amounts are summarised in Table 5.8.1, Table 5.8.2 and Table 5.8.3 at the end of this section. In general, quantities under critical uses are generally based on reports, that is to say that the quantities are reliable. Non-critical use quantities are based more on estimates and are thus less reliable.

The methodology and summarised results of an analysis of the Nordic civil aviation sector is shown in annex D. Estimates have been prepared of the amount of halons used in civil aircraft and the amounts characterised as probable.

Based on experience in Denmark, a number of installations and portable extinguishers are expected in each country where legislation on removal of halons has not been effectuated. Figures estimated for each country are classed as possible.

Many ships with Nordic owners operate under flags of convenience (Liberia, Bermuda etc.) and it is very likely that these vessels retain halon in engine room systems. No estimates are included.

It can be expected that smaller numbers of smaller portable halon extinguishers are still installed in mainly domestic applications, such as in specialist vehicles and small motorboats. No estimates are included.

The available capacity for destruction of halons is limited. Some countries have quantities of halons stockpiled awaiting destruction. Suppliers of extinguishing systems also have limited quantities of halons in stock, mainly halon 1301 recycled from recently decommissioned systems. These quantities, where reported, are noted under the relevant country heading.

The quantities identified in each country are presented below, with comparison summaries at the end of this section.

5.1 Denmark

Critical uses

The Danish Army has 4 tons halon 1211 and 343 kg halon 1301 installed. 4000 kg halon 1211 and 43 halon kg 1301 is installed in tanks for the protection of engine compartments, 300 kg halon 1301 installed in vehicles for the protection of spaces occupied by personnel.

The Danish Navy has 90 kg halon 1211 and 9.9 tons halon 1301 installed. 25 kg halon 1211 is in portable extinguishers on airport runways essential to personal safety and used for initial extinguishing by fire brigades, 78 kg halon 1301 for the making inert of existing manned command centres and 8377 kg halon 1301 in naval vessels for the protection of spaces occupied by personnel.

The Danish Air Force has 10.6 tons halon 1211 and 480 kg halon 1301 installed. Usage is as follows; in hand-held fire extinguishers and fixed extinguisher equipment for engines on board aircraft 211 kg halon 1211, in aircraft for the protection of engine nacelles 128 kg halon 1211, in portable extinguishers on airport runways essential to personal safety and used for initial extinguishing by fire brigades 10,294 kg halon 1211 and in aircraft for the protection of engine nacelles, 479 kg halon 1301.

40 kg halon 1211 is installed on crash tenders at Copenhagen airport.

From **Annex D Analysis of usage** in the civil aviation sector, it is probable that 3.3 tons halon 1211 and 9.6 tons halon 1301 are used in civil aircraft.

The armed forces have a halon bank containing 2.5 tons halon 1211 and 40 tons halon 1301. Use (re-filling) in 2003 was 300 kg halon 1301.

Non-critical uses

It is probable that 10 tons halon 1301 remain on several hundred fishing vessels and 5 tons on smaller coasters.

It is possible that drilling rigs and platforms in Danish areas of the North Sea with American operators have 10 tons halon 1301 in use.

Remaining installations, possibly 250 kg halon 1211 and 1 ton halon 1301.

It is possible that equipment installers have temporary stocks from de-commissioned systems of 5 tons halon 1301.

Table 5.1.1 Total amount in tons, for critical and non-critical uses, Denmark

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	15.13	3.3	0.25	18.68
1301	11.68	24.6	11	47.28

Table 5.1.2 Total amount in tons in critical uses, Denmark

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	15.13	3.3	-	18.43
1301	11.68	9.6	-	21.28

Table 5.1.3 Total amount in tons in non-critical uses, Denmark

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	-	0.25	0.25
1301	-	15	11	26

Table 5.1.4 Total amounts in tons in use per sector, Denmark

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others
1211	4	0.09	10.6	-	3.3	0.25
1301	0.34	9.9	0.48	15	9.6	11

¹ Reliable estimate, but not adequately documented.² Assumed estimate lacking documentation; large error margin.³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

5.2 Faroe Islands

Critical uses

Civil aviation, probably 10 kg halon 1211 and 50 kg halon 1301.

Non-critical uses

It is thought that some fishing vessels still use halon 1301, possibly totaling 2 tons.

Table 5.2.1 Total amount in tons, for critical and non-critical uses, Faroe Islands

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	0.01	-	0.01
1301	-	0.05	2	2.05

Table 5.2.2 Total amount in tons in critical uses, Faroe Islands

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	0.01	-	0.01
1301	-	0.05	-	0.05

Table 5.2.3 Total amount in tons in non-critical uses, Faroe Islands

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	-	-	-
1301	-	-	2	2

Table 5.2.4 Total amounts in tons in use per sector, Faroe Islands

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others	Total
1211	-	-	-	-	0.01	-	0.01
1301	-	-	-	2	0.05	-	2.05

¹ Reliable estimate, but not adequately documented.

² Assumed estimate lacking documentation; large error margin.

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

5.3 Finland

Critical uses

The figures used for the Finnish armed forces are for 2002.

The Finnish Army has in use 15 tons halon 1301. 10,500 kg is used in military land vehicles for protection of spaces occupied by personnel and 4446 kg is used in military land vehicles for the protection of engine compartments.

The Finnish Navy has in use 1.7 tons halon 1211 and 4.3 tons halon 1301. 1718 kg halon 1211 is used for portable extinguishers for use on persons and 4307 kg halon 1301 is used in naval vessels for the protection of spaces occupied by personnel.

The Finnish Air Force has in use 207 kg halon 1211 and 6.3 tons halon 1301. 207 kg halon 1211 is used in portable extinguishers for use on board aircraft. 12 kg halon 1301 is used in aircraft for the protection of crew compartments, 155 kg halon 1301 is used in aircraft for the protection of engine nacelles, 6123 kg halon 1301 is used in portable extinguishers essential to personal safety used for initial extinguishing by fire brigades (aircraft runways).

Military and civil command, data and communications centres, including critical television and radio centres, use 10.2 tons halon 1301, 9523 kg in flooding systems and 1732 kg in portable extinguishers.

The fire brigades have about 400 portable extinguishers, containing 2.2 tons halon 1211.

From Annex D Analysis of usage in the civil aviation sector, it is estimated that 1.1 tons halon 1211 and 5.5 tons 1301 are probably used in civil aircraft. In addition, Finnair has reported 600 kg halon 1211 in fire extinguishers and 4.3 tons halon 1301 installed in aircraft, with 20 kg halon 1211 in stock.

Total amount stored in military halon bank, 2.5 tons halon 1211 and 18.4 tons halon 1301.

Utilisation of 908 kg halon 1301 is reported for 2002.

Non-critical uses

There are 1.3 tons halon 1301 in flight control areas on Finnish airports, situated on five sites.

Based on the information from other Nordic Countries, it is estimated that some fishing vessels also in Finland still use halon 1301, possibly totalling 2 tons.

Remaining installations, possibly 1 ton halon 1301.

It is estimated that equipment installers have temporary stocks from decommissioned systems of 1 tons halon 1301.

Table 5.3.1 Total amount in tons, for critical and non-critical uses, Finland

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	4.7	1.1	-	5.8
1301	41.4	5.5	3	49.9

Table 5.3.2 Total amount in tons in critical uses, Finland

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	4.7	1.1	-	5.8
1301	40.1	5.5	-	45.6

Table 5.3.3 Total amount in tons in non-critical uses, Finland

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	-	-	-
1301	1.3	-	3	4.3

Table 5.3.4 Total amount in tons in use per sector, Finland (Reported and probable uses)

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others	Total
1211	-	1.7	0.2	-	1.7	2.2	5.8
1301	15	4.3	6.3	-	9.8	11.5	46.9

¹ Reliable estimate, but not adequately documented.

² Assumed estimate lacking documentation; large error margin.

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

5.4 Greenland

Critical uses

Kangerlussuaq Airport reports 1 ton halon 1211 and 1.36 tons 1301 in use, with stocks of 1 ton halon 1211 and 1 ton halon 1301.

Usage in civil aircraft is probably 30 kg halon 1211 and 150 kg halon 1301.

Non-critical uses

Two power stations in isolated communities use halon 1301, 196 kg

It is thought that some fishing vessels still use halon 1301, possibly totalling 5 tons.

Table 5.4.1 Total amount in tons, for critical and non-critical uses, Greenland

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	1	0.03	-	1.03
1301	1.556	0.15	5	6.7

Table 5.4.2 Total amount in tons in critical uses, Greenland

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	1	0.03	-	1.03
1301	1.36	0.15	-	1.51

Table 5.4.3 Total amount in tons in non-critical uses, Greenland

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	-	-	-
1301	0.196	-	5	5.196

Table 5.4.4 Total amount in tons in use per sector, Greenland

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others
1211	-	-	-	-	0.03	-
1301	-	-	-	5	0.15	0.196

¹ Reliable estimate, but not adequately documented.

² Assumed estimate lacking documentation; large error margin.

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

5.5 Iceland

Critical uses

From Annex D Analysis of usage in the civil aviation sector, it is estimated that 0.7 tons halon 1211 and 0.5 tons halon 1301 are used in civil aircraft.

50 kg of halon 1211 are reported on an airport fire truck.

Non-critical uses

Many fishing vessels still use halon 1301, probably totalling 15 tons.

Portable extinguishers containing halon 1211 are still in use; a estimated quantity is 16 tons.

Table 5.5.1 Total amount in tons, for critical and non-critical uses in 2003, Iceland.

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	0.05	16.7	-	16.75
1301	-	15.5	-	15.5

Table 5.5.2 Total amount in tons in critical uses in 2003, Iceland.

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	0.05	0.7	-	0.75
1301	-	0.5	-	0.5

Table 5.5.3 Total amount in tons in non-critical uses in 2003, Iceland.

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	16	-	16
1301	-	15	-	15

Table 5.5.4 Total amounts in tons in use per sector in 2003., Iceland

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others	Total
1211	-	-	-	-	0.7	16	16.7
1301	-	-	-	15	0.5	-	15.5

¹ Reliable estimate, but not adequately documented.

² Assumed estimate lacking documentation; large error margin.

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

5.6 Norway

Critical uses

From Annex D Analysis of usage in the civil aviation sector, it is estimated that 2.2 tons halon 1211 and 1 ton halon 1301 are probably used in civil aircraft.

The Army does not use halons. The Marine Forces (Navy) use 3.8 tons halon 1301. The Air Force uses 860 kg halon 1301 and 40 kg halon 1211.

Non-critical uses

About 9 tons of halon 1301 is used in underground hydroelectric power stations.

On the basis of relevant information in Denmark, it is estimated that in 2003 10 tons halon 1301 possibly remained on several hundred fishing vessels and 10 tons halon 1301 on smaller vessels and ferries.

Halon 1301 has been decommissioned from Norwegian offshore rigs.

Remaining installations contain possibly 1 ton halon 1301.

It is estimated that equipment installers have temporary stocks from decommissioned systems of 5 tons halon 1301. These stocks are not included in the following tables.

In 2003 the chemical destruction centre had between 50 and 60 tons in stock awaiting destruction.

Table 5.6.1 Total amount in tons, for critical and non-critical uses in 2003, Norway

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	0.04	2.2	-	2.24
1301	13.66	1	21	35.66

Table 5.6.2 Total amount in tons in critical uses in 2003, Norway

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	0.04	2.2	-	2.24
1301	4.66	1	-	5.66

Table 5.6.3 Total amount in tons in non-critical uses in 2003, Norway

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	-	-	-
1301	9	-	21	30

¹ Reliable estimate, but not adequately documented.

² Assumed estimate lacking documentation; large error margin.

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

Table 5.6.4 Total amounts in tons in use per sector in 2003, Norway

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others ¹	Total ²
1211	-	-	0.04	-	2.2	-	2.24
1301	-	3.8	0.86	20	1	10	35.66

¹ Underground hydroelectric power stations (9 tons halon 1301) and remaining installations (1 ton halon 1301)

² Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

5.7 Sweden

Critical uses

The Swedish army has 15 tons halon 1211 and 2 tons halon 1301 remaining.

The Swedish navy has 4 tons halon 1301 on naval vessels. This was reduced about 4 tons in 2003 and by 2005 all halon is expected to be replaced.

The Swedish air force has 1000 units containing halon in aeroplanes and helicopters. The total amounts are less than 1 ton halon 1211 and less than 500 kg 1301, although halon 1301 will increase on the introduction of a new aircraft type.

Underground military control centres use 2 tons 1301.

From Annex D Analysis of usage in the civil aviation sector, 4.4 tons halon 1211 and 2 tons 1301 are probably used in civil aircraft.

Non-critical uses

It is thought that some fishing vessels still use halon 1301, possibly totalling 2 tons.

Remaining installations are estimated at possibly 1 ton halon 1301.

It is estimated that equipment installers have temporary stocks from decommissioned systems of 1 ton halon 1301.

Table 5.7.1 Total amount in tons, for critical and non-critical uses, Sweden

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	16	4.4	-	20.4
1301	8.5	2	3	13.5

Table 5.7.2 Total amount in tons in critical uses, Sweden

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	16	4.4	-	20.4
1301	8.5	2	-	10.5

Table 5.7.3 Total amount in tons in non-critical uses, Sweden

Halon	Reported	Probable ¹	Possible ²	Total ³
1211	-	-	-	-
1301	-	-	3	3

¹ Reliable estimate, but not adequately documented.

² Assumed estimate lacking documentation; large error margin.

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

Table 5.7.4 Total amounts in tons in use per sector, Sweden

Halon	Army	Navy	Air Force	Small vessels	Civil aircraft	Others	Total
1211	15	-	1	-	4.4	-	20.4
1301	4	4	0.5	2	2	1	13.5

5.8 Nordic country totals

Total halon quantities for each country (Denmark DK, Faroe Islands FO, Finland SF, Greenland GL, Iceland IS, Norway N and Sweden S) are summarised in to Table 5.8.4 and shown graphically in Figure 5.8.1 and Figure 5.8.2.

Table 5.8.1 Total halon quantities in tons per country in 2003, reported

Halon	DK	FO	SF	GL	IS	N	S	Total
1211	15.13	-	4.7	1	0.05	0.04	16	36.92
1301	11.68	-	41.4	1.56	-	13.66	8.5	76.8

Table 5.8.2 Total halon quantities in tons per country in 2003, probable ¹

Halon	DK	FO	SF	GL	IS	N	S	Total
1211	3.3	0.01	1.1	0.03	16.7	2.2	4.4	27.74
1301	24.6	0.05	5.5	0.15	15.5	1	2	48.8

¹Reliable estimates, but not adequately documented.

Table 5.8.3 Total halon quantities in tons per country in 2003, possible ²

Halon	DK	FO	SF	GL	IS	N	S	Total
1211	0.25	-	-	-	-	-	-	0.25
1301	11	2	3	5		21	3	45

² Assumed estimates lacking documentation; large error margin

Table 5.8.4 Total estimated halon quantities in tons per country in 2003 (sum of reported, probable and possible)

Halon	DK	FO	SF	GL	IS	N	S	Total ³
1211	18.68	0.01	5.8	1.03	16.75	2.24	20.4	64.91
1301	47.28	2.05	46.9	6.7	15.5	35.66	13.5	167.59

³ Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

Figure 5.8.1 Halon 1211 amounts in 2003. "Total" reduced by factor 0.25 for easier reading.

Figure 5.8.2 Halon 1301 amounts in 2003. "Total" reduced by factor 0.25 for easier reading.

Nearly all the amounts of halon 1211 reported are categorised as reported or probable. This means that the actual quantities identified during the preparation of this report are considered to be close to the amounts actually present. Actual quantities of halon 1301 are more uncertain, especially with regard to usage in fishing vessels and off-shore platforms.

The total amounts per country are also shown in Table 5.8.5 and Table 5.8.6, according as to whether or not the application is considered as a critical or non-critical use and distribution is shown in Figure 5.8.3 and Figure 5.8.4. Division into critical and non-critical uses is based on the current EU definition for critical uses as shown in section 3.1. All other uses, including those allowed under national legislation or where dispensations have been issued, are reported as non-critical.

Table 5.8.5 Total amounts of halons in tons per country in 2003 - critical uses

Halon	DK	FO	SF	GL	IS	N	S	Total
1211	18	0.01	5.8	1.03	0.75	2.24	20.4	48.23
1301	20.32	0.05	45.6	1.51	0.5	5.66	10.5	84.14

Table 5.8.6 Total amounts of halons in tons per country in 2003 - non-critical uses

Halon	DK	FO	SF	GL	IS	N	S	Total *
1211	0.25	-	-	-	16	-	-	16.25
1301	26	2	1.3	5.2	15	30	3	82.5

* Total figures can be highly uncertain in cases they include *possible* halon use with a large error margin.

Figure 5.8.3 Distribution of critical and non-critical use of halon 1211 in 2003.

The main non-critical use of halon 1211 in Iceland is in portable extinguishers. Major critical uses in Denmark and Sweden are mainly in wheeled extinguishers on military aircraft flight lines and in Army vehicles, respectively.

Figure 5.8.4 Distribution of critical and non-critical use of halon 1301 in 2003.

The main non-critical uses of halon 1301 are in small vessels in Norway, Denmark and Iceland.

The predominant critical uses of halon 1301 are in the Finnish Army and the Danish Navy.

Table 5.8.7 and Table 5.8.8 show total quantities of halon 1211 and halon 1301 in areas of application for each country.

Table 5.8.7 Total amount in tons of halon 1211 per sector in 2003

1211	DK	FO	SF	GL	IS	N	S	Total
Army	4	-	-	-	-	-	15	19
Navy	0.09	-	1.7	-	-	-	-	1.8
Air Force	10.6	-	0.2	-	-	0.04	1	11.8
Small vessels	-	-	-	-	-	-	-	0
Civil aircraft	3.3	0.01	1.7	0.03	0.7	2.2	4.4	12.34
Others	0.25	-	2.2	-	16	-	-	18.45

Table 5.8.8 Total amount in tons of halon 1301 per sector in 2003

1301	DK	FO	SF	GL	IS	N	S	Total*
Army	0.34	-	15	-	-	-	4	19.34
Navy	9.9	-	4.3	-	-	3.8	4	22
Air Force	0.48	-	6.3	-	-	0.86	0.5	8.14
Small vessels	15	2	-	5	15	20	2	59
Civil aircraft	9.6	0.05	9.8	0.15	0.5	1	2	23.1
Others	11	-	11.5	0.2	-	10	1	33.7

* Some sectoral totals can be highly uncertain as they include *possible* halon use with a large error margin.

Figure 5.8.5 Distribution of all uses of halon 1211 and 1301 per sector in 2003. Sectoral totals include figures for *possible* halon use with a large error margin.

Major reductions in halon usage can be achieved in reduction in use in small vessels

Figure 5.8.6 Total halon quantities in 2003 as function of population

A final comparison shows that. Greenland, Iceland and Faroe Island have the greatest amount pr. 1000 inhabitants, due to the fishing industry and sparly population in respective countries.

6 Restrictions to halon substitution

This section deals only with the areas of usage found in the Nordic countries, as described in section 0. Restrictions to substitution will only be treated on a sector basis since a more detailed analysis is necessary for more specific areas of use.

The initial search for halon replacements was towards finding an alternative chemical agent that was a "drop in" replacement. This meant that the same extinguishant application system could be used and only the contents of the extinguisher bottle need be changed. Initial successes were achieved with various HCFC liquids and mixtures of these but the Ozone Depletion Potential of these agents was not zero. Subsequently a low Global Warming Potential of replacement agents was a further requirement. This led to extinguishing systems being developed where not only the extinguishing agent but also the agent container and application system, i.e. bottles, pipe work and hangers, nozzles etc. had also to be replaced. Use of alternatives therefore included re-fitting of installations, with consequent difficulties with access. Application systems were also both larger and heavier, making conversion in applications where space or weight is at a premium, such as in aircraft, more difficult. In military shipping and submarines, the extra weight can produce imbalances (trim changes) that have to be countered elsewhere.

Some applications, such as small fishing vessels or armoured vehicles, contain small amounts of halons but are very numerous, in the order of several hundred installations. Here, the limited number of facilities capable of carrying out replacements means that a replacement programme could take some years.

Restrictions to substitution can in general be classified as technical or economical. For many applications, technically viable alternatives are available or will be available in the near future. If alternatives appear to be available for the sectors described below, this is noted. However, even where technical alternatives are available, the cost of replacing many existing halon systems with substitutes, replacements or other alternative fire protection measures is an impediment to eliminating continued use of halons. Direct comparisons of costs between halons and alternative extinguishing agents are of little value, since use of alternatives nearly always involves modification or replacement of the agent application system. Indirect costs can be high, but can be reduced if system replacement is carried out in connection with a regular service interval.

Proposed alternatives are based on the current extinguishing agents described in section 8.

For use in hand-portable extinguishers, in all areas of application, many alternatives, such as carbon dioxide, dry powder, water/water mist, foam and chemical agents are available. It is considered that these are both technically and economically equivalent to halon 1211 or 1301, the only remaining substantial barrier to substitution possibly being training in their use.

6.1 Civil aircraft

For some applications, including systems for lavatory waste receptacles and portable fire extinguishers, approved replacements for halons are available.

However, for the majority of in-flight applications, including systems for engine nacelles and cargo compartments, progress in finding alternatives has been slow. The aviation industry and governments are reluctant to incur additional risk or expense associated with new systems, and, for portable extinguishers, extensive re-training of all cabin personnel is required. Aircraft will continue to require halons for their fire protection and Airworthiness Certification, with an expected airframe lifetime of thirty years. Aircraft now still only in the design phase are still relying on halon.

The progress to date in the current research programmes is described in section 9.1.

6.2 Airports (civil and military)

Large, portable (wheeled) extinguishers with halon 1211 are used in motor-start areas for both civil and military airports. For these applications, several of the extinguishing agents described in section 8, such as dry powder, chemical agents or foams appear to be technically feasible alternatives and it is reported that potential agents are under evaluation, although no Nordic programmes are reported. The conventional alternative, dry powder extinguishers, see 8.3, are discounted because of the high clean-up costs (including loss of operating time or operability) after powder discharge.

Airport fire brigades use portable extinguishers with halon 1211 as well as special equipment equipped with lances for penetrating aircraft cabins. No alternatives are immediately apparent.

Flooding systems with halon 1301 are used in flight controller rooms and alternatives such as inert gas systems, see 8.2, are readily available, at low conversion costs.

6.3 Merchant Shipping

Smaller vessels, such as cargo ships and ferries, use flooding systems with halon 1301 in engine rooms.

Alternative systems, such as active agents, inert gasses, foam, water mist and aerosols, see 8.1, 8.2, 8.4, 8.5 and 8.8, are readily available, but indirect conversion costs are relatively high, since the vessel has to be taken out of service for conversion to be carried out.

6.4 Fishing vessels

Fishing vessels use halon 1301 in flooding systems for engine rooms.

Alternative systems, such as active agents, inert gasses, foam, water mist and aerosols, see 8.1, 8.2, 8.4, 8.5 and 8.8, are readily available, but direct costs, as well as indirect costs caused by loss of service time while conversion is carried out, are apparently prohibitively expensive for the operator. An earlier report from the Danish Institute of Fire and Security Technology has estimated that the cost of replacing halon 1301 in fishing vessels in Denmark ranged from €3-10,000 per vessel, depending on size and alternative system chosen. The total cost for substitution for all the smaller Danish vessels (3-400) lies between €1-5 million, depending on the technical alternative chosen. The cost breakdown, in 2000 prices, was as follows:

Table 6.4.1 Costs of installing halon alternatives in fishing vessels in Denmark, 2000

Ship tonnage	Average engine room size m ³	Inert gas (Inergen/Argonite) €	Carbon dioxide €	Water mist €
20-100	45	3400	1350	5400
100-200	135	6800	2700	8100
Over 200	261	8800	4000	10,800

Strong industry lobbies have apparently enabled continuing dispensations and extensions of time limits to be achieved. As usage is spread over several hundred vessels, implementation of conversion has not been effective and will probably not be completed for some years.

6.5 Power stations

Hydroelectric power stations use systems with halon 1301. It is not known if there are any technical reasons why conversion to many of the available alternative systems, such as inert gasses 8.2, water mist 8.8, aerosols 8.4, chemical agents 8.1, has not been carried out.

Diesel-powered power stations in three isolated communities are planned converted from use of halon 1301 to water mist in 2004.

6.6 Offshore installations

None reported, although it is thought that drilling rigs and platforms operating in Danish areas owned by foreign (United States) operators, still use halon 1301. Nordic operators have removed halon successfully, substituting with inert gas 8.2 and water mist 8.8.

6.7 National communications centres

Underground defence action information rooms, using halon 1301. Alternatives are readily available, such as inert gas 8.8, with relatively low conversion cost but use in deep bunkers possibly has problems associated with personnel safety, increasing the costs of conversion. Proposed alternatives are flooding systems based on inert gas or possibly physically active agent systems 8.1, as well as increased use of portable extinguishers, combined with enhanced fire detector systems.

6.8 Army Vehicles

Halons are used in various applications in combat and armoured personnel vehicles. Halon 1211 flooding systems are used in engine compartments and halon 1301 in crew compartments with halon 1301 for explosion protection in tanks. Vehicles without halon 1301 in crew compartments will have halon 1211 portable extinguishers.

Substitution and test programmes are being carried out. Some replacements with HFC-gas and FE-36 8.1 have been carried out and use of foam extinguishers 8.5 with anti-freeze and chemical agents 8.1 is being investigated, although low temperature requirements lead to problems with freezing and slow evaporation. As usage is spread over several hundred vehicles, proposed conversion plans will probably not be completed for some years.

Norway has carried out a rebuilding plan for all army vehicles, which has eliminated use of halons, although details of the plan are not known.

6.9 Naval Vessels

Halon 1301 is used in flooding systems for engine rooms and control centres.

The Danish and Swedish navies have implemented conversion programmes for all surface vessels, the most recent conversions using water mist systems. Full phase-out for all vessels is expected for Sweden in 2005. Phase-out for smaller Danish vessels will be in the same year but

there is no definite plan for larger vessels yet. There is no information received on plans for the Norwegian or Finnish navies.

At present, no conversion plans exist for halon-protected areas in submarines, due to weight (trim) and space considerations.

6.10 Aircraft (military)

In aeroplanes and helicopters, portable extinguishers using halon 1211 and halon 1301 in cockpit, passenger and cargo areas, flooding systems using halon 1301 in auxiliary power units (APU), engines and cargo bays.

The opportunity for conversion of existing aircraft halon systems is very limited, due to even higher limitations on weight increase and space requirements than those prevailing for civil aircraft. A number of studies are underway and considerable investment in potential alternatives continues 9.1. Very significant technical, economic and logistical barriers to conversion remain. To maintain levels of national security and the safety of military personnel, halon systems may need to continue in service for the remainder of the operational life of the equipment concerned. For some units, this may be as long as 30 years.

7 Halon disposal in the Nordic countries

Various methods have been used to ensure that halons, which have been banned from use, have not been released to the atmosphere. Sector and national halon "banks" have been set up. A halon bank arranges for collection of halons from users, stores the collected quantities and subsequently arranges for disposal. Disposal has typically been by export for use in critical applications in other countries or by destruction, in local or other countries chemical waste destruction plants. The following sections describe briefly the methods used in the various Nordic countries.

7.1 Denmark

The world's first halon bank, the Danish Halon Banking System, Ltd., was a private company formed in 1991 by Danish fire protection companies and Skafor, the Danish national organization of non-life insurance companies. It was designed to recycle halons during the transitional period up to a total ban on the use of this gas, which came into effect in 1999. More than a dozen authorised operators across the country carried out collection, purification and distribution of halon 1301 for reuse.

The bank was wound up on 1st. July 2002. During its period of existence, the bank collected 9.8 tons of halon 1211, 145 tons of halon 1301 and 2.2 tons halon 2402. Of the collected halon 1211, 3 tons was from portable extinguishers and the rest from aircraft. Halon 1301 was collected by operators and directly from larger users. All halon 2402 was sent to destruction at the Danish waste disposal (incineration) plant, Kommunekemi. Halon 1211 and halon 1301 were sold for recycling except for 10 tons delivered to SAS and 28 tons to the Danish Air Force.

Authorised operators are still collecting halon 1301, mainly from refurbishing installations in coastal shipping and fishing vessels. It is mostly forwarded to a Defence Forces halon bank held by the Air Force. It is estimated that this bank currently receives 10-15 tons annually.

7.2 Faroe Islands

Halons are sent to Kommunekemi in Denmark for destruction.

7.3 Finland

In Finland, a total of 127 tons halon has been received by the end of 2003 for destruction by the Ekokem hazardous waste incineration plant. It is noteworthy that more than 80 % was received in the years around the deadline from legislation for removal from fixed fire fighting equipment in 1999. The figures available also show that a small remaining quantity is still being received, at present around 1% annually of the original total.

Some halon has been sold to halon banks in the European Union, but no information on amounts is available.

7.4 Greenland

Halons are sent to Kommunekemi in Denmark for destruction

7.5 Iceland

No centralised halon bank was established in Iceland. A halon bank for fire brigade requirements is established. Efnamóttakan collects halons 1211 and 1301 and exports to Kommunekemi in Denmark for destruction. Smaller airlines have a small stock for their own uses.

7.6 Norway

A national halon bank was established in 1994 with the objectives of traceability of all halon, control of their use, storage, treatment and movement, dismantling of systems, sale and destruction. One company, Bergens Interkommunale Renovasjonsselskap (BIR AS), has been approved by the State Pollution Control Authority (SFT) to conduct national halon banking activities. In principle, as far as Norwegian users are concerned, this was a one-way bank - only in, no returns being made to Norwegian users. Ownership of the halon remained with the original user until sold.

543 tons of halon was collected between 1994 and 2001, of which 382 tons were exported for critical use only. At present, halon export is restricted due to documentation requirements by the US EPA (Environmental Protection Agency).

There are also halon destruction facilities which operate at the cement plant Norcem AS Kjøpsvik.

7.7 Sweden

No centralised halon bank was established in Sweden. The military maintains a bank for its own needs. Some companies arranged a bank operation for their customers.

Used halons are sent to the Swedish destruction facility Sydkraft SAKAB AB in Kumla.

7.8 Other

The larger airlines have stocks of halons, most of which is for their own use but some is used by smaller airlines in the same region.

8 Current alternative extinguishing systems

The following is a brief description of halon extinguishing agents and agents currently available in commercial quantities. They are used as alternatives to halon 1211 and 1301, as streaming or flooding agents and either for use as substitutes in existing equipment or in new designs. For comparison purposes only, halons 1211, 1301 and 2402 are also included.

8.1 Active agents

Commercialised active agents can be divided into Physical Action Agents, which extinguish primarily by a cooling effect and Chemical Action Agents, which interfere with the flame reaction. Most of the Physical Action Agents are hydrochlorofluorocarbons or hydrofluorocarbons, (HCFC's or HFC's), or perfluorocarbons (PFC's), used as single chemicals or as proprietary mixtures. The only Chemical Action Agent is CF_3I .

Physical active agents used include FE-36, FM-200 (FE-227, HFC-227ea), Halotron IIB (FE-13, HFC-23) and Novec 1230. These compounds are generally liquids or easily compressible gases, non-flammable, have low toxicity and are non-ozone depleting. Weight and space requirements for application systems are similar to those for halons. The compounds can be used both in portable extinguishers and in flooding applications. For fluorine-containing extinguishants, toxic hydrofluoric acid can be produced during extinguishing.

Novec 1230 is a new product now being produced in commercial quantities. A liquid fluorinated ketone that evaporates rapidly, it has ODP (Ozone Depletion Potential) of zero and a GWP (Global Warming Potential) equivalent of 1. It is photosensitive and breaks down rapidly in the lower stratosphere.

8.2 Inert gas

Inert gasses are used as total flooding systems in confined spaces and work by cooling and by reducing the oxygen content in the atmosphere so that combustion is less easily supported. Since the extinguishing agent is stored as a gas, under high pressure, inert gas systems take up more space and are heavier than equivalent systems using liquid extinguishants.

Gasses are either used singly, such as carbon dioxide, CO₂, nitrogen, argon or as mixtures hereof. Carbon dioxide is toxic, in the concentrations used for extinguishing. Other agents are designed to be released in controlled quantities, which negate toxic effects from lack of oxygen. As proprietary mixtures, Argonite, comprising 50% nitrogen and 50% argon and Inergen, comprising 52% nitrogen, 40% argon and 5% carbon dioxide are well-documented and tested.

Oxyreduct is a system that uses automatic nitrogen generators to provide constant low levels of oxygen in a building or confined space. Under some jurisdictions, personnel are not allowed to work constantly in atmospheres with such low oxygen levels.

CO₂ is also used in portable extinguishers, for indoor use. Toxic concentrations can be achieved if used in small, confined spaces.

8.3 Dry Powder

Dry Powder comprises mixtures of small particles of dry chemicals, such as potassium carbonate, sodium bicarbonate and ammonium phosphate, used in portable or wheeled extinguishers and as explosion suppressors. Flow-enhanced forms are being tested for flooding applications. Powders interfere with the flame reaction. No toxic effects are reported.

8.4 Aerosol

Aerosol extinguishants consist of slow-burning solid mixtures which when activated release clouds of aerosol-sized particles and gasses. The particles typically contain potassium nitrate. As a solid, the extinguishant takes up little space and there is no distribution system (pipe work) for application. Aerosol extinguishant systems are generally used in confined spaces as a flooding system although point application is also used. The extinguishing mechanism is by interference with flame reaction. They are reported to be non-toxic.

8.5 Foam

Foam consists of water and a surfactant, which can be natural or synthetic, with mechanical air entrainment giving various foam densities using differing application methods. Extinguishing with foam can be by using portable or wheeled extinguishers, or indoor and outdoor flooding systems. Foams cool and hinder oxygen access to the fire. Foams are non-toxic.

8.6 Sprinkler

Automatic sprinkler systems use water pumped at low pressure and applied through a thermally activated spreader nozzle. Used in buildings and on board ships, the water extinguishes the fire by cooling. However, the large quantities of water used can have deleterious effects, such as water damage to sensitive materials or cause loss of stability on board ship.

8.7 Water

Water is used in portable extinguishers as straight stream or water fog (spray). Water works by cooling the fire.

8.8 Water mist

Water mist systems use water systems with pressures of up to 250 bar to achieve very small water fog droplets. Water consumption is low, compared with other water extinguishing systems, such as sprinkler systems. Water is distributed by pipe work to a large number of application nozzles, compared to a gas application system. Water mist is used in total flooding systems in enclosed spaces and work both by cooling and by inerting with steam. Many conversions have been performed in engine rooms on military and commercial ships.

8.9 Aqueous agents

Aqueous agents are solutions of known dry chemical suppressants in water. A patented agent contains surface-active agents for enhanced wetting properties. Both cooling and flame interference mechanisms occur.

8.10 Others

Combination products using dry powder with (liquid) FE-227 (HCFC 227ea) are being marketed. Flame interference and cooling are the extinguishing mechanisms.

8.11 Halon descriptions for comparison purposes

Halon 1211

Halon 1211, CF_2ClBr , is a liquid, used mainly in portable extinguishers. When applied to a fire, the halon is broken down. The subsequent decomposition products chemically interfere with the chain reaction in flames, halting the combustion process. There is also a cooling effect. Correct application controls toxic effects from the agent and its decomposition products.

Halon 1301

Halon 1301, CF_3Br , is a gas usually stored pressurised under nitrogen. On release in controlled quantities, normally into a confined space, the halon is broken down. The subsequent decomposition products chemically interfere with the chain reaction in flames, halting the combustion process. There is also a cooling effect. It is designed to be released in controlled quantities and at controlled (rapid) release rates, which control toxic effects from the agent and its decomposition products (hydrogen bromide and hydrofluoric acid).

Halon 2402

Halon 2402, $\text{C}_2\text{F}_4\text{Br}_2$, is similar to halon 1211.

9 Future alternative extinguishing systems

Portable extinguishers and most land-based and marine flooding systems are capable of being converted to one of the present alternative systems described in section 8. Considerations of weight and space in civil and military aircraft necessitate the development and evaluation of new agents and systems. These initiatives are described in this section.

9.1 Flooding and extinguishing systems in aircraft

The US Department of Defense Next Generation Fire Suppression Technology Program (NGP) completed in 2003 its seventh year of a scientific and engineering research programme. The goal is to develop and demonstrate technology for economically feasible, environmentally acceptable and user-safe processes, techniques, and fluids that meet the operational requirements currently satisfied by halon 1301 systems in aircraft. However, over the past five years, research to identify replacement fire suppressants has declined considerably, despite the continuing need. To date no commercial or military aircraft have had their halon 1301 systems replaced, while new halon systems are still being installed in the cargo bays of commercial jet aircraft.

The Advanced Agent Working Group (AAWG), a US/UK industry and government collaboration, is aiming to find and characterise an alternative to halon 1301 for use with existing halon system hardware. This work is focussing primarily on bromine-containing tropodegradable halocarbons, effective extinguishants that degrade rapidly in the lower atmosphere, thereby minimising their ozone depletion and global warming potentials. Bromoalkenes and phosphorus-containing compounds are being studied.

The following sections are a summary of the current results of the programmes.

9.1.1 *New flame suppression chemistry*

The criteria for new fire suppressant chemicals are:

- Fire suppression efficiency at least comparable to halon 1301 and higher than the hydrofluorocarbons (HFC's).

- Short atmospheric lifetime, to keep ODP (ozone depletion potential) and GWP (global warming potential) values and any future unidentified environmental contamination to a minimum.
- Low toxicity relative to the concentration needed for suppression.
- Boiling point sufficiently low that an extinguishing concentration can be achieved quickly following discharge.

The families of chemicals examined included:

Physically active suppressants.

The most effective compounds were lactic acid and $\text{CH}_3\text{OC}_4\text{F}_9$. The latter is four times more effective when introduced as a liquid aerosol, emphasizing the contribution of the heat of vaporization of the suppressant when the aerosol reaches the flame zone.

Tropodegradable bromocarbons.

Four brominated alkenes did well in all screens. However, the one compound tested for cardio toxicity produced effects on a test animal at a molar concentration of about 1 %.

Metal-containing compounds.

Some iron, manganese and tin compounds showed very high flame inhibition effectiveness on premixed flames and highly strained diffusion flames, but were unimpressive on cup burner flames. These condensed phase compounds would most likely be used with solid propellant gas generators.

Phosphorus-containing compounds

The phosphorus atom imparts good flame suppression efficiency to a compound and the binding state of the phosphorus is unimportant. Due to their high boiling points, these compounds would need to be dispersed as aerosols or be used with solid propellant gas generators.

9.1.2 Improved suppressant delivery

New ways of applying extinguishants are under consideration.

Solid Propellant Fire Extinguishers

New systems are being developed that have both reduced combustion temperatures and increased flame suppression efficiency, which in turn will enable freedom of selection of the momentum of the suppressant stream.

Dispersion of Suppressants at Low Temperature

In a space where the fire could be anywhere, efficient dispersal of a suppressant throughout the volume is essential. High boiling fluids (e.g., CF3I, -22 °C) might not disperse well at the lowest temperatures (ca. -40 °C) experienced in in-flight aircraft.

Suppressant Dynamics in Engine Nacelles

Computational fluid dynamic (CFD) computer models of the dispersion of a suppressant in a variety of engine nacelle geometries under diverse flight conditions in order to provide information on preferred location(s) and styling of suppressant discharge are being performed.

Powder Panels for Dry Bay Fire Protection

Powder panels comprising dry chemical fire extinguishing agents lining a dry bay can provide passive, lightweight, effective fire protection against ballistic impact by releasing powder into the fire zone to inert the space before the adjoining fuel spills into the space and is ignited by incendiaries.

9.1.3 Cost-benefit Assessment

A methodology to quantify a fire suppression technology by its total, life cycle cost has been developed, applicable to both legacy platforms for retrofit costs for existing platforms and future platforms, for decision makers currently designing new platforms. The figures are indicative, rather than definitive.

Cargo Aircraft

The total cost of ownership of the halon 1301 systems in the current fleet of an individual legacy aircraft platform is approximately 0.2 % of the total (life cycle) cost of the aircraft. Halon 1301 systems would save about four times this cost in avoided fire losses, with roughly the same figures for a future cargo aircraft platform. The difference in total cost of the two systems is a modest fraction of the cost of the systems and is small compared to the total cost of owning and operating the aircraft.

Fighter Aircraft

The total cost of ownership of the halon 1301 systems in the current fleet of an individual legacy aircraft platform and in a proposed fleet of future fighter aircraft is an even smaller fraction of the total cost of the aircraft, about 0.05 %. Either system would save about four times this cost in avoided fire losses.

Analysis of the changes in cost for altered fire suppression performance show that for either type of aircraft, the net cost change per single percent change in extinguishing effectiveness (i.e., 91 % successful vs. 90

% in the field) of the fire system was approximately - €2 M. These estimates show that additional investment in optimising fire suppression system performance pays off in assets (costs) saved.

10 Conclusion

The Nordic countries have considerably reduced the amounts of halon used as fire extinguishing agents over the past decade. This has been achieved by effective legislation, a high level of interest in environmental improvement and assisted by the establishment of halon banks and local halon destruction facilities.

Use in critical areas has been reduced considerably, especially within the armed forces, with all branches of the armed forces implementing specific local and Nordic projects for removal of halons. About 48 tons halon 1211 and 83 tons halon 1301 still remain, mostly in Denmark and Sweden, the major uses being in wheeled extinguishers on military aircraft flight lines and in Army vehicles. Norwegian experience with removal of all halons from army vehicles should be utilised in the other Nordic countries, as well as being further publicised.

Substitution in civil and military aircraft is dependent on the results of major long-term international research projects but further substitution is possible in other areas in the military sector. On-going reduction in flooding systems continues here, conversion of total flooding systems for communications centres and control rooms to inert gas and other systems should be possible. Use of alternatives in portable extinguishers on military flight lines appear to offer opportunities for large reductions in amounts of halon 1211.

The report shows that almost half of the present usage of halons, at present 16 tons halon 1211 and 97 tons halon 1301, is in areas classed as non-critical. The predominant use is of halon 1301 in small ships, ferries and fishing vessels, in Denmark, Iceland and Norway. Technical problems for substitution have been solved but conversion is hampered by economical and national political considerations.

The actual utilisation of halons is very low, requirements to servicing of installations by qualified personnel and bans on use in testing or exercises having resulted in halon release only occurring as designed (in a fire situation) or in one or two cases annually of accidental discharge. Collection and disposal facilities are effective.

The quantities of halon 1211 identified during the preparation of this report are considered to be close to the amounts actually present. The actual quantity of halon 1301 present in the Nordic area is more uncertain, especially with regard to usage in fishing vessels and off-shore platforms and a more detailed study will be necessary to ascertain the precise quantities involved.

With the number of technical solutions and alternative extinguishants that are currently available, it is only in the aviation sector that real tech-

nical problems remain to be solved. In all other sectors, mainly economical considerations hinder further substitution.

It is considered that removal of all halons used in non-critical areas, together with a more aggressive reduction in military usage, could result in reductions from the present usage of 233 tons halons to a level around 60 tons, within the next 3-5 years. This could be achieved with currently available alternatives, while substitution of the remaining quantities, predominantly in the aviation sector, await the results of long-term international research efforts.

11 Annex A, address list

Annex A is a list of companies and organisations that have been contacted in writing during the course of the project. Contacts made by telephone are not specifically listed. Web sites used as information sources are not listed here.

11.1 Denmark

Falck Teknik A/S
Meterbuen 14-16
Postboks 59
2740 Skovlunde

Rigspolitiet
Polititorvet 14
1780 København V

Mærsk Air A/S
Københavns Lufthavn Syd
2791 Dragør

SAS Component
Amager Strandvej 390
2770 Kastrup

Søværnets Materielkommando
Danneskiold-Samsøes Allé 1
Holmen
1434 København K

Beredskabsstyrelsen
Beredskabskontoret
Datavej 16
3460 Birkerød

Flyvematerielkommandoen
Postboks 130
3500 Værløse

Ginge-Kerr Danmark A/S
Stamholmen 111
2650 Hvidovre

Fire Eater A/S
Vølundsvej 17
3400 Hillerød

Rederiforeningen af 1895
Østerfælledtorv 3
2100 København Ø

Brandberedskabet
Thisted Lufthavn
Lufthavnsvej 10
7730 Hanstholm

Hærens Materielkommando
Arsenalvej 55
9800 Hjørring

TDC A/S
Nørregade 21
0900 København C

Sterling European
Københavns Lufthavn Syd
2791 Dragør

Mærskolie og Gas A/S
Esplanaden 50
1098 København K

Københavns Lufthavne A/S
Brand- og Redningstjenesten
Lufthavnsboulevarden 6
Postboks 74
2770 Kastrup

DONG
Agern Allé 24-26
2970 Hørsholm

Ikaros Fly ApS
Solhøjgårdsvej 6
Københavns Lufthavn Roskilde
4000 Roskilde

Benair A/S
Lufthavnsvej 4
Stauning Lufthavn
6900 Skjern

Copenhagen Airtaxi A/S
Lufthavnsvej 34-38

Københavns Lufthavn Roskilde
4000 Roskilde

DanCopter A/S
Dalbækvej 2A
6670 Holsted

Karlog Air
Lufthavnsvej 1
Sønderborg Lufthavn
6400 Sønderborg

Brandberedskabet
Billund Lufthavn
7190 Billund

Brandberedskabet
Esbjerg Lufthavn
6705 Esbjerg Ø

Brandberedskabet
Sønderborg Lufthavn
6400 Sønderborg

Starling Air
Dortheadalsvej 11
Ærø Flyveplads
5960 Marstal

Uni-Fly A/S
Tordengårdevej 4
5700 Svendborg

Air Alsie A/S
Sønderborg Lufthavn
6400 Sønderborg

Aviation Assistance A/S
Solhøjgårdsvej 10
Københavns Lufthavn Roskilde
4000 Roskilde

Execujet Scandinavia A/S
Hangarvej H11
Københavns Lufthavn Roskilde
4000 Roskilde

MyTravel Airways A/S
Københavns Lufthavn Syd
2791 Dragør

Newair A/S
Stratusvej 12
Billund Lufthavn
7190 Billund

Cimber Air A/S
Sønderborg Lufthavn
6400 Sønderborg

Sun-Air of Scandinavia A/S
Cumulusvej 10
Billund Lufthavn
7190 Billund

Star Air A/S
Københavns Lufthavn Syd
2791 Dragør

Danish Air Transport ApS
Kolding/Vamdrup Flyveplads
6580 Vamdrup

North Flying A/S
Aalborg Lufthavn
9400 Nørresundby

CHC Danmark ApS
John Tranumsvej 20
Esbjerg Lufthavn
6705 Esbjerg Ø

Mærsk Air A/S
Københavns Lufthavn Syd
2791 Dragør

Brandberedskabet
Storegade 57
3700 Rønne

Brandberedskabet
Århus Lufthavn
Stabrandvej 24
8560 Kolind

Brandberedskabet
Thisted Lufthavn
Lufthavnsvej 10
7720 Hantsholm

11.2 Faroe Islands

Atlantic Airways P/F
Vagar Lufthavn
FO-380 Sørvagur

Brandberedskabet

Vagar Lufthavn
FO-380 Sørvagur

Brandchef Petyr Olsen

11.3 Finland

Finlands rederiförening r.f. (Suomen Varustamoyhdistys r.y.) P.O.Box 155 FIN-00161 HELSINKI	FIN-00811 HELSINKI
FCAA Finland (Ilmailulaitos) P.O.Box 50 FIN-01531 VANTAA	Federation of Finnish Insurance Companies (Suomen vakuutusyhtiöiden keksusliitto ry) Bulevardi 28 FIN-00100 HELSINKI
Finnish Environment Institute (Suomen ympäristökeskus) P.O.Box 140 FIN-00251 HELSINKI	Safety Technology Authority (Turvatekniikan keskus) P.O.Box 123 FIN-00181 HELSINKI
Finnish Defence Forces (Puolustusvoimat, Pääesikunta) Fabianinkatu 2 FIN-00130 HELSINKI	If insurance (Ifvakuutus) P.O.Box 1131 FIN-00025 IF
Ministry of Interior (Sisäasiainministeriö) P.O.Box 26 FIN-00023 VALTIONEUVOSTO	Finnair Oyj P.O.Box 15 FIN-01053 FINNAIR
Total Walther (Tyco International) P.O.Box 105	Ekokem Oy Ab P.O.Box 181 FIN-11101 RIIHIMÄKI

11.4 Greenland

Air Alpha Greenland A/S Postboks 1 3952 Ilulissat	Brandberedskabet Kangerlussuaq Lufthavn 3910 Kangerlussuaq
Greenland Seafishery and Export Association (Aalisariutinik Piginneqatigiiffiit Kattuffiat)	Brandberedskabet Aasiaat Lufthavn 3950 Aasiaat
Air Greenland A/S Postboks 1012 3900 Nuuk	Brandberedskabet Nuuk Lufthavn 3900 Nuuk
Brandberedskabet Uumannaq Lufthavn 3964 Qaarsut	Brandberedskabet Sisimiut Lufthavn 3911 Holsteinborg
Brandberedskabet Ilulissat Lufthavn 3952 Jakobshavn	Brandberedskabet Narssarsuaq Lufthavn Narssarsuaq
Brandberedskabet Nerlerit Inaat Lufthavn 3985 Constable Pynt	Brandberedskabet Maniitsoq Lufthavn 3912 Maniitsoq
Brandberedskabet Kulusuk Lufthavn 3915 Kulusuk	

11.5 Iceland

Icelandic Civil Aviation Administration
(Flugmálastjórn Íslands)
Reykjavíkurlugvelli
101 Reykjavík

Iceland Shipowners Association (Land-
samband íslenskra útvegsmanna)
Borgartúni 35
105 Reykjavík

Fisheries Association (Fiskifélag Íslands)
Skiptiholti 17
105 Reykjavík

Umhverfisstofnun
Sudurlandsbraut 24
108 Reykjavík

11.6 Norway

Forsvaret (Norwegian Defence)
Oslo mil/Akershus
0015 Oslo

Rådhusgata 25
Postboks 1452 Vika
0116 Oslo

National Police Directorate (Politidirekto-
ratet)
Postboks 8051 Dep
0031 Oslo

Avinor
Postboks 150
2061 Gardemoen

Fishing boats association (Fiskebatreder)
Postboks 67 Sentrum
6001 Ålesund

Norges Fiskarlag
Pir-senteret
7462 Trondheim

Federation of Norwegian Coastal Shipping
(Rederienes Landsforening)
Postboks 5201 Majorstua
0302 Oslo

Heien-Larssen, Kidde Offshore & Marine
AS
Autronica Fire and Security AS
Division Maritime
Industriveien 7
3430 Spikkestad

Norwegian Shipowners' Association
(Norges Rederiforbund)

11.7 Sweden

Swedish Civil Aviation Administration
(Luftfartsverket), LFV
Vikboplan 11
Box 601 79 Norrköping

107 85 Stockholm

Försvarets materielverk
Box 1002
732 26 Arboga

Wormald Fire systems AB
Flöjelbergsgatan 20B
431 37 Mölndal

Försvarmakten
Lidingövägen 24

Swedish shipping association (Sveriges
Redareförening)
Box 330
401 25 Göteborg

12 Annex B, Reference list

Annex B is a non-exclusive list of publications consulted in the course of preparation of the report.

UNEP 2002 Assessment Report of the Halons Technical Options Committee.	DIFT report (in Danish) Replacement of halon 1301 as extinguishing agent in the Danish merchant and fishing fleets 2000.
UNEP Report of the Technology and Economic Assessment Panel May 2003.	Danish EPA Environmental Report No. 312, Going towards natural extinguishants, experience from Danish Industry, 1995.
UNEP Report Maintaining Military Readiness by managing ozone depleting substances 1999.	National Institute of Standards and Technology, NIST Technical Note 1451, Next Generation Fire Suppression Technology Program 2002
UNEP Halon Technical Options Committee, technical note #1 - revision 2 1999	
DIFT report (in Danish) Halons and Fire Extinguishing 1993.	

13 Annex C, Legislation

Annex C contains a chronological overview of the halon controlling legislation introduced in each country. It contains titles and links to relevant national legislation in which use of halons is named, together with a summary in English of each legislation of the parts of the legislation that are considered relevant to the current report. These include areas of usage of halons in fire extinguishing systems and extinguishers, together with timetables for restrictions in usage, as well as allowances for the use of recovered, recycled or reclaimed halons.

13.1 European Union

Regulation (EC) No 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer

http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=en&numdoc=32000R2037&model=guichett

This regulation controls marketing and use of halons (1211, 1301 and 2402) and is effective from 1st October 2000. Exceptions are use of halons for critical uses.

Use of HCFC's as replacements for halons in critical use applications is permitted, under certain conditions.

The critical uses listed in this legislation were later modified slightly to include a specific military area of use not covered in the initial list.

2003/160/EC: Commission Decision of 7 March 2003 amending Regulation (EC) No 2037/2000 of the European Parliament and of the Council with regard to the use of halon 1301 and halon 1211

http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=en&numdoc=32003D0160&model=guichett

The amended list now reads:

Use of halon 1301:

- in aircraft for the protection of crew compartments, engine nacelles, cargo bays and dry bays, and fuel tank inerting,
- in military land vehicles and naval vessels for the protection of spaces occupied by personnel and engine compartments,
- for the making inert of occupied spaces where flammable liquid and/or gas release could occur in the military and oil, gas and petrochemical sector, and in existing cargo ships,
- for the making inert of existing manned communication and command centres of the armed forces or others, essential for national security,
- for the making inert of spaces where there may be a risk of dispersion of radioactive matter,
- in the Channel Tunnel and associated installations and rolling stock.

Use of halon 1211:

- in military land vehicles and naval vessels for the protection of spaces occupied by personnel and engine compartments,
- in hand-held fire extinguishers and fixed extinguisher equipment for engines for use on board aircraft,
- in aircraft for the protection of crew compartments, engine nacelles, cargo bays and dry bays,
- in fire extinguishers essential to personal safety used for initial extinguishing by fire brigades,
- in military and police fire extinguishers for use on persons.

13.2 Denmark

Meddelelser fra Søfartsstyrelsen B. Skibes bygning og udstyr m.v. Kapitel B II-2 C Konstruktion brandsikring, opdagelse og slukning af brand, Forebyggelse af brandes opståen og spredning, 1. juli 2002, BEK nr. 9198 af 19/04/2001

<http://147.29.40.91/DELFIN/HTML/B2002/0919805.htm>

Publication from the Danish Maritime Authority dated 1st July 2002, banning the use of halons or perfluorocarbons in fixed fire-fighting systems on board ships.

Bekendtgørelse om visse ozonlagsnedbrydende stoffer (forbud og anvendelsesbegrænsninger) BEK nr. 243 af 19/04/2002

<http://147.29.40.91/DELFIN/HTML/B2002/0024305.htm>

Regulation from the Ministry of Environment, effective 1st June 2002, where use of halons in all areas forbidden, except for

- in aircraft
- in systems in fishing and merchant ships under 100 metres length, until 31st December 2003.

Exceptions are

- Use of recycled halon in systems or extinguishers in aircraft, or in fishing and merchant ships under 100 metres length, until 31st December 2002.
- Usage in life-threatening areas in ships, aircraft control towers and the military was allowed until 1st December 2002.

The Danish Environmental Protection Agency gives dispensations for the use of halons in areas of critical use, as defined in the current EU regulations.

13.3 Faroe Islands

The Danish-language text of the Faroe Islands legislation is used in this survey.

Bekendtgørelse nr. 82 frá 9. August 1990 af den til wienerkonventionen af 22. Marts 1985 om beskyttelse af ozonlaget knyttede montrealprotokol af 16. September 1987 om stoffer, der nedbryder ozonlaget

<http://www.logir.fo/foldb/bek/1990/0000082.htm>

Ratification of the Vienna convention on substances that affect the ozone layer.

13.4 Finland

The Swedish-language text of Finnish legislation is used in this survey.

Nr 962/ 1989 begränsning av importen av fullständigt halogenerade klorfluorkolväteföreningar samt bromfluorklorolväteföreningar och bromfluorkolväteföreningar (repealed by 262/1998)

http://finlex1.edita.fi/dynaweb/stp/stp/1989fs/@Generic__BookTextView/92478;nh=1;hf=0;lang=se?DwebQuery=halon#1

Import of halons from states that have not signed the Montreal Treaty forbidden from 1st January 1990.

Vatten och miljöstyrelsens beslut om förbjudna eller i fråga om hanteringen kraftigt begränsade kemikalier

http://finlex1.edita.fi/dynaweb/stp/stp/1991fs/@Generic__BookTextView/216650;nh=1;hf=0;lang=se?DwebQuery=halon#1

All import of halons forbidden 1st April 1991

Nr 891_1992 Statsrådets beslut om begränsning av användningen av haloner (repealed by 262/1998)

http://finlex1.edita.fi/dynaweb/stp/stp/1992fs/@Generic__BookTextView/117068;nh=1;hf=0;lang=se?DwebQuery=halon#1

- Import and sale of portable extinguishers that contain halon and use of halon in new flooding systems forbidden from 1st. January 1993.
- Use of hand and transportable fire extinguishers that contain halon forbidden from 1st January 1997.
- Testing which involves release of halons is forbidden.
- All use in flooding systems forbidden from 1st January 2000.
- Halons, which are taken out of use, shall be treated as hazardous waste.

Limitations in use do not apply to portable extinguishers or flooding systems in aircraft or underwater vessels, or use by the fire brigade in initial fire attack where personal safety is of prime importance, nor to the use of halons in manned command, communications and computer centres essential for the country's government and security, or in manned communications and command centres, combat vehicles and warships of the Defence Forces.

442_1993 begränsning av import av produkter som innehåller vissa fullständigt halogenerade klorfluorkolväteföreningar samt bromfluorklorolväte- och bromfluorkolväteföreningar (repealed by 262/1998)

http://finlex1.edita.fi/dynaweb/stp/stp/1993fs/@Generic__BookTextView/289840;nh=1;hf=0;lang=se?DwebQuery=halon#1

Import of products containing halons forbidden from 27th May 1993

Nr 262 1998 Statsrådets beslut om ämnen som bryter ned ozonskiktet

http://finlex1.edita.fi/dynaweb/stp/stp/1998fs/@Generic__BookTextView/123733;nh=1;hf=0;lang=se?DwebQuery=halon#1

Use of halons in hand and portable extinguishers forbidden, with removal from flooding systems by 1st January 2000. Exceptions to use are in portable extinguishers or flooding systems in aircraft or underwater vessels, or use by the fire brigade in initial fire attack where personal safety is of prime importance, or the use of halons in manned command, communications and computer centres essential for the country's government and security, or in manned communications and command centres, combat vehicles and warships of the Defence Forces. Halons are to be treated as chemical waste.

13.5 Greenland

The text of the Danish edition is used.

Hjemmestyrets bekendtgørelse nr. 30 af 10. august 2001 om forbud mod anvendelse af visse ozonlagsnedbrydende stoffer.

<http://www.nanoq.gl/gh.gl-love/dk/2001/bkg%2030-2001%20dk.htm>

Use forbidden, except refilling of flooding systems, until 1st January 2002. Mobile and fixed systems to be removed by 1st January 2002, except life-saving use of recycled material in ships, aircraft and airport control towers and defence forces, unless approved alternatives are available.

13.6 Iceland

Halon was first regulated in regulation no. 268/1993, according to the Montreal Protocol. In article 3 in the regulation all import and sale of virgin CFC and halons was prohibited. From 10 March 1999, regulation no. 187/1999 on halon fire extinguishing systems, all use of fixed flooding systems with halon 1301 was prohibited from 1 October 2000. All stationary halon fire extinguishing systems were removed before end of year 2000. Fixed halon system for fire extinguishing purposes in fishing ships and cargo ships was prohibited from 1 January 2002. Dispensation was first given to the ships owners until 31 December 2003 and again dispensation was given until 2007/2008.

Nr. 586/2002 Reglugerð um efni sem eyða ósonlaginu.

<http://www.reglugerd.is/interpro/dkm/WebGuard.nsf/lookByNumer/5862002?OpenDocument>

Use of halon 1211 in portable extinguishers not allowed after 31st December 2003. Refilling of total flooding systems on smaller ships and fishing vessels not allowed.

Nr. 659/2002 Reglugerð um breytingu á reglugerð nr. 586/2002 um efni sem eyða ósonlaginu.

<http://www.reglugerd.is/interpro/dkm/WebGuard.nsf/8f4a7d7ca32eedc1002565000051607a/5d27aa0cc228dae300256c39004057fe?OpenDocument&Highlight=0,586%2F2002>

Use of halon 1301 in small vessel engine rooms allowed until 31st December 2003.

A dispensation has been issued by the Ministry of Environment allowing the use of halon 1301 in flooding systems until year 2007/2008.

13.7 Norway

Halon in fire extinguishers was first regulated in Norway through the "Regulations concerning Manufacture, Import, Export and Use of Chlorofluorocarbons (CFCs) and Halons", laid down by the Ministry of Environment on 21 January 1991 with amendments of 22 July 1991 and 26 August 1992. According to Section 10 in the regulation, manufacture, import, export or use of new halon-containing fire extinguishing systems was prohibited as from 1 January 1993; recharging/exchanging halon containers for use in fixed fire-extinguishing systems was prohibited as from 1 January 1995; all fixed fire-extinguishing systems containing halon were to be withdrawn from use by 1 January 2000. Fixed halon systems for fire-extinguishing purposes used on board ships or floating installations were not covered by the regulation.

Dispensation for use of halon systems for fire-extinguishing purposes on board civil and military aircraft was granted through a provisional regulation, pursuant to the above regulation, laid down by the Norwegian Pollution Control Authority on 26 August 1994.

On 20 December 2002 the Ministry of the Environment laid down the "Regulations relating to substances that deplete the ozone layer" ("Forskrift om ozonreduserende stoffer") pursuant to the EC Regulation No. 2037/2000.

http://www.sft.no/lover/forskrifter/ozonelayer_regulations.pdf
<http://odin.dep.no/archive/mdvedlegg/01/18/Forsk071.doc>

This regulation is now incorporated in a broader one on limitations regarding the use of chemicals and other products that are endangering health or environment. ("Forskrift om begrensning i bruk av helse- og miljøfar-

lige kjemikalier og andre produkter (produktforskriften)"). This new regulation came into force on 1 July 2004.

<http://www.lovdata.no/for/sf/md/md-20040601-0922.html>

Portable extinguishers are to be taken out of service by 31st. December 2003 and flooding systems no longer allowed. Flooding systems were prohibited on ships and moveable constructions after 31st. December 2003. Exceptions for import, use and refilling in critical areas, defined as

for halon 1301:

- in aircraft for protection of crew and passengers, engine rooms, cargo rooms and dry bays,
- in military vehicles for protection of manned areas and in engine rooms
- for the making inert of occupied spaces where flammable liquids and/or gas release could occur in the following sectors:-
- moveable constructions in the oil, gas and petrochemical sector
- existing cargo ships.

for halon 1211:

In portable extinguishers and flooding systems for aircraft engines and in aircraft for protection of crew and passengers, engine rooms, cargo rooms and dry bays.

13.8 Sweden

Kungörelse med föreskrifter om hantering av brandsläckningsnordningar med halon m.m; SNFS (1993:7)

<http://www.naturvardsverket.se/dokument/lagar/foreskri/snfstext/193-7.htm>

The order contains requirements for registration and control of use of fire extinguishing devices containing more than 20 kg halon. The local authority is to be notified and there shall be annual reporting on halon quantities lost, recharged, stored and destroyed. Halons which are not reused or exported must be delivered to an authorised body for destruction, with effect from 2nd. June 1993.

Förordning (2002:187) om ämnen som bryter ned ozonskiktet

http://rixlex.riksdagen.se/htbin/thw?%24%7BOOHTML%7D=SFST_DOK&%24%7BSNHTML%7D=SFSR_ERR&%24%7BBASE%7D=SFST&BET=2002%3A187&%24%7BTRIPSHOW%7D=format%3DTHW

This follows up on EU legislation 2037/2000 and regulates the production, use, sale import and export of halons and products containing halons. It names regulations from Environmental Ministry regarding system owner's requirement for destruction of halon in systems containing more than 20 kg halon and contains a specific ban on release of halon under full-scale testing of extinguishing systems, release only being allowed for prevention or reduction of fire damage.

Use and installation are allowed in extinguishing systems in military combat units and command and control centres, as well as in aircraft and underwater vessels, where halon cannot be replaced by other products or systems.

The Swedish Rescue Services Agency (Räddningsverket) or the Swedish Maritime Administration (Sjöfartsverket) can make exceptions or issue dispensations on a case-by-case basis but only for use of halons in life-threatening areas.

14 Annex D Analysis of usage in the civil aviation sector

All engine-powered aircraft are required to have a fire extinguisher installed. Nearly all aircraft manufacturers have originally used halons as fire extinguishants. No information as to numbers of fire extinguishers or halon contents is available centrally. This section estimates the amount of halon 1211 and halon 1301 in the civil aviation sector in the Nordic countries.

Most of the larger commercial airlines have reported in detail on their utilisation of halon and these figures have been extrapolated to cover all commercial airlines. Figures for smaller operators and private aircraft are based on a study in Denmark. These figures are extrapolated for the other Nordic countries, based on the number of aircraft registered in each country.

Denmark has currently 1162 engine-powered civil aircraft registered, Iceland 374, Norway 1037, Sweden 2147 and Finland 783, in total 5,500 aircraft. These figures are sub-divided into use categories as shown in Table 14.8.1 below, where figures in brackets are estimates.

Table 14.8.1 Number of powered aircraft registered in each country

Aircraft type	DK	SF	IS	N	S	Total
Engine-powered	1025	609	336	836	1831	4637
Helicopters	55	74	5	151	214	499
Motor gliders	82	(100)	33	(50)	102	367
Total	1162	783	374	1037	2147	5503

Greenland and the Faroe islands are included under Denmark.

There are also several hundred ultra-light aircraft in the Nordic countries, some of which carry extinguishers. These are not included.

In Denmark, 15 companies (of which 3 in Greenland and Faeroes) are registered for commercial transport of passengers and a further nine companies for passenger traffic with aeroplanes under 10 tons or less than 20 seats.

In Denmark (including Greenland and the Faeroes), 12 companies possess a licence for commercial transport of passengers with aircraft under 10 tons weight or less than 20 passenger seats. It is estimated that these companies are licensed, on average, for 20 aircraft each. Returned figures show that each aircraft has, on average, 2 kg halon, as halon 1211.

Twelve companies possess an unlimited licence for passenger traffic. Of these, seven operate smaller aircraft and are thus categorised with the companies in the group above.

Smaller commercial operators are thus estimated to operate in all 380 aircraft, with 760 kg halon 1211.

The five large operators have larger passenger aircraft, which have proportionally more halon on each aircraft, although the total number of aircraft is smaller. The quantities and type of halon varies according to aircraft type. Star Air operates seven aircraft with in all 55 kg halon 1211 and 134 kg halon 1301. MyTravel has eight aircraft with 148 kg halon 1211 and 350 kg halon 1301. Mærsk Air has 44 aircraft with 203 kg halon 1211 and 480 kg halon 1301. SAS Danmark has operational responsibility for halon extinguishers for the whole SAS fleet. SAS operate 176 aircraft and it is estimated these have 1110 kg halon 1211 and 8610 kg halon 1301. The total for large operators is thus 231 aircraft with 1516 kg halon 1211 and 9574 kg halon 1301.

It is reported that small light aircraft use portable extinguishers containing 0.5, 1 and 2 kg halon 1211. For the remaining 700 light aircraft and helicopters in Denmark, it is estimated that each aircraft has on average 1 kg halon 1211, as an upper figure.

Civil aviation in total in Denmark is thus estimated to have halon in use as:

1211	3342 kg, of which 406 kg reported
1301	9574 kg, of which 964 kg reported

Since analysis of the Norwegian aircraft registry shows a similar structure as regards breakdown of small aircraft, and smaller and larger operators, the Danish breakdown is extrapolated to all the other countries. Excluding SAS, the extrapolation is based on the total number of aircraft registered for each country and results in the following estimated quantities for each country

Table 14.8.2 Amount of halons estimated in civil aviation sector per country

Halon, kg	DK	SF	IS	N	S	Total
1211	3342	1100	700	2200	4400	11,700
1301	9570	350	450	950	2000	13,320

The larger airlines have small stocks of halons, most of which is for their own use but some is used by smaller airlines in the same region.