

# MAINTAINING MILITARY READINESS BY MANAGING OZONE DEPLETING SUBSTANCES

Guidelines for armed forces in developing countries



United Nations Environment Programme  
Division of Technology, Industry and Economics  
OzonAction Programme



Multilateral Fund for the  
Implementation of the  
Montreal Protocol

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## Foreword

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*‘With the first control measure coming into force in 1999 for Article 5 Parties, it is important that military organizations in these countries identify their ODS uses and begin planning their transition to alternatives. There is a wealth of experience in non-Article 5 Parties on specific military uses and alternatives which countries operating under Article 5 can call upon in order to simplify the transition.’*

*1998 Report of the UNEP Technology and Economic Assessment Panel*

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We should not seek to preserve national security through the deployment and maintenance of armed forces at the expense of the environment. Indeed, environment and security interests are interrelated and should be mutually supportive.

In the last few decades, military organizations throughout the world have become increasingly aware of the impact of their operations on the local, regional, and global environment. Environmental management has been integrated into the operations and policies of armed services worldwide, and in many countries the armed forces have assumed a leadership role in specific areas of environmental protection. Although there are many reasons for this ‘greening’ of the armed forces—improving the health, safety, and well-being of military personnel and the civilian communities among whom they live; saving costs by using energy and materials more efficiently; reducing waste-management burdens; complying with national, regional, or international regulations and policies, and improving the public image of the armed forces—perhaps the most important factor has been that environmental conditions affect military readiness and hence national security.

One environmental issue that can impact on military readiness is the need to protect the stratospheric ozone layer from the damaging effects of ozone depleting substances (ODS). Widely used in both military and civilian applications, these man-made chemicals include chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, hydrochlorofluorocarbons (HCFCs), hydrobromofluorocarbons (HBFCs), and methyl bromide. Although they are used in hundreds of applications ranging from refrigeration and air-conditioning to firefighting, component cleaning, and medical sterilants, the production and use of ODS is being phased out worldwide.

Following scientific proof that these substances deplete the stratosphere (the upper atmosphere that protects human, animal, and plant life from the damaging effects of ultraviolet radiation), nations concerned about this potential crisis signed the Montreal Protocol on Substances that Deplete the Ozone Layer in September 1987. This landmark global environmental treaty established a timetable for the phase-out of ODS and established a Multilateral Fund to provide technical and financial assistance to developing countries (known as Article 5 countries) to enable them to comply with the terms of the Protocol.

### **Is your country considered an Article 5 Party?**

The countries listed on page 49 are currently considered as operating under Article 5 of the Montreal Protocol.

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The armed forces in developed countries quickly discovered that virtually every weapons and support system in their arsenal used ODS—in refrigeration, for fire protection, as solvents, or to perform some other vital function. Since many weapons and support systems rely on ODS and cannot function effectively without them, the use of these chemicals is directly linked to military readiness. Accordingly, armed forces must attach a high priority to ensuring that their ODS use is properly managed and that the transition to alternatives under the Montreal Protocol is a smooth one. Many armed forces may, however, be unaware of their government's commitments under the Protocol and that, beginning in 1999, the quantity of ODS available will be severely restricted.

Developed as part of UNEP's Work Programme under the Multilateral Fund for the Implementation of the Montreal Protocol, this guide is designed for members of the armed forces in Article 5 countries who are responsible for operations, facilities, and/or equipment that relies on ODS. It is targeted at personnel involved in environmental compliance/protection issues, as well as operation chiefs and managers whose responsibilities include design, production, operation and maintenance of weapon systems, support systems, and facilities using ODS. Based on the first-hand experience of, and lessons learned by, armed forces in developed countries, the guide is intended to assist armed forces with establishing and implementing their own ODS management programmes in line with their national obligations under the Montreal Protocol.

Both this document and many other information resources related to ODS phase-out are available on the OzonAction Programme's web site: <http://www.uneptie.org/ozonaction.html>

The information in this guide was compiled from interviews with members of armed forces responsible for implementing programmes that comply with the Montreal Protocol. Additional information was obtained from military organizations taking part in a series of three international workshops on the role of the armed forces in implementing the Montreal Protocol (see Annex 2 for more details). Contributors include military organizations in NATO and other European countries, and countries with economies in transition (CEITs), as well as Article 5 countries in Africa, Asia, the Pacific region, the Indian Ocean, and South and Central America.

UNEP hopes that this guide will help armed forces organizations in Article 5 countries to undertake a safe and orderly phase-out of ODS without prejudice to their operational readiness.

*UNEP TIE OzonAction Programme*

## How to use these guidelines

There is no single ‘right way’ to manage military ODS uses. In every country, the armed forces will have to develop an appropriate response that takes into consideration their own particular circumstances. However, certain common critical considerations were encountered by those armed forces in developed countries that successfully met the deadlines set down under the Montreal Protocol, and these can be incorporated into your country’s forward planning. This guide presents these common considerations as a series of steps which, once completed, will result in a valid military ODS management programme that will produce a successful and orderly transition away from ODS and towards the adoption of acceptable alternatives.

The armed forces in developed countries have already implemented ODS management programmes, and now operate without recourse to fresh ODS production. It is, then, possible to manage this transition. Those who have done so are in possession of a tremendous amount of knowledge and experience—including the lessons they learned the hard way, the mistakes they made, and the simple solutions they came up with only after they had invested a great deal of time and money in a search for more complex ones.

It is also important to emphasize that not all military ODS uses have been phased out in developed countries, and that having a successful management programme in place is not the same thing as ceasing to use ODS altogether. Small but important ODS needs remain and these must be met through careful management, recycling, and re-use of existing stocks. The needs that remain in developed countries are currently being met from existing ODS reserves. To manage those continuing needs, a number of countries have set up and now run what they call military ODS ‘banks’ or ‘reserves’. These consist of controlled supplies of ODS used to support the remaining mission-critical military uses for which no suitable alternatives are currently available.

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# Section 1: Introduction

## 1.1

### What are ODS, and why are they controlled?: A brief history of the Montreal Protocol

The Vienna Convention for the Protection of the Ozone Layer was attended by 41 countries and signed by 21 states and the European Economic Community in March 1985. It established the principle that countries would agree internationally to take steps to protect the ozone layer and pledged its signatories (known as Parties) to protect human health and the environment from the effects of ozone depletion. The Convention placed no restrictions on ozone depleting substances (ODS) but allowed for the future elaboration of specific controls.

The Montreal Protocol, developed under the auspices of the United Nations Environment Programme (UNEP) in 1987, came into force on 1 January 1989. The Protocol defined the measures that Parties had to take to limit production and consumption of the controlled substances — originally five CFCs (CFC-11, CFC-12, CFC-113, CFC-114, and CFC-115) and three halons (halons 1211, 1301, and 2402). The 1987 Protocol required a 50 per cent cut in CFC consumption and a freeze in the consumption of the three halons by the end of the century. Article 5(1) of the Protocol granted developing countries a ten-year grace period to enable them to meet their basic domestic needs.

Soon after the Protocol came into force, new scientific information made it clear that the original controls on ODS consumption would not be adequate to protect the ozone layer. The Technology and Economic Assessment Panel (TEAP), which was established by the Parties to identify alternatives to ODS, reported that a faster phase-out was both technically and economically possible. In June 1990 at the London meeting of the Parties, decisions were made to amend the Protocol by enacting further control measures. These are known as the London Amendments. They placed controls on ten additional CFCs, as well as methyl chloroform and carbon tetrachloride, and set deadlines for phasing out the original controlled substances altogether. Under the London Amendment, the Parties also agreed to create a mechanism to provide financial and technical assistance to Article 5 Parties, and established the Interim Multilateral Fund to pay the incremental costs of conversion to alternative technologies.

#### National Ozone Unit (NOU)

The National Ozone Unit is the government unit in an Article 5 country responsible for managing the national strategy to implement the Montreal Protocol.

Your country's NOU is an invaluable information resource that can help ODS users to access financial and technical assistance to phase out ODS.

Armed forces interested in developing an ODS management programme should work with their NOU.

(Contact the UNEP TIE OzonAction Programme if you are unsure of how to reach your NOU.)

ODS solvents were previously required for the manufacture and maintenance of the F-16 fighter aircraft. The manufacturer, Lockheed Martin, worked with the US Air Force to change manufacturing processes to use alternatives and to rewrite maintenance manuals to allow the use of alternatives in field maintenance activities.



As scientific understanding of the mechanism of ozone depletion grew, it became obvious that the London Amendment would not be adequate to protect the ozone layer. In addition, the TEAP demonstrated that an accelerated phase-out was both technically and economically feasible. As a result, in Copenhagen in 1992, the Parties amended the Protocol again. The Copenhagen Amendment further accelerated the phase-out schedule for those substances that were already controlled, and introduced controls on new ones in developed countries (HCFCs and HBFCs). The Vienna Amendment subsequently established the HCFC phase-out schedule for Article 5 countries.

From the original Protocol of 1987 through to the Copenhagen Amendments of 1992, the controls on ODS consumption were significantly strengthened. During the five years between 1987 and 1992, halon controls developed from a simple consumption freeze at 1986 levels by the year 2000 to a complete production phase-out by 1 January 1994. During those same five years, CFC consumption controls were strengthened from a 50 per cent reduction in 1987 to a complete production phase-out by 1 January 1996. Despite these greater restrictions, both industry and the armed forces were able to devise and implement programmes to meet the technical challenges without compromising military operations.

### Most common ODS controlled under the Montreal Protocol

	Chemical Name	Ozone depleting potential (ODP)
<b>Annex A, Group I</b>		
CFC-11	trichlorofluoromethane	1
CFC-12	dichlorodifluoromethane	1
CFC-113	1,1,1-trichlorotrifluoroethane	0.8
	1,1,2-trichlorotrifluoroethane	0.8
CFC-114	dichlorotetrafluoroethane	1
CFC-115	monochloropentafluoroethane	0.6
<b>Annex A, Group II</b>		
Halon-1211	bromochlorodifluoromethane	3
Halon-1301	bromotrifluoromethane	10
Halon-2402	dibromotetrafluoroethane	6
<b>Annex B, Group I</b>		
CFC-13	chlorotrifluoromethane	1
CFC-111	pentachlorofluoroethane	1
CFC-112	tetrachlorodifluoroethane	1
CFC-211	heptachlorofluoropropane	1
CFC-212	hexachlorodifluoropropane	1
CFC-213	pentachlorotrifluoropropane	1
CFC-214	tetrachlorotetrafluoropropane	1
CFC-215	trichloropentafluoropropane	1
CFC-216	dichlorohexafluoropropane	1
CFC-217	chloroheptafluoropropane	1
<b>Annex B, Group II</b>		
CCl <sub>4</sub>	carbon tetrachloride	1.1
<b>Annex B, Group III</b>		
methyl chloroform	1,1,1-trichloroethane	0.1
<b>Annex E, Group I</b>		
CH <sub>3</sub> Br	methyl bromide	0.7

## Latest phase-out schedule agreed by the Parties to the Montreal Protocol

### Article 5 countries

BEGINNING	CONTROL MEASURES
1 July 1999	Freeze on Annex A CFCs <sup>1</sup> at 1995-97 average levels <sup>7</sup>
1 January 2002	Freeze on halons <sup>3</sup> at 1995-97 average levels <sup>7</sup> Freeze on methyl bromide at 1995-1998 average levels
1 January 2003	Annex B CFCs <sup>2</sup> reduced by 20 per cent from 1998-2000 average consumption <sup>8</sup> Freeze on methyl chloroform at 1998-2000 average levels
1 January 2005	Annex A CFCs reduced by 50 per cent of 1995-97 average levels <sup>7</sup> Halons reduced by 50 per cent of 1995-97 average levels <sup>7</sup> Carbon tetrachloride reduced by 85 per cent of 1998-2000 average levels Methyl chloroform reduced by 30 per cent of 1998-2000 average levels
1 January 2007	Annex A CFCs reduced by 85 per cent of 1995-97 average levels <sup>7</sup> Annex B CFCs reduced by 85 per cent of 1998-2000 average levels <sup>8</sup>
1 January 2010	CFCs, halons and carbon tetrachloride phased out Methyl chloroform reduced by 70 per cent of 1998-2000 average levels
1 January 2015	Methyl chloroform and methyl bromide phased out
1 January 2016	Freeze on HCFCs <sup>4</sup> at base-line figure of year 2015 average levels
1 January 2040	HCFCs phased out

### Developed countries

BEGINNING	CONTROL MEASURES
1 July 1989	Freeze on Annex A CFCs <sup>1</sup>
1 January 1992	Freeze on halons
1 January 1993	Annex B CFCs reduced by 20 per cent of 1989 levels <sup>2</sup> Freeze on methyl chloroform
1 January 1994	Annex B CFCs reduced by 75 per cent of 1989 levels Annex A CFCs reduced by 75 per cent of 1986 levels Halons <sup>3</sup> phased out <sup>6</sup> Methyl chloroform reduced by 50 per cent
1 January 1995	Methyl bromide frozen at 1991 levels Carbon tetrachloride reduced by 85 per cent of 1989 levels
1 January 1996	HBFCs <sup>4</sup> phased out <sup>6</sup> Carbon tetrachloride phased out <sup>6</sup> Annex A and Annex B CFCs phased out <sup>6</sup> Methyl chloroform phased out <sup>6</sup> HCFCs <sup>5</sup> frozen at 1989 levels of HCFC + 2.8 per cent of 1989 consumption of CFCs (base level)
1 January 1999	Methyl bromide reduced by 25 per cent of 1991 levels
1 January 2001	Methyl bromide reduced by 50 per cent of 1991 levels
1 January 2003	Methyl bromide reduced by 70 per cent of 1991 levels
1 January 2004	HCFCs reduced by 35 per cent below base levels
1 January 2005	Methyl bromide phased out
1 January 2010	HCFCs reduced by 65 per cent
1 January 2015	HCFCs reduced by 90 per cent
1 January 2020	HCFCs phased out allowing for a service tail of up to 0.5 per cent until 2030 for existing refrigeration and air-conditioning equipment

<sup>1</sup> Annex A: CFCs 11, 12, 113, 114, 115

<sup>2</sup> Annex B: CFCs 13, 111, 112, 211, 212, 213, 214, 215, 216, 217

<sup>3</sup> Halons 1211, 1301, 2402

<sup>4</sup> 34 hydrobromofluorocarbons

<sup>5</sup> 40 hydrochlorofluorocarbons

<sup>6</sup> With exemptions for essential uses. Consult the *Handbook on essential use nominations* prepared by UNEP TEAP, 1994, for more information

<sup>7</sup> calculated level of production of 0.3 kg/capita can also be used for calculation, if lower

<sup>8</sup> calculated level of production of 0.2 kg/capita can also be used for calculation, if lower




With the deadline for the first ODS consumption controls for Article 5 Parties now in effect, it is important that the lessons learned by developed countries be made as widely available as possible to Article 5 countries. The TEAP produced assessment reports on alternative technologies in 1989, 1991, 1994, and 1998. It has also produced many other reports on the progress made in implementing alternatives after 1992. These reports are useful in describing ODS uses and the alternatives which have been successfully implemented, and they provide practical information for phasing out ODS in fire protection (halons), solvents, refrigerants, foams, and other uses important to the armed forces. These are essential documents for any organization using ODS. This guide is intended as a supplement to those reports, and provides information specific to the armed forces.

**1.2**

## Operational readiness: Why armed forces need to take action on ODS

In developed countries the phase-out of ODS production could have had a profound effect on the armed forces and on the industries providing them with support and equipment. In the years immediately following ratification of the Montreal Protocol in 1989, developed countries surveyed their ODS uses and discovered their presence in virtually every weapon system. ODS were actually required in standards, specifications, and codes governing operations ranging from design, engineering, manufacture, and purchasing to operations and maintenance activities. Given the widespread reliance of armed forces on these chemicals, any sudden shortage or interruption to supply could have had serious repercussions for both operations and personnel. Without CFCs, cooling systems and halon-based fire-protection systems in aircraft, ships, and tactical vehicles might not function. If that happened, critical weapons systems would fail, or become more vulnerable to fire and explosion. For every ODS application, an alternative chemical, process and/or new system design had to be identified, engineered, demonstrated, tested to meet operational requirements, and introduced as standard. Many armed forces

### Typical Military ODS Uses

	 <b>Aircraft</b>	 <b>Ships</b>	 <b>Tactical Vehicles</b>
<b>CFC Refrigerants</b>	Cockpits/cabins (certain aircraft only) Avionics pods	Electronics and onboard computer/ communications facilities	Crew compartments
<b>Halons</b>	Engine housings Back-up power units Cargo bays Cockpits/cabins Dry bays Fuel tanks (certain aircraft only) Lavatories	Electronics facilities Machinery rooms	Crew compartments Engine compartments
<b>CFC Solvents</b>	Maintenance procedures (cleaning and degreasing) Electronics and precision cleaning	Maintenance procedures (cleaning and degreasing) Electronics and precision cleaning	Maintenance procedures (cleaning and degreasing)

took advantage of the phase-out, seeing it as an opportunity to modernize industrial processes which had remained unchanged for years. In many cases, the alternatives eventually implemented resulted in higher reliability and lower production costs.

## Potential impacts on military readiness

<b>Halons</b>	<b>Refrigerants</b>	<b>Solvents</b>
<b>protection against fire/explosion in:</b>	<b>maintaining electronic equipment at operational temperatures in:</b>	<b>maintenance to:</b>
aircraft and tactical vehicles	tactical vehicles	keep systems in operation readiness
ships (flash fires in electronics/machinery rooms)	combat and communications centres (ships) avionics and weapons pods (aircraft)	prevent failures

Similarly, in the case of Article 5 countries, failure to plan for the eventual phase-out of ODS production could compromise military readiness. Each organization in the armed forces should undertake detailed surveys of all weapons systems, support systems, and installation infrastructures to identify all ODS uses. This task may be performed either by military personnel or by outside contractors (or both). Failure to identify ODS uses and to plan for the end of ODS production could render weapons systems, support systems, and facility infrastructures inoperative as soon as the ODS supplies required to keep them working are no longer available.

To prevent the phase-out of ODS production from impacting adversely on operational readiness, armed forces must establish comprehensive programmes to manage their ODS requirements. Like any other military operation, this means forward planning, resource programming, and ensuring a strategy is in place. This guide describes the basic elements of planning that have worked successfully for many developed countries and are equally applicable to armed forces in Article 5 countries. It also sets out a number of real-case scenarios detailing how specific ODS uses were phased out in particular military applications, and describing others where informed management will facilitate a successful phase-out

### 1.3

## Military uses of ODS

ODS applications relevant to armed forces fall into one of five categories: aerosols, foams, refrigerants, halons, and solvents. Several different ODS feature in each category.

### Solvents

CFC-12 and CFC-114 have primarily been used as propellants in aerosols, while CFC-113 and methyl chloroform are the most widely used solvents. In both cases, they are emitted directly into the atmosphere and cannot be recovered once they have been used. In developed countries, the use of ODS for these purposes has been phased out almost entirely. Such CFC applications were also among the least expensive to replace, offering some of the greatest cost savings. All routine maintenance applications involving solvents and aerosols are candidates for replacement in the immediate future.

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### The five major solvents used by the US armed forces

- methyl chloroform (1,1,1-trichloroethane)
- carbon tetrachloride
- CFC-113 (1,1,2 trichloro-1,2,2-trifluoroethane)
- CFC-11 (trichlorofluoromethane)
- CFC-12 (dichlorodifluoromethane)

### Refrigerants

CFC-11 and CFC-12 are used as refrigerants on ships and aircraft and in ground vehicles and facilities, while CFC-114 is used in chilled water plants aboard ships and submarines and in the electronics needed by aircraft cooling systems. In a number of cases, alternative HFC blends have been developed that can be used in military cooling plants with little or no modification to existing equipment. (Section 4 provides specific examples of alternatives currently available for a variety of cooling applications used by armed forces.)

### Halons

Halons 1211 and 1301 are used as firefighting agents on board aircraft and ships, in armoured combat vehicles, and for ground/shore facility fire protection.

Halon-1211 is a streaming agent used in hand-held systems for: onboard fire protection and for aircraft protection aboard aircraft carriers; in crash, fire, and rescue (CFR) vehicles; and in portable fire extinguishers at ground facilities.

Halon-1301 is a total flooding agent, used to protect shipboard propulsion machinery areas, armoured combat vehicles, flammable-liquid storerooms, fuel-pump rooms, facility computer and communications/electronics centres, and aircraft simulators. It is employed as a fire-prevention agent in engine housings, dry bays and cargo bays, and for protecting fuel tanks on several types of aircraft. In a few cases, it is also used in hand-held extinguishers on board aircraft, ships, and tactical vehicles.

Halon-2402 is used as a thrust vector control system in certain missile systems. In a few countries, notably in Russia and in Italy, it was used more widely in the engine compartments of combat vehicles and in some facility and aviation applications.



# Section 2: Important issues affecting military ODS management plans

Armed forces do not operate in isolation. The terms of the Montreal Protocol, the policies of the national government, the policies of other armed forces, the practices of the military supply industry, and a whole host of other external factors can influence the actions necessary to manage ODS use and phase-out. The whole issue is so complex that it is essential that these groups simplify it by learning to work together constructively in order to meet the challenge of change.

## 2.1

### National Policies

It is important to note that the Montreal Protocol contains no provision to exempt military ODS consumption. As a result, national governments which pass domestic legislation, enact regulations, or adopt policies exempting their armed forces from the provisions of the Montreal Protocol will thereby cease to comply with the treaty. National governments are able to permit armed forces some latitude in complying with the interim step-by-step reduction of consumption by re-allocating national consumption allowances to favour the armed forces at the expense of other sectors of industry and society. However, there are no known instances where the government of a developed country has taken such an approach. It would in any case offer only temporary relief from the necessity to plan for production phase-out and would provide an incentive to delay implementation of any phase-out programme, thereby setting up the possibility that planning will begin too late to meet phase-out deadlines without an adverse impact on military capability.

Fire protection in tactical vehicles (such as this M1A1 tank) typically involves the use of halon fire-extinguishing systems for crew and engine compartments. Armed forces should identify such mission-critical ODS applications and carefully evaluate which of these are candidates for replacement, and which would best be met through an ODS banking programme.



The Montreal Protocol final phase-out dates were agreed by a consensus of countries (known as Parties) that now number 170—virtually the entire global community—and CFC and halon production ceased several years ago in developed countries. It would be extremely perilous for armed forces to do nothing in the hope that it might prove possible to renegotiate the timetable for Article 5 Parties phase-out. All adjustments made thus far to the Montreal Protocol schedule have brought forward the phase-out dates, not postponed them.

Other important considerations in formulating management programmes include national legislation regulating the use of chemicals and industrial processes in the workplace in order to protect the environment and the health and safety of workers. These must be considered when selecting alternatives. In some countries, regulations of this kind include restrictions on the use of equipment containing HCFCs and/or other ODS that go beyond the requirements of the Montreal Protocol. Thailand, for example, restricts the import of CFCs in domestic refrigeration appliances. In cases like this, national legislation takes precedence over the controls imposed by the Montreal Protocol. Military policies therefore have to reflect national regulations which may be more stringent than the Montreal Protocol but cannot be less so. For the deadlines for reducing ODS consumption in Article 5 countries see page 9.

## 2.2

## Replacement options

### HCFCs

HCFCs are CFC replacements which deplete the ozone layer but at much lower rates. Although total phase-out of ODS production is the ultimate aim of the Montreal Protocol, the use of HCFCs as ‘transitional substances’ is still permitted. Before deciding to use HCFCs, it is important to balance their phase-out schedule, the economic lifetime of the equipment involved, and the benefits of their use. If HCFCs are selected as an alternative, it is important to recognize that an additional transition from HCFCs to another alternative will be necessary at some point in the future.

### HFCs

HFCs were among the first alternatives identified and were adopted widely for some applications. Since that time, less expensive, environmentally preferable, and more efficient alternatives have been developed. Many HFCs have a long atmospheric lifetime and high global warming potential (GWP) and are controlled greenhouse gases under the Kyoto Protocol of the Framework Convention on Climate Change. It is important to evaluate the full range of alternatives implemented worldwide and select those which offer the best long-term viability, lowest cost, and highest efficiency.

### Essential uses

Armed forces need also to be aware of the ‘essential use’ provision in the Montreal Protocol. The Parties to the Protocol can allow very limited ODS production beyond the phase out dates—for specific substances, quantities, uses, and for a limited time only. Such exemptions may be granted only by the Parties to the Protocol, and not by national governments. National governments may only nominate substances they wish to be exempted. To date, the Parties have rejected most nominations, granting very few exemptions. Armed forces should familiarize themselves with the ‘essential use’ process, and review the stringent criteria that have been applied to previous nominations submitted by developed countries. A handbook explaining the ‘essential use’ provision and how it works is available from your National Ozone Unit.



## 2.3

## The challenge for governments

National governments have a role to play in supporting industry in its efforts to develop effective programmes. Governments can do this by creating a conducive policy framework to facilitate phase-out at a national level, and by acting internationally in cooperation with other Parties to the Protocol. The armed forces are often the largest and most visible agency of government. As such, they have an opportunity to provide leadership to the rest of the nation, and to demonstrate the technical and economic viability of phasing out ODS and adopting specific alternative technologies. In many developed countries, the armed forces proved to have the technical and organizational capacity for implementing alternatives to ODS more quickly than industry. In addition, because armed forces purchase large quantities of equipment and supplies, procurement policies favouring non-ODS technologies provide a clear and convincing message to industry that it needs to abandon ODS products. The challenge lies in developing a coordinated national programme in which the armed forces, national regulatory enforcement agencies, and industry work together constructively to meet their country's ODS phase-out obligations. Many opportunities will arise in the course of the process to create formal working arrangements between such groups.

Maintenance manuals for the Bradley Tank once required ODS solvents for many cleaning applications. These manuals have now been changed to specify the use of non-ODS alternatives that perform as well as the earlier solvent or better. Rewriting manuals and guidance documents is a key factor in the elimination of ODS.



One of the most significant challenges for national governments is how best to communicate a sense of urgency that will trigger the planning process in all government agencies using ODS. While the Montreal Protocol may appear generous in the length of time it allows for transition to alternatives, the reality is that national ODS production may well end long before the 2010 deadline. In countries with free-market economies, ODS are manufactured by private companies. As market demand for ODS declines, the profit motive to produce them also declines. Reductions in ODS demand and production capacity have already been observed in a number of Article 5 countries. This may be partly because all equipment imported from developed countries now uses alternatives. Armed forces that delay in identifying their long-term needs and establishing their ODS banks, in the belief that they have until 2010 to do so, may find that domestic production of the ODS necessary to satisfy their operational requirements is no longer adequate. The 'essential use' provision of the Montreal Protocol does not offer much relief in such an eventuality. A successful 'essential use' application simply generates an allowance enabling the applicant to procure new ODS. It does not guarantee a source of those ODS, a producer, or a price. The successful applicant still has to find a producer willing to sell ODS in exchange for the allowance, and the price will remain a private matter to be negotiated between the licence holder and the producer.

### Country Programme

Your country's national strategy to implement the Montreal Protocol is contained in its Country Programme.

ODS phase-out activities in the armed forces should be developed within the context of that Country Programme.

Contact your NOU to obtain a copy of this key reference document.

## 2.4

Once a developing country ratifies the Montreal Protocol and is classified as operating under Article 5 of the treaty, it must produce a Country Programme that is approved by the Executive Committee of the Protocol's Multilateral Fund. The Country Programme describes the national strategy to implement the Protocol and phase out ODS. It establishes a baseline survey of the use of the controlled substances in the country concerned and draws up policy, strategies, and a phase-out plan for their replacement and control. It also identifies investment and non-investment projects for funding under the Protocol's Multilateral Fund. The National Ozone Unit (NOU) manages the implementation of the Country Programme.

Military planners should work with the NOU and familiarize themselves thoroughly with the Country Programme. Military ODS phase-out objectives and activities should be reflected in the Country Programme, or at least coordinated with it.

## The Challenge for the armed forces

### Commitment among the leadership: the cornerstone of success

A strong commitment at the highest leadership level among the armed forces is the most important guarantee of success. If the most senior military leadership does not believe a programme to eliminate ODS dependence is really necessary, resources will not be made available and decision makers will not have the necessary incentive to expend resources, in terms of man-hours and finance, on solving the problem. Military readiness will suffer in the long run because the materials necessary for the manufacture, maintenance, and operation of weapons systems and support systems will not be available.

A strong commitment at the highest level has been shown to be vital in every company and in all armed forces affected so far by the Montreal Protocol, and that commitment has been the most important indicator of success. In developed countries, policy statements committing the armed forces to comply with the Montreal Protocol were usually signed at the highest level, often by Secretaries and Ministers of Defence and by military Chiefs of Staff. That level of commitment underlines the importance of ODS phase-out in sustaining the operational readiness of the armed forces and of weapons and support systems. It has proved a crucial first step in gaining the internal support needed to develop a realistic plan of campaign and ensuring its successful implementation.

The plan itself should identify specific objectives and assign specific responsibilities. The six-step process outlined in this guide mirrors the procedures followed successfully by the developed nations. In developed countries, the armed forces have been operating without CFC production since January 1996 and without halon production since January 1994. Operational readiness has been maintained throughout as a result of determined leadership and the successful implementation of a carefully designed plan.

The armed forces also have a key role to play in the broader national effort to phase out ODS without any adverse impact on industry, the public at large, or the armed forces themselves. Many national phase-out plans were designed along the lines of a military campaign, with the specifications, codes, and standards that typify orders in the armed forces. The documentation was initially drawn up to identify technical

specifications required by the armed forces. In many cases, however, those specifications became industry standards. In many developed countries, the armed forces took the lead by issuing new standards, specifications, and codes prohibiting ODS use, and also procurement regulations making it clear that the armed forces would no longer purchase certain types of equipment containing ODS. Examples of such declarations can be found later in this guide (pages 21–22). Leadership of this kind benefits both the armed forces themselves and also the private sector. Firstly, it stops the armed forces purchasing equipment which they would find it difficult to maintain in the future, and, secondly, it harnesses the purchasing power of the armed forces to begin moving private industry towards ODS alternatives. Proactive policies like this are good for the armed forces, good for industry, and good for national compliance with the Montreal Protocol.

### **The value of collaboration with industry and government**

In many countries, the armed forces are among the most technologically sophisticated and stable organizations. Because the Montreal Protocol affects both the armed forces and industry alike, it offers the military a unique opportunity to act as a catalyst to improve the strength and capacity of government and of a country's established industries. The experience of developed countries demonstrates that when the armed forces contrive work together with other government agencies and industry, both the armed forces and industry can phase out ODS use faster and at a lower cost than either could by working alone.

It is therefore important that the armed forces' ODS management plan includes collaboration with industry and government agencies. By establishing working groups and committees to formalize working relationships and assign specific responsibilities, it is possible to avoid duplication of effort, share the cost burden,

### **International workshops on the role of the armed forces in implementing the Montreal Protocol**

NATO has co-sponsored three workshops to assess military ODS uses, exchange information about alternatives, share policy strategies, and discuss the best ways to implement banking and recycling programmes. The first of these was held in September 1991 in the US, the second in January 1994 in Brussels, Belgium, and the third in November 1997, once again in the US. Sponsorship was available to facilitate the participation of representatives from Article 5 countries. In addition, many bilateral and trilateral military groups were formed to work on specific military environmental issues of common concern. Here too, the participation of developing countries was regularly sponsored.

Developing countries already collaborate on issues of mutual security, both regionally and globally, and they work together with developed countries through organizations such as NATO and the UN. Broadening the agenda of these relationships to address environmental issues in general, and the Montreal Protocol in particular, could provide an additional opportunity for them to learn from the experiences of others.

A multilateral working group of Article 5 military officials tasked with Montreal Protocol compliance would improve accessibility to the limited resources available from developed countries and through UNEP. National and

international mechanisms of this sort should be an integral and vital part of any military programme to meet the challenges of the Montreal Protocol.

Workshops also offer the opportunity to interact with military officials from other countries who are trying to solve the same problems. Contacts have resulted in data-exchange projects between countries and have led to a more efficient and less costly implementation of alternatives than would otherwise have been possible. Such contacts provide an additional bonus in that they strengthen the working relationship between the armed forces of different countries and create networks of technical experts who can pool information efficiently.

Armed forces in North America and Europe have had access to international sources of information through their participation in the TEAP and its various Technical Options Committees (TOCs). As members of these panels, military personnel are exposed to commercial and government programmes, technical alternatives, policies, and examples of initiatives that have worked and of others that have not. Military personnel are strongly encouraged to put their names forward to their National Ozone Units for membership of these organizations.

and accelerate the identification, verification, and implementation of alternatives. The plan should identify specific investment projects, and provide mutual technical support so that projects can be successfully implemented. Some of the organizations established in developed countries to coordinate the efforts of government, industry, and the armed forces proved so successful that they continued to operate once their initial short-term goals had been achieved, even expanding their mandate to take on board other environmental issues of mutual concern—issues such as the handling and disposal of hazardous materials, air pollution, pollution prevention, and climate change. Similar organizations dedicated to mutual security could address Montreal Protocol compliance.

International collaboration has also proved a useful channel for sharing experiences and solutions. For example, the Committee on the Challenges of a Modern Society (CCMS) of the North Atlantic Treaty Organization (NATO) was set up in 1969 to address environmental issues relevant to armed forces. Under the CCMS umbrella, NATO established a range of technical groups to address specific military ODS uses. These included the use of halons in military aviation, halons and refrigerants on board ships, halon systems in armoured combat vehicles, solvents in the maintenance and production of weapons systems, and methyl bromide as a fumigant on both ships and aircraft.

### **Strategies for the enhanced implementation of a phase-out plan**

These strategies are relevant to all six steps described in the following section. They are crucial to the ongoing effort to ensure the programme continues to receive high-level attention and is neither forgotten nor abandoned. Any military commander who finds himself unable to complete a mission because he does not have the materials he needs to keep his ships' engines turning, his aircraft in the air, or his tanks operational is certain to regret not having paid more attention to this whole issue.

It is always easy to create an atmosphere of perpetual crisis management and forget that long-term effort is required to manage ODS availability and meet requirements. The importance of this issue for armed forces wishing to maintain their operational capability cannot be overemphasized. The ODS management approach described in this document has proved successful when it has been followed by the armed forces in a number of developed countries. It indicates the road ahead for successful management of the ODS issue while ensuring armed forces retain operational capacity during the military transition to ODS alternatives.

#### **Useful phase-out strategies**

There are a number of useful strategies available to any military organization intent on implementing a phase-out plan. Those that have been used successfully by developed countries include:

- announcing policies restricting purchase of new ODS using equipment once alternatives are available;
- modifying technical specifications to phase out ODS requirements as soon as alternatives are identified;
- coordinating efforts with private industry and other branches of the armed forces;
- conducting training and awareness for maintenance personnel working on systems using ODS;
- monitoring the ODS bank and reviewing deposits and withdrawals;
- using existing technical assistance and cooperation agreements with other organizations and armed forces in other countries to exchange experiences in phasing out ODS;
- conducting periodic programme reviews to ensure the phase-out is on schedule and keeping the high command abreast of any problems;
- funding the phase-out as an integral part of military forward budget planning; and
- using national and international forums on military issues to address ODS phase-out issues.



# Section 3: Implementing a step-by-step ODS management plan

Ensuring continued military readiness without ODS production phase-out can be thought of as a military operation. It is a useful analogy to think of ODS as strategic materiel vital to the ongoing viability of a military system.

A step-by-step approach to the issues described above might go as follows:

## ➡ Step 1: The plan

- commit the leadership to a timetable compatible with national regulations to implement the Montreal Protocol;
- assign responsibilities for particular tasks;
- set up the team;
- identify ways of monitoring progress; and
- prepare an outline budget and assign resources.

## ➡ Step 2: Determine the magnitude of the problem

- compile an inventory of all equipment and applications using ODS;
- compare the inventories from different branches of the armed forces; and
- prepare a definitive inventory of all ODS applications.

Thai and US troops using hand-held field radios. Electronics systems such as these were manufactured using ODS solvents, and maintenance procedures called for those same solvents. Manufacturing and maintenance processes in developed countries have been changed and now use non-ODS alternatives.



➔ **Step 3: Choose appropriate replacement technologies**

- identify potential alternatives for each application;
- select the appropriate alternative;
- implement that alternative; and
- link implementation to the Article 5 phase-out schedule.

➔ **Step 4: Identify mission-critical uses**

- identify uses for which no alternative is currently available;
- identify uses which cannot be phased out before ODS production ends; and
- determine which uses are critical to operational readiness.

➔ **Step 5: Secure supplies to meet critical needs**

- implement conservation and recovery/recycling programmes;
- estimate the quantities of ODS needed to meet mission-critical needs; and
- establish or join an ODS bank to cover those needs.

➔ **Step 6: Keep progress on track**

- establish a programme to collect data on ODS purchases, recycling, and consumption;
- collect and collate periodic progress reports;
- assess progress on the basis of the collected data and the timetable established under Step 1; and
- adjust the timetable as circumstances dictate.

**US Department of Defense (DoD) plan to reduce and phase out ODS**

To prevent ODS production phase-out from impacting adversely on operational readiness, the DoD established a comprehensive programme to reduce and eliminate its operational ODS requirements. The general approach used by the DoD for developing alternatives is as follows:

**Develop plans for identifying acceptable alternatives**

The preferred short-term approach is to adopt alternatives and technical solutions developed by industry; then test and approve these solutions for military applications. Since many military applications are identical (or nearly identical) to industrial applications, this approach can eliminate many military ODS uses. This is particularly true for ODS uses in ground/shore facilities and in some maintenance situations. In cases where there is no similar industrial use, military research and development programmes need to be established. Examples would be halon systems installed in the crew compartments of armoured combat vehicles, and refrigerants used in some shipboard cooling systems. In yet other cases, the armed forces and industry have important uses in common, but neither industry nor the armed forces possess the wherewithal to solve the problem on their own. In these cases, joint development projects become necessary. An example would be halon use on board aircraft. The armed forces participate with industry and international aviation regulatory authorities to develop and approve non-halon systems for aircraft. Many such efforts are already underway in developed countries. Article 5 countries may wish to join these efforts.

**Implement alternatives**

After an alternative is identified or developed, and has been fully tested, it can be implemented in new equipment under design, or retrofitted into existing equipment. Implementation costs vary widely depending on specific circumstances. In some cases, reasonably

priced retrofits are possible; in others, significant investment may be required; and yet others require little investment and may be less expensive to operate than ODS processes. It is important to ensure all documentation describing equipment operation and maintenance is updated, and personnel are trained in using the new alternative.

**Identify critical ODS uses**

Identification is done through surveys, site visits, and documentation searches (of military specifications and standards, technical orders and manuals, maintenance documentation, and so on). Mission-critical uses are limited to those necessary for the operation of combat systems, and for which alternatives do not exist or have not yet been implemented. Once an alternative has been implemented, ODS use ceases to be mission-critical.

**Establish an ODS Reserve**

The armed forces determine the quantities of each critical use of each ODS needed, and the time frame during which they will be needed in order to sustain operations until alternatives can be implemented. The ODS are obtained through a combination of purchases made during the period when ODS were still being produced, and of recycled ODS from equipment withdrawn from service. Recyclable ODS in the reserve come from ODS installed in equipment owned by the armed forces plus what is available from industry. In some cases, a decision can be made to 'vintage' equipment. This means allowing ODS equipment to continue operating until the end of its useful life. The criteria for vintaging include very high retrofit cost, a use which was not emissive in nature, and the need for relatively small quantities of ODS that can be met from the reserve. On 11 August 1992, the Under-Secretary of Defense (Acquisition) directed the US Defense Logistics Agency to set up and run a military ODS reserve to support mission-critical uses in the armed forces.

## 3.1

## Step 1: The plan

The basic objective of the military ODS management plan is simple: to achieve an orderly phase-out of ODS use. The first objective of the plan is getting the armed forces to accept that they must learn to live with limited ODS availability. The plan should be developed in coordination with the Country Programme and with national policies. A clearly defined ODS management plan will help ensure that the needs of military users are fully taken into consideration, and enable a smooth transition at the lowest possible cost without disruption to military operations.

The plan should take into consideration domestic policies and the production and consumption phase-out schedule required by the Montreal Protocol and its Amendments. It must balance environmental benefits, cost-effectiveness, economic benefits, safety concerns, and practical considerations. Balancing all these factors is difficult and requires an understanding of the available options and their relative costs and benefits.

Five actions are needed to establish a framework for an ODS management programme.

### A. Commit the leadership

Commitment must start at the highest level of the armed forces and must be reflected at each and every subordinate level. Policy documents must provide clear direction and assign specific responsibilities. The Defense Minister or equivalent should assign the overall responsibility for success of the ODS programme to a General or officer of similar rank. Ensuring that orders come from the highest command level sends a clear message concerning the importance of the mission.

The following are examples taken from high-level military policy statements issued by Ministers or Secretaries of Defence, the Chiefs of Staff of Defence ministries, and the Armed Forces Departments in developed countries:

It is the policy of the Ministry of Defence to comply with national commitments made under the Montreal Protocol on Substances that Deplete the Stratospheric Ozone Layer.

Under the terms of the Montreal Protocol on Substances that Deplete the Ozone Layer, which has been ratified by our national government, the worldwide production of ozone-depleting substances will end.

Ozone-depleting substances are used for the manufacture, maintenance, and operation of virtually every weapons and support system used by our armed forces.

In order to avoid adverse impact on our military readiness, I am immediately implementing a programme to adopt alternatives to ozone-depleting substances.

By 1 January each branch of the armed forces will appoint a General or officer of comparable rank who will be responsible for developing and implementing a plan to comply with the Montreal Protocol on Substances that Deplete the Ozone Layer.

This directive establishes an Inter-Service ODS Committee to coordinate Defence Department efforts to eliminate ODS use.

The Inter-Service ODS Committee will report to a council consisting of the Generals and/or officers of comparable rank from each branch of the armed forces responsible for the ODS programme.

By 1 June each branch of the armed forces will survey its uses of ozone-depleting substances as defined under Annex A of the Montreal Protocol and will report its findings to the commanding officer with overall responsibility for the ODS programme.

### Raising awareness

Raising awareness is not easy. The document *Five steps for raising awareness on ozone depletion*, produced by UNEP TIE, contains a number of suggestions about how to address a meeting on the issue and how to design an Awareness and Communication Plan.

The concepts set out in that booklet apply equally well to armed forces and their defence suppliers as they do to the rest of industry.

Further details about this publication are available on the OzonAction Programme web site listed in Annex 1.

With effect from today, ODS emissions from testing and training activities will cease, including halon emissions used in firefighter training.

With effect from 1 June, no new halon fire-suppression systems will be installed in buildings.

With effect from 1 December, procurement of CFC refrigeration and cooling equipment is prohibited.

With effect from 1 January, the purchase of ODS solvents will be prohibited without a specific waiver granted by the commanding officer in overall charge of the ODS programme.

Orders like these demonstrate commitment to Montreal Protocol compliance and have been followed by armed forces without any adverse effect on their operational readiness or effectiveness.



## Responsibilities

### ***The research, development, testing and evaluation manager***

produces a comprehensive plan for the identification of short-term alternatives for military ODS uses. That plan then provides in-depth information on each research and development project to identify short-term ODS alternatives, detailed implementation plans, and associated costs.

### ***Procurement and logistics managers***

develop plans and policies to restrict armed forces ODS purchase, distribution, and access.

### ***The funding manager***

prepares the final budget, distributes funds and monitors expenditure, and assists the officer in overall command to monitor and evaluate all implementation initiatives.

Raising awareness of this commitment both within the armed forces and beyond is a key factor in ensuring that military personnel as well as industry and government regulatory authorities play an active role in meeting the challenges posed by the ODS production phase-out.

## **B. Assign responsibility for particular tasks**

Ultimately, a senior manager with appropriate technical, organizational, and planning skills must be given the authority, the responsibility, and the staff necessary to prepare a management plan and oversee its implementation. It is important to have a single source of authority on ODS programme policy and implementation. The manager should report directly to the General or officer of similar rank entrusted with overall responsibility for military compliance with the Montreal Protocol.

It is crucial that the manager is committed to the plan, and enjoys the support of the high command in all the armed forces. Senior management should announce the ODS management programme and their own high-level commitment, set out its aims and objectives, assign responsibility for particular aspects of the programme, monitor overall progress, and ensure ongoing feedback to everyone involved in the process.

## **C. Set up the team**

The General or officer of comparable rank entrusted with overall responsibility for the phase-out programme should establish the necessary committees and chain of command to set the policy goals and deadlines, establish the mechanisms and channels for reporting and feedback, set the budgetary constraints, and make the ODS banking arrangements.

A high-level Steering Committee may be used to set up a number of working committees to deal with specific sectors and/or applications.

The Steering Committee should include high-level representatives from each branch of the armed forces that purchases, maintains, uses, or has at its disposal ODS or equipment containing ODS. The Steering Committee is responsible for the development and allocation of budgets and for reporting progress to the officer in overall charge. Key personnel would be appointed by the EC and their responsibilities closely defined (see box).

An interdisciplinary team of this sort is essential to coordinate the various parts of the plan. These could include: consolidating and restricting ODS purchases and distribution; managing the introduction of replacement, retrofit, and design initiatives; determining 'vintaging' requirements; and establishing and controlling access to an ODS reserve (or bank), and ensuring that permits are granted for critical needs only.

In a number of developed countries, there are standing ODS Committees made up of personnel from each branch of the armed services. These committees meet periodically to exchange information and report progress in implementing alternatives, reducing ODS consumption, and monitoring the status of their ODS supplies. Such committees have proved invaluable in keeping ODS management programmes on track, maintaining momentum, and acting as an information clearinghouse to keep the commanding officer with overall responsibility for the phase-out programme briefed on progress.

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#### **D. Identify ways of monitoring progress**

It is important to establish ways to measure progress in implementing the plan. Unless there is a duty to monitor and report progress on a regular basis, it is only too likely that the first sign of trouble will be an operational breakdown resulting from the non-availability of ODS, such as a plane that will not fly, a tank that will not run, or a ship that will not steam. The frequency of reporting will be dictated by the size of the armed forces, the extent of ODS use, and other local factors. Performance indicators are invaluable at every stage of the process: they are like milestones, and they also require periodic re-evaluation as implementation proceeds. Examples of performance indicators are:

- the quantity of ODS purchased;
- the number of systems using ODS that are withdrawn from service or retrofitted;
- the degree to which maintenance procedures have been adapted to phase out ODS;
- the speed of any move to establish an ODS bank; and
- the implementation of procedures to recover ODS from existing systems.

Whatever the ways selected to monitor progress, it is vital that regular reports on the issue are passed up the chain of command and that the senior leadership is kept fully briefed.

#### **E. Prepare an outline budget and assign resources**

Among the costs involved in implementing a military ODS phase-out programme will figure such items as: staff costs; the purchase and maintenance of equipment; contractor support and materiel; research and development; and testing and monitoring. It is important to remember that not all ODS-management efforts result in a net cost and that some actually save money. Lower material costs may emerge because some of the alternatives are less expensive than ODS, many non-ODS cooling and refrigeration systems are more-energy efficient than systems using ODS, ODS recycling reduces the quantities of ODS that need to be purchased, and better maintenance practices reduce leaks and maintenance costs.

At this early stage, budget figures will be estimates. A more accurate working budget can only be developed once a comprehensive inventory of ODS uses has been compiled and those involved have acquired some hands-on experience in assessing and implementing alternatives. The budget for this programme should be presented in the same way as for any other military project. All armed forces prepare budget estimates and plan their expenditure in advance. The cost of managing ODS should be integrated into the normal planning, programming, and budgeting cycle.

Some ODS uses will have more significant budget impacts than others. The cost and the speed at which specific alternatives can be implemented will depend on the particular circumstances of each case—including the quantities of ODS used, the specific applications, the age of the equipment, and the degree to which state-of-the-art industrial technology can be applied to a military initiative. The most rapid and cost-effective progress can be made in equipment using large quantities of ODS for which off-the-shelf replacements are readily available. Some industrial applications of solvents, refrigerants, and halons fall into this category.

## 3.2

## Step 2: Determine the magnitude of the problem

The first step is to identify all ODS applications. This involves compiling a complete inventory of all systems and procedures. The results of that survey will reveal the extent to which ODS are used in many different types of equipment and systems. Some applications will be identical to uses encountered in industries that have nothing to do with the armed forces, others will share certain similarities with them, while yet others will be unique to the armed forces. Different applications will require different solutions: there is no single replacement for all applications. ODS are widely used throughout both industry and the armed forces in refrigeration, fire protection, component cleaning during maintenance, and manufacturing. Military specialists will have to be convinced that commercial solutions really meet military requirements before they are willing to place them into service. Many developed countries ran formal research, development, test and evaluation programme to confirm the suitability of industrial alternatives for military applications. Many of those initiatives were recorded in the regular assessment reports of the Technical Options Committees of the TEAP (see Annex 1). Questions about specific applications can be informed to the experts listed in that Annex.

### Identify ODS equipment

It is important to identify at the outset equipment that may contain ODS, and the specific ODS used in that piece of equipment. A comprehensive programme survey will inspect:

- military bases, including all buildings and infrastructure systems;
- military weapons systems;
- support equipment;
- maintenance equipment; and
- documentation describing the maintenance procedures for both weapons systems and support systems, and also any drawings accompanying those systems.

In developed countries, the armed forces realized significant benefits by closely coordinating their efforts with those of industry. Those benefits included:

- more rapid identification of alternatives;
- practical information about the best alternatives and how to implement them; and
- reduction of the time taken up by testing and the costs involved.

Collaboration often took the form of joint participation in organizations developing standards, specifications, and codes of practice for various industries, such as refrigeration, electronics manufacture, fire protection, and aircraft maintenance. In some instances, industry joined with the armed forces in setting up bodies to identify alternatives for common uses. This was how the International Cooperative for Ozone Layer Protection (now the International Cooperative for Environmental Leadership, or ICEL) was originally formed. The US Department of Defense, North American electronics manufacturers, and various panels of experts collaborated to change US military specifications to eliminate the requirement of ODS use in electronics manufacture.

### Facility programme

Ground/shore facility applications constitute one area where military ODS uses are close to those in industry and also unlikely to be mission-critical. They offer a relatively easy opportunity to make rapid progress in any ODS management programme. Each facility manager should develop and implement a plan to tighten maintenance procedures, recapture ODS for re-use, and retrofit or replace equipment with non-ODS alternatives as it nears the end of its useful life. Such alternatives are readily available, and an easy first step in any plan is to stop purchasing equipment requiring ODS. The UNEP TIE publication *Saving the ozone layer: guidelines for United Nations offices* describes how to conduct an inventory of ODS-containing equipment at a facility, including refrigeration and air-conditioning systems, vehicles (excluding tactical vehicles), and firefighting equipment. The results of that survey will provide the basis for evaluating available alternatives, creating a phase-out schedule (including provisions for recovery, reclamation, and recycling, as well as the re-use of serviceable material), and implementing alternatives.

### Products containing ODS

The OzonAction Programme has compiled a list of substances and common trade names for products containing ODS and their substitutes. While it is impossible to produce a comprehensive list and keep it up to date because there are so many products and trade names change so frequently, the list of trade names is an excellent first port of call.

It is available on the UNEP TIE web site:  
<http://www.uneptie.org/ozonaction.html>

## Weapons systems

ODS are currently used in the operation and maintenance of nearly all types of weapons system—armoured combat vehicles, aircraft, waterborne craft, command, control and communications systems, and personnel support equipment.

To compile an inventory of all the ODS uses in a weapons system requires the cooperation both of the industry that designed and manufactured the system, and of procurement officers, weapons-system programme managers, and maintenance staff. If the system was manufactured in a developed country and is still in use in a developed country, a solution will already have been identified and implemented.

Systems produced or significantly modified in a developing country may not yet have been evaluated. Technical documentation describing the manufacture and maintenance of the system will help when to identify processes requiring ODS. Maintenance staff are likely to prove the most accessible and reliable source of such information. It is important to communicate clearly to everyone involved which substances are ODS and which are not. Because identical ODS products are marketed under different names, maintenance personnel may not recognize the chemical name of a particular substance, but they will recognize its trade name.

## Maintenance processes

The first step in identifying ODS requirements for maintenance is to review the technical literature, including maintenance instructions and purchase documents. In developed countries maintenance operations such as vapour degreasing, precision cleaning, electronics cleaning, cold cleaning, and wipe-solvent applications were all found to use solvents containing ODS. One of the most popular solutions was to purchase and implement new cleaning equipment such as water-based component washers and detergents, and particle counters to verify cleanliness levels. Once an alternative has been approved, all the relevant technical documentation must be revised and distributed. Maintenance personnel also have to be trained in the use of the alternative technology. As before, if maintenance involves a system produced in a developed country, alternatives will have been identified and approved and will now be up and running. Contact the foreign military sales office in the country of origin, or the manufacturer, for the solution.

## 3.3

## Step 3: Choose appropriate replacement technologies

In determining how best to eliminate or reduce ODS use it is important to identify each application, and to find the solution which best suits that application. In some cases, it will be a simple matter of announcing a new policy and replacing the ODS in the supply chain with a readily available substitute. In other cases, the solution will be more complex, and there will be instances where it may be impractical to achieve phase-out before ODS production ceases. If this happens, the application concerned will have to be serviced through banking, recycling, and careful management. This process is known as ‘vintaging’. Armed forces experts and industrialists in developed countries are often excellent sources of application-specific information since they will have been working on solutions to virtually all ODS applications. There is also an increasing number of workshops being held around the world to address environmental issues, their impact on the armed forces, and successful military responses to them. The issue of ODS features often

**Vintaging**

If the alternatives identified to date cannot be retrofitted into existing weapons systems because of space and/or weight constraints, or for some other reason, then that equipment will be 'vintaged'.

The ability to 'vintage' important military equipment depends on responsible use of ODS stocks by the market at large. Minimizing use and emission of the remaining ODS will enable armed forces to 'vintage' their equipment for that much longer.

Access to the ODS reserve or bank will be necessary to support each 'vintaged' weapons system through to the end of its useful life.

on the agenda at such gatherings and funding is regularly available to sponsor participants from the armed forces of Article 5 Parties. Publicity about these events, details of armed forces contacts, and technical information on specific solutions are available on the Internet. Some useful sites are listed at the end of this guide.

Determining the most appropriate alternative for a specific use of ODS can be a complicated business. The type of equipment and the kind of ODS it uses are only the first considerations. Safety, space/weight constraints, age, budgetary issues, and other factors also play a large part in determining the alternative to be adopted. What is needed is a systematic approach that addresses each application in turn and weighs carefully the factors influencing the selection of an alternative.

The next step is to use the findings of the ODS inventory to determine which applications have a commercially developed, off-the-shelf alternative that is readily available. Reports of the TEAP/TOCs and OzonAction Programme provide sector-specific information on alternatives for refrigerants, solvents, foams, halons, and other ODS.

It is important to participate in joint armed forces/industry technical meetings to exchange information on ODS substitutes in manufacturing and maintenance processes. Such meetings proved extremely helpful in accelerating the implementation process in developed countries.

Research, development, and approval initiatives need only be undertaken in cases where industry has been unable to identify alternatives, or where commercial alternatives must be evaluated to ensure they meet military requirements. Investigation of this kind is unlikely to be necessary in the case of systems purchased from developed countries.

Most of the research undertaken in developed countries has concentrated on testing, approving, and modifying alternatives developed by industry to meet the requirements of a given weapons system. Referring to research on replacements that has been done elsewhere and scrutinizing case studies carried out by other armed forces could save Article 5 armed forces a great deal of time and money.

Retrofitting or replacing existing equipment on weapons platforms can be very costly, and in some cases it is technically impossible because of dedicated equipment integration and high performance requirements. In other cases, retrofits can be made over a period of years

In the US, for example, ships using CFC-12 will be converted to HFC-134a, widely used in commercial and industrial air-conditioning and refrigeration systems. Ships which operate with CFC-114 will be converted to HFC-236fa; aircraft using CFC-12 and CFC-500 will be converted to HFC-134a; while submarines with CFC-114 will most likely be 'vintaged'.

**Solvents**

There are many different ODS solvent applications for military weapons systems, platforms, and facilities. Each application must be evaluated in terms of the end-use of the product or system, the pollutant and substrate requiring cleaning, and the compatibility of the solvent with other materials with which it will come into contact. Each and every use and substance must be individually identified, potential alternatives identified and evaluated, and a solution chosen and

implemented. The armed forces and industry have many uses that are identical. The importance of cooperating with industry to identify solvent and aerosol alternatives cannot be overemphasized. Since most military systems are manufactured by industry, the manufacturer will often have the best technical expertise to advise on appropriate alternatives, and in many cases may already have adopted such alternatives. For systems purchased from developed countries, companies will already have identified and implemented alternatives to ODS solvents. The most expeditious way to select an alternative is to ask the manufacturer or the armed forces in a developed country what they are using.

### Facility air-conditioning and refrigeration

Purchase of non-critical air-conditioning and refrigeration equipment should be curtailed before production phase-out starts.

One way to do this would be to get each facility to develop its own phase-out plan, detailing schedules for replacing each air-conditioning and refrigeration unit containing ODS with a ODS-free system, and/or retrofitting with a ODS-free refrigerant.

The most cost-effective approach would be to replace individual ODS air-conditioning and refrigeration units (or retrofit existing units with ODS-free refrigerants) as soon as that unit requires major maintenance or has reached the end of its useful life.

### Refrigerants

Refrigerants are more difficult to replace quickly. Equipment will have been designed to use specific chemicals, and alternatives will not generally be direct replacements. Some equipment modification will be necessary. In some cases, reasonably priced retrofits are available to allow existing systems to use alternative refrigerants. In others, the modifications required are too extensive to be practical, and these systems are candidates for 'vintaging'. In the case of ships, plant designed to use CFC-12 can often be modified at reasonable cost to use HFC-134a (a number of countries are already doing this) and plant designed to operate with CFC-114, for example, can be converted to HFC-236fa. Aircraft systems designed to function with CFC-12 or CFC-500 can be converted to use HFC-134a.

Submarines are often a special problem because of the way the cooling units were integrated into the hull of the vessel. In many cases, such systems will have to be 'vintaged', and the requirements for long-term maintenance met from an ODS reserve. Modifying maintenance procedures to include CFC recycling can significantly reduce the quantities of refrigerant the ODS reserve will need to set aside for uses such as these.

### Halons

For ground/shore facility applications, alternatives are widely available. They include dry-powder agents, foams, and water sprinklers. Military fire-protection specialists should consult the Halons Technical Options Committee assessment reports and technical notes. These can be obtained from your NOU or downloaded directly from the TEAP web site (<http://www.teap.org>) and then searched electronically for specific applications.

### Procurement policy: a powerful weapon in implementing alternatives

When new ODS-free equipment comes on the market, buy it. There is no reason to go on purchasing ODS equipment when alternatives are available. The longer the purchase of ODS equipment continues, the longer ODS-dependent equipment remains operational and the longer the armed forces will in their turn depend on ODS. Armed forces in the developed countries found procurement policy to be a powerful weapon in the fight to convince industry to adopt ODS-free technology without delay and to persuade suppliers to begin offering ODS alternatives.

Article 5 countries which purchase military equipment and systems from foreign companies should specify in the contract that these should use only those ODS alternatives adopted in the purchasing country. This will prevent the arrival of new equipment which then has to be converted to an ODS alternative. In addition, policies that simply prohibit the purchase of new ODS equipment (such as those

described in Step 1) are a very effective incentive when it comes to implementing alternatives. Developing countries should be particularly sensitive to companies selling inexpensive ODS-based equipment. While the price may be attractive today, the equipment will be very difficult and costly to maintain in the future.

### **Prioritize your implementation: easy first, hard last**

The basic process is to identify readily available solutions that are easy to implement and to begin with those first. Work on the more difficult problems can come later.

## **Easy first, hard last: a useful phase-out sequence**

### **Eliminate the introduction of new ODS equipment and processes**

Institute policies prohibiting the procurement of equipment using ODS and modify the design of new systems currently on the drawing-board. Changes like these often require modifications to military specifications, standards, codes, and maintenance procedures. The armed forces in developed countries discovered that much of their technical documentation stipulated ODS use. Rewriting the documentation to allow the use of alternatives was an important step in eliminating the requirement for ODS in their own systems. In some cases this involved rewriting the documentation or issuing new directives themselves; in others, it involved handing over to a civilian standards authority the responsibility for issuing the documentation setting out specifications and/or standards. It was sometimes difficult at first to convince members of the armed forces that doing this would not compromise the quality of military systems, but experience has shown that civilian standards authorities are often better able to keep abreast of rapidly changing technology than are the armed forces.

### **Change to available 'drop-in' alternatives**

Where available, implement alternatives that require little or no modification to equipment. There are some applications where this is possible. Solvents used for maintenance can sometimes be directly replaced by alternatives. However, this is frequently not the case with component-cleaning equipment which often has to be replaced or modified to function with water-based cleaning agents. To ensure changes of this kind are adopted across the board, technical documentation prescribing ODS use—including military specifications, weapons-system specific technical manuals, general series technical manuals, and other related handbooks—must be modified to allow the use of alternatives. Various approaches have been adopted to ensure this is what happens. In some cases, global changes have been made in the form of a statement added to the beginning of each document to the effect that it is no longer mandatory to use ODS solvents. In others, each specific document stipulating use of an ODS solvent has been amended to require a different material or process.

### **Implement recycling/reclamation**

Set up a national ODS reserve (or 'bank') for those military uses for which alternatives do not currently exist. The size of this bank will be determined by the number of systems which must be 'vintaged' or retrofitted, the length of time such systems are expected to remain in service, and the estimated annual quantity of ODS lost to the reserve as a result of maintenance or use. It is important to restrict the number of applications eligible to use recycled stocks to those which really are operationally vital, and to limit the quantities of ODS permitted to the absolute minimum that is necessary to maintain operational capability. It is essential to be vigilant and to maintain tight supply discipline if you are to ensure stocks remain available for essential military operations.

### **Determine cost and alternative availability**

There are times when it may be theoretically possible, but not practical, to implement an alternative. For other applications, alternatives may not yet have been developed. Submarine cooling systems could theoretically be replaced and yet the cost of doing so might be prohibitive because of a number of factors, including the need to make modifications to the hull. Halon systems in aircraft engine nacelles are just one example where solutions have not yet been identified. Researchers are working on the problem, but so far no solution has been found that meets operational safety requirements in some types of aircraft. Since aircraft typically use smaller quantities of ODS than do ground facilities, 'vintaging' is appropriate.

### **Adopt interim solutions**

In some cases, interim solutions (such as the use of HCFCs) will be appropriate—and even desirable in cases where they represent the only viable solution, are readily available, and their adoption involves little or no capital investment. The reason why capital investment is an important factor here is that the implementation of an interim solution or 'transitional substance' (such as an HCFC) still leaves additional conversion costs to be met in the future when HCFCs are phased out.

### **'Vintage' equipment**

There are important military applications for which feasible alternatives have not yet been identified or developed. Such applications are candidates for 'vintaging'. 'Vintaging' is the last resort and should only be adopted when all other options have been exhausted. The principle of 'vintaging' is that the quantity of ODS that will be needed to keep the equipment running for the rest of its expected life is established at the outset, and a plan is then developed ensuring, through recovery and recycling, the continued availability of the ODS concerned. It is critical that emissions are reduced to the absolute minimum—maintaining an ODS bank can be expensive. Minimizing the quantities needed reduces costs and makes the management of the bank that much easier.

### **Early replacement**

Early replacement of ODS systems near the end of their useful lives is often an option worth considering. As ODS production declines in response to the Montreal Protocol, prices will climb. The cost of repairing systems that leak large quantities of ODS can also often be steep. As a result, maintenance becomes expensive, whether or not you fix the leaks. In such a scenario, phasing out a system as soon as possible and replacing it with one that is ODS-free can be the most cost-effective option.

## 3.4

**Step 4: Identify mission-critical uses**

Mission-critical uses are those ODS applications which have a direct impact on combat mission capability, and for which no alternative has yet been identified, developed, or implemented. They include uses integral to combat mission systems or that directly affect their operational capability.

Mission-critical uses may include:

**CFCs**

- shipboard chilled-water air-conditioning and/or refrigeration systems;
- shipboard cargo refrigeration systems; and
- aircraft environmental control systems.

**Halons**

- shipboard room-flooding applications;
- aircraft fire-protection and explosion-suppression systems;
- portable extinguishers on board aircraft;
- flight-line fire protection;
- explosion suppression in crew compartments of armoured combat vehicles.

Once mission-critical uses have been identified, research and development projects can be established. Research to find alternatives for these uses is under way in developed countries, and opportunities exist for armed forces from Article 5 countries to participate in these efforts.



A Navy service technician recovering refrigerants from a system during regular maintenance. Training technicians in good maintenance procedures to avoid accidental releases, prevent refrigerant leaks, and recover and recycle refrigerants can reduce operating costs, increase refrigeration system efficiency, and protect our environment at the same time.

## 3.5

**Step 5: Secure supplies to meet critical needs**

Securing mission-critical supplies normally involves establishing or joining an ODS bank. However, one of the most important steps in reducing the quantities of ODS needed is to minimize current emissions. Regardless of the application or the difficulty of finding a replacement, there is almost always an opportunity to reduce emissions and losses through improved practices and procedures. In many cases such reductions can be significant. Armed forces in developed countries found this a useful first step in creating awareness that these substances are a problem and must be handled with respect. That awareness was quite often responsible for field initiated reduction efforts. The most dramatic reductions in ODS use during the years 1987–1990 were achieved simply by adopting more careful maintenance practices. ODS not released into the atmosphere as a result of poorly maintained systems or poor maintenance procedures then became available to service critical military applications. The importance of this initial step cannot be overemphasized.

To ensure sufficient quantities of ODS are available to meet mission-critical requirements until retrofitting or replacement is complete, participation in an ODS reserve or bank is necessary. ODS banking requires a plan for the recycling and re-use of CFCs and halons. The plan then allows available ODS to be transferred from one user to satisfy the needs of another, while at the same time discouraging emissions into the atmosphere.

There is no ‘right’ or ‘wrong’ way to establish a bank. It can be a physical storage and processing location with a stockpile of material available for withdrawal and redistribution for mission-critical applications. It can also be a clearinghouse that matches sellers with excess ODS to buyers seeking ODS. Banks can either provide quality-control and processing services or operate under a ‘buyer beware’ principal which places the responsibility for testing the material squarely on the purchaser.



### International Defence and Environment workshops

Alternatives for mission-critical ODS uses were discussed at two recent international Defence and Environment workshops.

The first was held in Honolulu, Hawaii, in 1996 with the participation of representatives of armed forces from the Asia-Pacific and Indian Ocean regions; the second took place in 1997 in Miami, Florida, and involved armed forces from the Western Hemisphere. Follow-up workshops are being planned for both regions. A third meeting—the Third International Workshop on the Role of the Military in the Montreal Protocol—was held in November 1997 near Washington DC, and included discussion of mission-critical uses in developed countries, Article 5 countries, and countries with economies in transition.

Armed forces from Article 5 countries are encouraged to participate in these workshops, and to come prepared to discuss their ODS phase-out programmes and challenges. Sponsorship covering the cost of participation is often available from the organizers of the workshop or conference.

Armed forces should always test the quality of any ODS they buy, either by establishing an in-house testing facility or by entering into an arrangement with a private contractor. Placing contaminated ODS or the wrong substance in a military system can destroy equipment and result in significant losses of operational readiness and high financial costs.

Article 5 countries should now begin assessing their future ODS requirements by developing credible estimates of future needs. It also takes time to establish and implement procedures for recovering ODS, a recycling mechanism, and a market for recycled ODS. It is best to begin this process while ODS are still being manufactured so that this recycling market can begin to take over as new production declines in response to the control measures phased in under the Montreal Protocol. As large consumers of ODS, the armed forces can play a leadership role in the establishment of a national ODS banking system. It is in their own best interest to become leaders in this field since it is the military that has the largest interest in ensuring that such a bank is in place and functioning reliably when ODS production ends.

### Essential Use Exemptions

It is important to note that one of the requirements for an ‘essential use’ exemption under the Montreal Protocol is that supplies adequate to meet the need involved are not available from stockpiles of recycled material. In the absence of an ODS bank, this is a difficult criterion to apply. Participation in a functioning banking scheme is a virtual prerequisite for satisfying the ‘essential use’ criteria. It is also significant that the terms ‘mission-critical use’ and ‘essential use’ are not synonymous. The term ‘essential use’ has a very specific meaning under the Montreal Protocol. Just because the armed forces declare a use ‘mission-critical’ does not mean it will qualify as an ‘essential use’ under the Montreal Protocol. An ‘essential use’ can only be determined by the Parties.

ODS banks take different forms in different countries and they can be operated by the public or private sector. Most operate at a national level. Many developed countries have established military ODS reserves or banks. While they may begin as a small stockpile with warehouses and storage tanks, they tend to develop into agencies with lists of ODS users who no longer require their ODS and users who still have mission-critical needs. An initial quantity of ODS can be purchased in storage containers and stored in the bank. As the armed forces begin to implement their ODS management programmes, recovered ODS are taken to the bank where they are kept for ‘mission-critical’ applications. ODS management consists of keeping a careful track of the quantities of ODS installed in existing systems, held in storage, and present in the pipeline (see page 32 for an example of a military ODS bank). Reports from the Halons Technical Options Committee (HTOC) and the Technology and Economic Assessment Panel (TEAP) discuss in detail the various models used by countries to establish and operate ODS banks.

Information is also available from the proceedings of military workshops and conferences on the Montreal Protocol. Details of web sites with additional information on establishing military ODS banks can be found at the end of this guide. Both HTOC and TEAP reports list individuals who can provide advice on managing ODS banks. Anyone considering establishing a bank is encouraged to contact these individuals for assistance.

At their 1992 meeting in Copenhagen, the Parties to the Montreal Protocol decided to allow unrestricted international trade in recycled halons. This encourages international cooperation among military and civilian organizations to ensure that one nation’s surplus halons can be exported to meet the needs of another.

### US DoD ODS Reserve

The Defense Logistics Agency (DLA) manages the DoD ODS Reserve which will support military ODS uses after production phase-out. In some cases it is not practical or possible to retrofit the ODS alternatives presently available into existing weapons systems. Alternatives may have consequences in terms of space loss or additional weight that impact adversely on weapons-system performance and make a retrofit costly or technically impossible. Based on analyses of such issues, each branch of the US armed forces has decided to 'vintage' some of its existing weapons systems. The DoD ODS Reserve will support these mission-critical ODS applications through to the end of their useful lives or until technological and economically feasible alternatives are developed.

The DoD ODS Reserve was established by the Defense Authorization Act of 1993 to provide support to the Military Services and DoD Agencies for their mission-critical requirements involving halons, refrigerants, and solvents until alternatives can be fully implemented.

The Reserve is managed by the Defense Logistics Agency through its Defense Supply Centre in Richmond, Virginia.

The Reserve of Class I ODS has been built up from recycled ODS held by the armed forces in non-mission-critical applications and from recycled ODS purchased on the open market. The armed forces and DoD agencies recover material from their non-mission-critical systems, or from systems withdrawn from use because they have reached the end of their useful life. Recovered ODS are turned over to the Reserve for reclaiming, storage, and future issue. The Reserve only purchases recycled ODS on the open market when absolutely necessary; it relies primarily on ODS recycled from internal sources. It is important to note that the Reserve has safeguards in place to audit the source of the recycled ODS and so avoid purchasing 'black-market' material. The programme began its operations in January 1994 with halons, then expanded into refrigerants in January 1995, and finally into solvents in January 1996. Halons constitute the largest ongoing ODS requirement.

### Factors crucial to any successful ODS bank:

- procedures to minimize emissions from current operations and require all ODS removed from systems to be recovered for re-use;
- procedures to collect ODS from military units and transport them to the bank (it being essential that the bank, and not the organization collecting the ODS, pays all transport costs involved);
- purchase of ODS when quantities available from internal sources are insufficient to meet projected needs;
- proper location and facilities for the bank storage facility;
- careful monitoring of stocks deposited, processed, dispensed, and held in storage; and
- hands-on control of access to the facility and monitoring of the organizations authorized to make ODS withdrawals.

### Recovery, recycling and reclamation: its role in managing an ODS bank

The Parties to the Montreal Protocol have defined recovery, recycling and reclamation as follows:

- **Recovery:** The collection and storage of controlled substances from machinery, equipment, container vessels, etc., during servicing or prior to disposal.
- **Recycling:** The re-use of recovered controlled substances following a basic cleaning process such as filtering and/or drying (for refrigerants, recycling normally involves their being put back into the machinery/equipment from which they have been temporarily removed and often takes place on site).
- **Reclamation:** The reprocessing and upgrading of a recovered controlled substance through such mechanisms as filtering, drying, distilling, and chemical treatment, in order to ensure that the substance once again meets specified performance standards. Such processing often takes place off site at some central facility.

(Note: The term 'recycling' is often used to cover all the activities of ODS recovery, recycling, and reclamation described in this guide.)

A good recycling strategy is essential to any military phase-out plan. Any successful strategy will require industry standards (covering mandatory recycling, purchasing and procurement, as well as training criteria), monitoring, reclamation equipment, decontamination facilities, and specialist training. Such industry standards have been developed and are discussed in TEAP and HTOC reports.

The steps described in this guide should be useful to armed forces that have not yet embarked on this process. In addition, now that electronic communications are so widely available, it is as easy to ask for information and assistance as it is to send e-mail. To help establish a network of military experts involving specialists from developed and developing countries, information about contact points is provided in Annexes 1 and 2 along with details of useful web sites. Many military personnel in developed countries have come to believe in the importance of preserving the earth's ozone layer, and that the armed forces should lead by example.

## 3.6

## Step 6: Keep progress on track

It is important to regularly review the progress being made in reducing ODS use, and to compare this progress against probable future restrictions in ODS availability resulting from the implementation of the Montreal Protocol. This review procedure is an insurance policy that guarantees that a weapons system is not grounded because it lacks the ODS it needs to function.

This review procedure should continue throughout the programme implementation period until ODS use is completely phased out. Regular reviews should be conducted by the senior manager, and reported at the most senior levels of the armed forces. Reviews should provide the following information:

- total ODS purchased before the commencement of phase-out;
- total ODS purchased to date;
- percentage reduction;
- percentage remaining to be cut;
- total available ODS reclaimed from ODS systems withdrawn from use;
- total amount of equipment replaced;
- total amount of equipment requiring replacement;
- mission-critical applications;
- total ODS quantities required to service mission-critical uses;
- quantities available and plans to secure quantities outstanding;
- progress in establishing an ODS bank; and
- forecast for meeting deadlines laid down under the Montreal Protocol.

### Evaluating military 'essential use' nominations

Let us take the case of an application to TEAP for an exemption covering a CFC solvent used in a maintenance procedure on a weapon system.

The application declared the use 'mission-critical', and stated that no alternative existed despite efforts to identify one.

The TEAP was unable to recommend the nomination, and the Parties denied the application. The TEAP did, however, offer a team of military solvents experts to review the use and assist in the identification of appropriate alternatives.

"Smart weapons" such as this shoulder-fired assault weapon rely heavily on electronics, which are often manufactured and maintained using ODS solvents. Encourage weapons suppliers to switch to non-ODS manufacturing processes, and ensure that maintenance procedures do not require ODS.







# Section 4: Examples of successful ODS management by armed forces

Several ODS may be associated with a single military application: in this case, halons could be found in the ground crew's fire extinguisher and on board in engine housings, cockpits, cargo bays, and back-up power units. Avionics pods and cockpits may rely on ODS refrigerants. ODS may also be used as solvents for cleaning and degreasing during aircraft maintenance. It is essential to be aware of these multiple uses.



The armed forces in many developed countries recognized shortly after ratification of the Montreal Protocol that successful ODS phase-out could not be achieved in isolation. The complexity of the challenge and the existing state of technological know-how made it clear that cooperation with industry, other government agencies, and with armed forces elsewhere was essential to success. As a result, many nations developed military ODS phase-out programmes in which partnership was seen as playing a key role from the outset. Where industry had a commercial incentive to develop alternatives for specific applications, it generally took the lead in doing so; armed forces have been able to focus on applications unique to their own activities; and joint projects between the two have been set up to help solve applications common to both. Generally speaking, armed forces have tended to implement policies that rely, as far as possible, on alternatives developed by industry.

Many armed forces use private contractors to maintain many of their ODS systems and to provide some ODS recycling services. These contractors are required to comply with national ODS regulations governing the recovery and recycling of halons and refrigerants. In the US, for example, the DoD ODS Reserve uses standard commercial equipment to recover and recycle ODS. In some cases, such as shipboard environments, standard industry equipment may need to be modified to meet special military requirements for greater impact resistance and durability. Design features of such military equipment have been made available internationally through initiatives taken jointly by the armed forces and the manufacturers of similar commercial equipment. In addition, once the initial development work on such systems has been completed, industry has proceeded to repackage some of the technology that has been developed into commercial systems, and is now manufacturing and selling it.

## 4.1

### Aircraft air-conditioning

New aircraft are being designed to use non-ODS refrigerants such as HFC-134a (also used in motor vehicle air-conditioning systems) or HFC-236fa.

The issue of halon use on board aircraft remains an interesting challenge for the armed forces. Technology using halons for aircraft fire protection was developed by the armed forces over two decades ago to improve the combat survivability of military aircraft. That technology was later adopted by the civil aviation sector. The regulatory requirements of most civil aviation authorities worldwide for fire protection on civil aircraft cannot be met today without using halon-1301 and halon-1211. Because it is both technically difficult and expensive to identify and implement alternatives for this particular application, an international partnership consisting of military and civil aviation regulatory authorities, aircraft fire-protection equipment suppliers, and airframe manufacturers was established with the aim of finding a solution to the problem. This group has been in existence for approximately five years, and has successfully developed and tested an alternative for one of the aircraft halon applications involved. A number of challenges remain. As additional alternatives are identified, they will be incorporated on board both military and civil aircraft.

## Air-conditioning and refrigeration

In several developed countries, the armed forces and industry are working together to identify alternatives for military-specific cooling systems, mostly on board Navy ships. The alternatives under examination include both retrofit options and new equipment. Retrofits are under development for existing equipment using CFC-11, CFC-12, CFC-500, and CFC-114. In each case, the armed forces are adopting the alternative refrigerant most commonly used in the private sector.

In the US, because of specific problems encountered in replacing cooling

equipment engineered into ship designs, the Navy has its own refrigerant alternatives testing programme that relies heavily on private-sector testing data and alternatives. Navy researchers worked closely with DuPont, Carrier, York, Castrol, and other private-sector firms to collect data on industry-developed alternative refrigerants and lubricants prior to testing. Once testing began, data collected by the Navy was shared with these firms in an effort to help them develop commercial alternatives.

**Motor vehicle air-conditioning**

All new motor vehicles with air-conditioning use the zero-ODP refrigerant HFC-134a. Non-tactical military vehicles are normally standard commercial models purchased from commercial manufacturers. Any air-conditioning systems in such vehicles will use the same refrigerant as vehicles sold on the open market—HFC-134a.

**Retrofitting CFC-11 chillers with HCFC-123**

The primary alternative refrigerant used in the private sector for retrofits of existing CFC-11 chilled-water air-conditioning equipment (chillers) is the low-ODP refrigerant HCFC-123. It is also used by the armed forces for retrofitting commercial CFC-11 chillers in facility-cooling applications. No retrofits are currently being made on weapons system applications involving CFC-11. The US Navy is the only user of CFC-11 in weapons systems in the US, and it plans to withdraw from service all existing CFC-11 shipboard chillers at the end of their service life. These systems are being ‘vintaged’.

**Retrofitting CFC-12/CFC-500 chillers with HFC-134a**

The principal alternative refrigerant employed in the private sector in retrofits of existing CFC-12 and CFC-500 chilled-water air-conditioning equipment is the zero-ODP refrigerant HFC-134a. HFC-134a is also being used in retrofits of commercial CFC-12/CFC-500 chillers in shore-facility cooling applications, as well as in retrofits of US Navy shipboard chillers.

**Retrofitting CFC-114 chillers with HCFC-124**

The main alternative refrigerant used in the private sector for retrofits of existing CFC-114 chilled-water air-conditioning equipment is HCFC-124. CFC-114 is a very uncommon refrigerant in private-sector applications and is used primarily in industrial-process cooling and heavy-duty industrial air-conditioning. In US Navy shipboard plants, however, CFC-114 is used instead of CFC-12, CFC-500, or CFC-11 on many larger combat ships, including submarines. The US Navy initially conducted research into the use of HCFC-124 to replace CFC-114. The high cost of retrofits driven by the higher operating pressures of HCFC-124 as well as the future HCFC production phase-out made this an unattractive option. The US Navy has chosen to pursue a zero-ODP refrigerant, HFC-236fa, which is not subject to future production phase-out and operates at a pressure closer to that of CFC-114. This may well reduce the cost of any retrofit. Several chemical manufacturers are developing HFC-236fa as a commercial product.

**New alternative refrigeration equipment**

**Chillers**

New vapour compression chillers developed by the private sector use one of four refrigerants—HFC-134a, HCFC-123, HCFC-22, and R-410A (a blend of HFC-32 and HFC-125). In many developed countries the armed forces procure these types of chiller because of low life-cycle cost, application-specific availability, and other factors. In addition, most weapons-system refrigeration systems, such as refrigeration plants on new ships, will use HFC-134a.

**Refrigeration**

The private sector has developed several alternative non-CFC refrigerants for use in the refrigeration sector. These include HFC-134a, HCFC-22, HFC blends (R-404A and R-507), and a number of HCFC blends. As these are developed by industry, so armed forces are adopting them.

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### **CFC-12 refrigeration retrofit**

CFC-12 is used in many applications for refrigeration purposes. These include household appliances, dehumidifiers, retail food refrigeration, refrigerated transport, water coolers, and vending machines. The private sector has chosen a range of retrofit alternatives for these applications. Much of the private sector uses HFC-134a in medium-temperature, large-capacity applications, and employs one of several different HCFC-blend refrigerants for lower-temperature, smaller-scale equipment. The HCFC blends have advantages over HFC-134a in some applications because they more closely match the capacity of the existing refrigerant at low temperatures and require a less expensive retrofit. HFC-134a has some advantages over the blends in that it does not change composition as a result of any leakage and is not subject to a future production phase-out. Both alternatives are being implemented in armed-forces ground/shore facilities. After thorough evaluation of each available alternative, HFC-134a has proved a popular choice over the HCFC blends in weapon-systems applications such as Navy shipboard refrigeration plants.

### **R-502 (CFC-502) refrigeration**

R-502 is a chlorofluorocarbon refrigerant used extensively in low-temperature refrigeration applications such as supermarket refrigeration, refrigerated transport, ice-skating rinks, and ice machines. Retrofit alternatives for R-502 include a number of different HCFC blends, HFC blends, and HFC azeotropes. These can be adopted as alternatives in applications where recommended by original equipment manufacturers or some other competent technical authority.

### **R-503/R-13 (CFC-503/CFC-13) very low-temperature refrigeration**

R-503 and R-13 are used in very low-temperature dedicated refrigeration applications in medicine, laboratory analysis, electronics, and equipment testing. Only two retrofit options are currently available for this equipment: HFC-23 and proprietary HFC/perfluorocarbon blends. Both are being adopted as and when appropriate.

### **Non-fluorocarbon vapour compression technologies**

Several non-fluorocarbon refrigerants have been used over the years in vapour compression systems. These include hydrocarbons, ammonia, carbon dioxide, and water. In recent years, industry has been using these refrigerants more and more as a result of the CFC phase-out. For example, household refrigerators in Europe using isobutane are now on the commercial retail market and this technology is being promoted elsewhere around the world. Both in Europe and the US, ammonia systems have dominated the cold-storage and food-processing sectors in recent years. Wherever appropriate, armed forces are adopting these same alternatives for ground/shore facility applications. However, it is unlikely they will adopt them for weapons-system applications in the near future because of space and weight constraints, as well as toxicity/safety factors and concerns about flammability in a battlefield environment.

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## **4.2**

### **Non-vapour compression technologies**

New cooling technologies are being developed and some old ones are being improved by the private sector for possible future use. While some of these technologies are already in use in limited applications, it will be several years before they are fully developed. Examples include: direct and indirect evaporation cooling, adsorption cooling, absorption cooling, Stirling-cycle cooling, Joule-cycle



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cooling, thermoelectric cooling, magnetic cooling, thermoacoustic cooling, and gas expansion. A number of these technologies have been investigated for possible military applications and equipment has been developed using them. For example, the US Navy has one research submarine with thermoelectric cooling, and a Navy thermoacoustic refrigerator was flown aboard a NASA space-shuttle flight. Armed forces in the US and other developed countries will continue to investigate new technologies like these as and when they emerge.

## **Solvents, foams and other alternatives**

CFC-113, methyl chloroform, and carbon tetrachloride are commonly used solvents for cleaning and in laboratory analysis. In addition, CFC-11 has been used on a limited basis as a solvent. CFCs—primarily CFC-11—have also been used as foam-blowing agents, especially for flotation foams and insulating foams. ODS are also used in other applications including medical sterilants, adhesives, propellants, freeze sprays, mould-release agents, document-preservation sprays, fabric protection, pesticides, and many other uses. Very few, if any, applications of these ODS are unique to the military. In developed countries, armed forces have monitored closely the alternatives developed and adopted by industry and are adopting industry-pioneered alternatives wherever possible. This section addresses only some of the major ODS applications and their alternatives.

### **Metal cleaning**

Industry has developed a number of alternatives to general metal-cleaning applications. These including water-based cleaning agents, semi-aqueous cleaners, organic solvent cleaners (petroleum hydrocarbons, terpenes, ketones, ester, ethers, alcohols, and so on), and several other less widely used alternatives. Many of these are appropriate for military applications and have been widely adopted by armed forces. For example, water-based spray washers have replaced methyl chloroform vapour degreasers in a large number of military industrial activities.

### **Electronics component cleaning**

Industry-developed alternatives include: water-based and semi-aqueous cleaning agents, organic solvents, trichloroethylene, perchloroethylene, supercritical fluids, plasma gas cleaning, UV/ozone cleaning, volatile methyl siloxanes, trans-1,2-dichloroethylene, HCFCs, PFCs, hydrofluoroethers (HFEs), HFCs, water-soluble fluxes, and no-clean alternatives. The US DoD has been working closely with the international electronics industry through the Joint US EPA/DoD/IPC Ad Hoc Solvents Working Group. The programme they developed to evaluate ODS alternatives for manufacture and/or cleaning in the electronics sector is still used by much of industry and by the armed forces to screen alternatives for the defluxing of printed circuit boards. By far the most widely-adopted and cost-effective alternative has been no clean flux.

### **Precision cleaning**

Military precision-cleaning applications are identical to many found in industry. Joint testing programmes conducted by the armed forces and by companies manufacturing systems requiring precision cleaning have produced alternatives for all applications identified to date.

### **Medical sterilants**

CFC-12 blended with ethylene oxide (EO) has been used for many years as a sterilization gas. Industry has developed several alternatives for the sterilization of heat-sensitive medical devices including HCFCs and EO, HFCs and EO, 100 per

## 4.3

cent EO, and a blend consisting of 90 per cent EO and 10 per cent carbon dioxide (CO<sub>2</sub>). No requirement unique to the armed forces has been identified for these applications to date.

### Foam-blowing agents

Alternatives developed by industry include: HCFCs, HFCs, saturated light hydrocarbons, CO<sub>2</sub>, and vacuum panels. Companies manufacturing systems for military use incorporating foams have entered into joint testing projects with their customers to evaluate the performance of alternatives in specific applications. No military-specific foam application has yet been identified that cannot be met using commercially available alternatives.

### Oxygen-based systems cleaning

The use of CFC-113 for cleaning oxygen-based life-support systems on aircraft, submarines, and in diving applications constitutes one of only two cases where private-sector alternatives have been only partially successful in solving problems affecting the armed forces. In this area, the US Navy worked with industry to develop a water-based cleaner—the Navy Oxygen Cleaner (NOC)—which is expected to replace CFC-113 in most applications. More recently, other alternatives have been developed by aerospace companies and adopted by armed forces in other countries. No military application has yet been identified that cannot be covered using an alternative currently available commercially.

## Halons

### Halon-1301 firefighting agent replacements

Alternatives to halon-1301 generally require either the installation of new chemical distribution systems (cylinders, piping, sprinkler heads, and so on) or major modifications to existing ones. As such, there are no true ‘drop-in’ replacements for halon-1301. Almost all replacements require a greater quantity of chemical to achieve the same firefighting capability as halon-1301. The US DoD has been working together with industry to investigate alternatives for fire and/or explosion suppression systems in both inhabited and uninhabited spaces aboard aircraft, ships, and tactical vehicles. Research, development, and testing in this area has been undertaken separately for halon-1301 applications and halon-1211 applications.

### Gaseous agent replacements

There are a number of commercially available gaseous agents that have been developed by industry to replace halon-1301 in inhabited spaces. These include HFC-227ea, HFC-23, HCFC blends, HFC blends, inert gases, and inert gas blends. Most non-HCFC alternatives have been approved by the regulatory environmental authorities in North America and Europe, albeit with some restrictions. In addition to the agents listed, gases such as CF<sub>3</sub>I, HCFC-22, HCFC-124, HFC-125, HFC-134a, and several inert gas blends have been developed for use in uninhabited spaces. Wherever appropriate, the armed forces in developing countries are adopting these in ground/shore facility applications. For weapons-system uses, all research on gaseous alternatives is being conducted on one or more of these alternatives developed by the private sector. Most of the activity is taking place in the US. The Joint Aircraft Halon Replacement Testing Programme (involving the Army, the Navy, the Air Force, and the FAA) selected HFC-125 as the alternative agent for further testing to see whether it might be used in newly designed aircraft. Designers of the new V-22 have selected HFC-125 for use in its engine nacelle fire-extinguishing system. The US Navy

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Shipboard Halon Replacement Programme recently selected HFC-227ea as the replacement for halon-1301 on a number of ships currently under construction.

### **Fine water mists**

Water sprinklers have been used for many years in fire-protection applications. However, in recent years, it has been discovered that tiny droplets of water spray in a mist are much more efficient at extinguishing fires. Fine water mists also use much smaller water volumes and so cause less residual water damage. British Petroleum (BP) was one of the early pioneers in fine water mist technology, using it for fire protection on oil platforms. Fine water mist systems have flourished in Europe, especially in marine applications. However, in the US their use has been very limited. In both North America and Europe, armed forces have taken a keen interest in these systems, but implementation has not been widespread because of the difficulty of developing sufficiently effective delivery systems. In the US, the Army and Navy have worked closely to evaluate these systems and are interested in installing them on small boats and waterborne craft. The Navy has found that these systems must be carefully designed to be effective on larger-scale applications such as the main engine rooms of large ships. A fine water mist system has been selected for use by the Navy to replace halon-1301 in the main engineering space of its newest amphibious ship, the Class LPD-17. Preliminary successes have been registered in the development of rapid-dispersion nozzles for use in aircraft engine-nacelle and dry-bay applications.

### **Pyrotechnically generated gases and aerosols**

A number of companies are developing fire-protection systems which use a pyrotechnic device to generate large quantities of inert gases and of inert gases mixed with fine chemical powders. This technology is similar to the inflation devices used on vehicle air bags. The armed forces in North America and Europe have been actively monitoring commercial developments and testing these alternatives. Initiatives include joint working groups to exchange information, and partnerships with industry to deploy this technology on board new aircraft. The US F/A-18 E/F and the V-22 will be the first such aircraft to employ this technology. The US Navy has also been working with industry to develop and test a similar alternative to replace halon-1301 on board ships. Adaptations of this technology for shipboard uses have so far been disappointing in tests but work continues in this area.

### **Halon-1211 streaming agent replacements**

Unlike halon-1301 which is used primarily in fixed total-flooding systems, halon-1211 is used in portable or hose-reel systems as a liquid fire-extinguishing agent that can be directed at the base of a fire (or 'streamed') through a nozzle. It has been used most extensively in the aviation industry for flight-line fire protection, crash and fire rescue vehicles, and in portable fire extinguishers on board aircraft. It is also used widely in the electronics industry, in general fire protection for buildings, the petroleum industry, and even in domestic fire extinguishers. Halon-1211 is considered to be a 'clean agent' because it leaves no harmful residue after extinguishing a fire.

### **Halocarbons**

Industry has developed a number of different halocarbons to replace halon-1211. These include HCFC-22B1, HCFC-123, HCFC-124, HFC-236fa, and several HCFC blends. The US Air Force is testing these alternatives as replacements for halon-1211 in aviation applications. Since no alternative for military-aircraft ground support has yet been approved, halon-1211 is being banked in the reserve to support mission-critical applications. Further testing of alternatives will continue in the future.

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**Dry chemicals**

Dry chemicals have been the most widely used alternative to halon-1211. In most applications where a ‘dirty agent’ is permitted, dry chemicals have been adopted by both industry and the armed forces.

**Carbon dioxide**

In areas where a ‘clean agent’ is required—especially close to electronic installations—carbon dioxide has become one of the alternatives to halon-1211 preferred by both industry and the armed forces. It cannot, however, be used in all applications because of its high ODP, the large volume and weight of CO<sub>2</sub> that is required, and the short range over which it is effective. CO<sub>2</sub> is also replacing small halon-1301 hand-held fire

**Aircraft/  
aircraft systems**

- CFC-12 replacement in fixed-wing aircraft air-conditioning
- CFC-113 elimination in the B-2 Aircrew Training Device programme
- Removal of ODS solvent references from technical manifest (C/KC-135 aircraft)
- Elimination of ODS solvents from manufacturing process (F-16 aircraft)
- Introduction of ODS substitutes for depot and field solvents (F-16 aircraft)
- Installation of water-based landing-gear cleaning system
- Implementation of ODS-free solvent alternatives, ground-radar simulators
- CFC-12 to HFC-134a conversion in ground support equipment
- Replacement of CFC-12 with HFC-134a (T-1A Jayhawk aircraft)
- Replacement of 1,1,1-trichloroethane in aircraft fuel-tank repair
- P-20 ramp truck conversion from halon-1211 to aqueous film-forming foam
- P-23 CFR truck conversion from halon-1211 to dry-chemical system
- Crash rescue truck air-conditioning conversion
- Replacement of CFC-12 in tactical shelter air-conditioning and environmental control units
- CFC-12 replacement in ambulance air-conditioning systems
- Removal of halon-based fire-suppression system (C-17 aircrew training system)
- Replacement of 1,1,1-trichloroethane (conformal stripping with ODS-free alternatives)
- Replacement of ODS refrigerants, air-transportable galley lavatory
- Installation of ODS-refrigerant recovery equipment aircraft systems

<p><b>Missile and satellite systems</b></p>	<p>ODS solvent elimination, Missile Warning and Space Surveillance System</p> <p>Replacement of CFC-113 with non-Class I ODS alternative, NAVSTAR (satellite) GPS</p> <p>ODS Elimination, processing of solid rocket motor unit, Titan IV</p> <p>Stage IV shipping and storage container environmental control unit, Peacekeeper</p> <p>Refrigerant replacement, ballistic-missile early-warning system, Cyber Mainframe Computer</p> <p>Brine chiller modification, Minuteman and Peacekeeper missiles</p> <p>CFC-12 chiller modification, Minuteman guidance and control system (G&amp;C)</p> <p>Air-conditioning service certification, Aerospace ground equipment</p> <p>On-pad spacecraft ODS-free air-conditioning, Delta-II launch vehicle</p>
<p><b>Water craft</b></p>	<p>CFC-12 replacement using HFC-134a and HCFC-22 retrofit kits, watercraft refrigeration and cooling equipment, US Army</p>
<p><b>Ground vehicles</b></p>	<p>Replacement of halon-1301 portable extinguishers with CO<sub>2</sub> units</p> <p>Replacement of halon-1301 engine-compartment fire-extinguishers with HFC-227ea or dry powder (retrofits start in 1999)</p>
<p><b>Field equipment</b></p>	<p>CFC-12 replacement in field refrigeration equipment</p>
<p><b>Vehicles</b></p>	<p>ODS removal, Milstar mobile constellation control vehicle and Milstar communication vehicle</p>
<p><b>General</b></p>	<p>DoD participation in the development of an industry standard for recycled halon-1301</p> <p>CFC-12 replacement in water chillers</p> <p>DoD participation in the Halon Alternatives Research Corporation</p> <p>DoD participation in the International Cooperative for Environmental Leadership (formerly the Industry Cooperative for Ozone Layer Protection, or ICOLP)—an industry group dedicated to identifying and testing ODS-free solvents</p>
<p><b>Munitions</b></p>	<p>General-purpose bomb-and-fuse ODS solvent elimination in conventional weapons</p>

# Annex 1: Additional sources of information and assistance

## Multilateral Fund Secretariat, Ozone Secretariat and Implementing Agencies

### Multilateral Fund Secretariat

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### UNEP Ozone Secretariat

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## Useful websites

### Alternative Fluorocarbons Environmental Acceptability Study

<http://www.afeas.org>

An industry consortium providing general information about ozone depletion, global warming, and alternative fluorocarbons as well as production, sales, and emissions data

### Brazil: Ministério Brasileiro do Meio Ambiente — Proteção da Camada de Ozônio

<http://www.mma.gov.br/port/SMA/ozonio/ozonio.html>

Web site of Brazil's National Ozone Unit

### Colombia: La Unidad Técnica Ozono Colombia

<http://www.minambiente.gov.co/ozono>

Web site of Colombia's National Ozone Unit

### Costa Rica: Comisión Gubernamental del Ozono (COGO)

<http://163.178.56.21>

Web site of Costa Rica's National Ozone Unit

### EnviroSense/Integrated Solvent Substitution Data System (ISSDS)

<http://es.inel.gov/>

Gateway to a number of databases on the Internet that contain substitution and process alternatives to ODS. Enquiries can be addressed to more than one database at a time so that information can be retrieved from several with just the one query

### Environment Canada

<http://www.ec.gc.ca/ozone/index.htm>

Technical, policy, and general background information related to ozone protection, the Montreal Protocol, and ODS substitutes

### Halon Alternatives Research Corporation (HARC)

<http://www.harc.org>

A voluntary, non-profit trade association formed by concerned halon users and the fire protection industry to assist users of halons to redeploy the existing bank of halons from applications where alternatives have replaced halons, to those still requiring halons. HARC facilitates halon recycling, helps determine critical use, acts as an information clearinghouse, and is a focal point for national/international halon recycling

### Halon Users National Consortium (HUNC)

<http://www.hunc.org>

A UK-based halon bank that assists members with legislative information and advises on halon purchase and sales, together with advice on alternative replacements. HUNC is associated with the Refrigerant Users Group (RUG)

### Instituto Nacional de Ecología (INE)

<http://www.ine.gob.mx/ucci/upo/inicio.html>

Web site of Mexico's National Ozone Unit

**International Cooperative for Environmental Leadership (ICEL)**

<http://www.icel.org>

An international industry consortium providing technical information on climate change and ozone depletion issues

**Lebanon Ministry of Environment Ozone Office**

<http://www.moe.gov.lb/moe/ozone>

Web site of Lebanon's National Ozone Unit

**Multilateral Fund Secretariat**

<http://www.unmfs.org>

Information about the Secretariat and Executive Committee of the Multilateral Fund for the Implementation of the Montreal Protocol

**Programme for Alternative Fluorocarbon Toxicity Testing (PAFT)**

<http://www.paft.org>

An industry consortium that conducts research on the toxicology of substitute fluorocarbons

**UNEP Ozone Secretariat**

<http://www.unep.org/unep/secretar/ozone/home.htm>

On-line versions of official reports of the Vienna Convention and Montreal Protocol meetings, ratification status, ODS consumption and production data, and the text of the Montreal Protocol

**UNEP Technology and Economic Assessment Panel (TEAP)**

<http://www.teap.org>

Information about background and current activities of the TEAP and its Technical Options Committees (TOCs), including full-text reports, meeting schedules, members, etc.

**UNEP TIE OzonAction Programme**

<http://www.uneptie.org/ozonaction.html>

A wide range of on-line technical, policy, and general awareness information, including full-text reports relating to ODS management, alternative substances, halon banking, policies, case studies, etc. Includes links to other ozone-protection web sites, contacts for further assistance, and an on-line newsletter

**US Airforce Centre for Environmental Excellence (AFCEE)**

[http://www.afcee.brooks.af.mil/pro\\_act/pro\\_actHOME.htm](http://www.afcee.brooks.af.mil/pro_act/pro_actHOME.htm)

A field-operating agency of the Civil Engineer of the US Air Force, providing a complete range of environmental, architectural and landscape design, planning, and construction management services and products. The site includes success stories, fact sheets, and discussion forums that address ozone protection and other environmental topics affecting the US Air Force

**US Army Acquisition Pollution Prevention Support Office**

<http://www.aappso.com/odc/odc.html>

The central point of contact for US Army regulations and expertise related to ozone protection, providing information about the Ozone Depleting Chemical Elimination Programme, including policies, programmes, Army ODS reserve, etc.

**US Department of Defense's Defense Environmental Network & Information eXchange (DENIX)**

<http://denix.cecer.army.mil/denix/denix.html>

Provides US DoD personnel in the environmental security arena with information and guidance supplied by the DoD on compliance with environmental legislation, restoration and clean-up, and occupational health and safety. Includes the on-line Guide to Decommissioning Halon Systems

**USEPA's Solvent Alternatives Guide (SAGE)**

<http://clean.rti.org/>

A comprehensive on-line guide designed to provide pollution-prevention information on non-ODS solvent and process alternatives for component cleaning and degreasing. It operates both as an 'expert system' evaluating alternative processes and chemicals for particular problems and as a hypertext manual on cleaning alternatives

**USEPA Stratospheric Ozone Protection Homepage**

<http://earth1.epa.gov/ozone/>

Web site with information on the science of ozone depletion, US regulations designed to protect the ozone layer, information on methyl bromide, flyers about the UV index, information for the general public, and other topics

**US Navy Shipboard Environmental Information Clearinghouse (SEIC)**

<http://www.navyseic.com>

Formerly known as the Navy CFC & Halon Clearing house, SEIC provides the US Navy with a central point of contact for information, data, and expertise on US Navy environmental policy, regulations of the US Environmental Protection Agency (USEPA), and alternative chemicals, processes, and equipment. Contains an on-line newsletter, full-text documents, news, links to other sites, military specifications, and technical information on ODS alternatives



## Annex 2: Further reading

### UNEP TIE OzonAction publications

Electronic versions of many of the following publications, as well as an exhaustive list of available publications, can be obtained from the OzonAction Programme web site <http://www.uneptie.org/ozonaction.html> or in hard copy (contact UNEP TIE directly):

*Five steps for raising awareness on ozone depletion: a handbook for NOUs.* 1996

*Elements for establishing policies, strategies and an institutional framework for ozone-layer protection.* 1995

*Regulations to control ozone depleting substances.* 1996

*Guidelines for development of refrigerant management plans.* October 1997

*Protecting the ozone layer: guidelines for United Nations offices.* 1997

*Guidebook for implementation of codes of good practice in the refrigeration sector.* August 1998

*Guidelines for establishment of recovery and recycling systems.* 1997

*Inventory of trade names of chemical products containing substances controlled under the Montreal Protocol and trade names of HFC alternatives.*

*Sourcebooks of technologies to protect the ozone layer: refrigeration, air-conditioning, and heat pumps.* 1996

*Halon management: banking for the future Information Kit.* 1993

### UNEP Ozone Secretariat publications

An electronic version of the following publication is available on the Ozone Secretariat website (<http://www.unep.org/unesep/secretar/ozone/home.htm>), or in hard copy (contact UNEP Ozone Secretariat directly):

*1997 Update of the handbook of international treaties for the protection of the ozone layer.* UNEP. 1998.

### Military-related publications

*The safety guide for decommissioning halon systems.* USEPA/USDOD/HARC/HRC. 1998. Available from the Navy SEIC and DENIX web sites: <http://www.navyseic.com> <http://denix.cecer.army.mil/denix/denix.html>

*Matériel developer's guide for pollution prevention.* Second Edition. 1994 Available from: Headquarters Army Materiel Command, 5001 Eisenhower Avenue Alexandria, VA 22333-0001, USA

*Navy's CFC and halon elimination programme.* David A. Breslin, Gregory Brunner, Joseph Thill. Available from the Navy SEIC and DENIX web sites listed previously

*Proceedings of the role of the military in implementing the Montreal Protocol, Williamsburg, Virginia, USA, 11-13 September 1991*

*Proceedings of the second international NATO/CCMS conference on the role of the military in protecting the ozone layer, Brussels, Belgium, 24-25 January, 1994.* Volumes I and II

*Proceedings of the 1997 international workshops on military progress in implementing the Montreal Protocol and the military role in global climate protection, Herndon, Virginia, 6-7 November 1997.*

*Strategic guidance and planning for eliminating ozone depleting chemicals from US Army applications.*

Evans, George H., 1995. Available from Prospective Technologies, Inc PO Box 1106, Graham, NC 27253, USA

*USDoD ODS Milspec database.* Navy Shipboard Environmental Information Clearinghouse. Available from the Navy SEIC web site listed previously

*US Airforce halon replacement programme: solving a global environmental problem.* 1991 Available from Headquarters, Air Force Civil Engineering Support Agency, Air Force Civil Engineering Laboratory, Fire Protection and Crash Rescue Systems Branch, Tyndall AFB, Florida 23404, USA

*NAVFAC shore facilities ODS conversion guide for heating, ventilation, air-conditioning/refrigeration and fire-protection systems.* Bell, B., Mestey, F., Gott, J. US Naval Facilities Engineering Command, December 1997. Available from the US Navy SEIC web site

### USEPA/ICEL Ozone depleting solvent alternatives manuals

Electronic versions of the following publications are available on the ICEL web site <http://www.icel.org>, or in hard copy (contact ICEL directly):

*Alternatives for CFC-113 and methyl chloroform in metal cleaning.* Washington, DC. US EPA. 1994. Reference: EPA/400/1-91/019

*Aqueous and semi-aqueous alternatives for CFC-113 and methyl chloroform cleaning of printed circuit board assemblies.* Washington, DC US EPA. 1994. Reference: EPA/400/1-91/016

*Eliminating CFC-113 and methyl chloroform in precision-cleaning operations.* Washington, DC. US EPA. 1994. Reference: EPA/400/1-91/018

*Eliminating CFC-113 and methyl chloroform in aircraft maintenance procedures.* Washington, DC. US EPA. 1993. Reference: EPA/430/B-93/006

*No-clean soldering to eliminate CFC-113 and methyl chloroform cleaning of printed circuit board assemblies.* Washington, DC. US EPA. 1993. Reference: EPA/430/B-93/005

*Conservation and recycling practices for CFC-113 and methyl chloroform.* Washington, DC. US EPA. 1991. Reference: EPA/400/1-91/017

*Manual of practices to reduce and eliminate CFC-113 use in the electronics industry.* Washington, DC. US EPA. 1990. Reference: EPA/400/3-90/003

*Source book of technologies for protecting the ozone layer: specialized solvent uses.* UNEP TIE/US EPA/ICEL. Paris. 1996

## Montreal Protocol assessment reports

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Electronic versions of the many of the following publications are available on the TEAP web site (listed previously), or in hard copy (contact UNEP Ozone Secretariat directly):

*Scientific assessment of ozone depletion: 1998 World Meteorological Organization, Global Ozone Research and Monitoring Project. Report No. 44*

WMO/UNEP/NOAA/NASA/EC.  
Reference: ISBN 92-807-1722-7

*1998 Assessment report of the Technology and Economic Assessment Panel.* UNEP.  
Reference: ISBN 92-807-1704-9

*Environmental effects of ozone depletion: 1998 assessment.* UNEP.  
Reference: ISBN 92-807-1724-3

*Synthesis of the reports of the Scientific, Environmental Effects, and Technology and Economic Assessment Panels of the Montreal Protocol, 1999.* UNEP. Reference: ISBN 92-807-1733-2

*1998 Assessment report of the Economic Options Committee.* UNEP.  
Reference: ISBN 92-807-1727-8

*1998 Assessment report of the Aerosols, Sterilants, Miscellaneous Uses and Carbon Tetrachloride Technical Options Committee.* UNEP.  
Reference: ISBN 92-807-1726-X

*1998 Assessment report of the Flexible and Rigid Foams Technical Options Committee.* UNEP. Reference: ISBN 92-807-1728-6

*1998 Assessment report of the Methyl Bromide Technical Options Committee.* UNEP.  
Reference: ISBN 92-807-1730-8

*1998 Assessment report of the Refrigeration, Air Conditioning and Heat Pumps Technical Options Committee.* UNEP.  
Reference: ISBN 92-807-1731-6

*1998 Assessment report of the Solvents, Coatings and Adhesives Technical Options Committee.* UNEP.  
Reference: ISBN 92-807-1732-4

*1998 Assessment report of the Halons Technical Options Committee.* UNEP.  
Reference: ISBN 92-807-1729-4

## Ordering UNEP publications

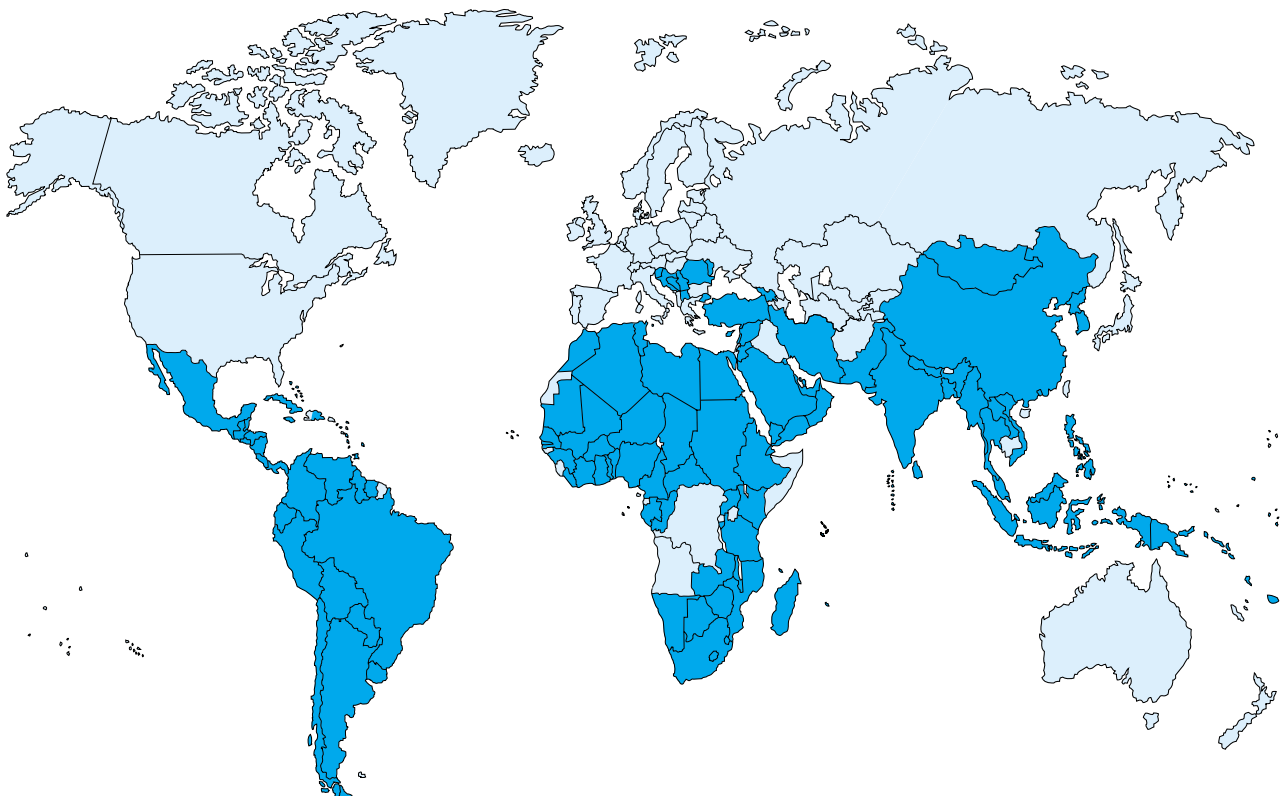
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Hard copies of TEAP/TOC reports, as well as other publications produced by the OzonAction Programme and the Ozone Secretariat, can be purchased from:

SMI (Distribution Services) Ltd  
PO Box 119  
Stevenage, Hertfordshire SG1 4TP  
United Kingdom  
phone: +44 1438 748111  
fax: +44 1438 748844  
e-mail: Anthony@smibooks.com  
<http://www.earthprint.com>

## Countries operating under Article 5 of the Montreal Protocol

Algeria	Ecuador	Malawi	Saudi Arabia
Antigua & Barbuda	Egypt	Malaysia	Senegal
Argentina	El Salvador	Maldives	Seychelles
Bahamas	Ethiopia	Mali	Singapore
Bahrain	Fiji	Malta	Slovenia
Bangladesh	Gabon	Marshall Island	Solomon Islands
Barbados	Gambia	Mauritania	South Africa
Belize	Georgia	Mauritius	Sri Lanka
Benin	Ghana	Mexico	Sudan
Bolivia	Grenada	Federated States of Micronesia	Suriname
Bosnia / Herzegovina	Guatemala	Moldova	Swaziland
Botswana	Guinea	Mongolia	Syrian Arab Republic
Brazil	Guyana	Morocco	United Republic of Tanzania
Brunei Darussalam	Honduras	Mozambique	Thailand
Burkina Faso	India	Myanmar	Togo
Burundi	Indonesia	Namibia	Tonga
Cameroon	Islamic Republic of Iran	Nepal	Trinidad & Tobago
Central African Republic	Jamaica	Nicaragua	Tunisia
Chad	Jordan	Niger	Turkey
Chile	Kenya	Nigeria	Tuvalu
China	Kiribati	Oman	Uganda
Colombia	Democratic People's Republic of Korea	Pakistan	United Arab Emirates
Comoros	Republic of Korea	Panama	Uruguay
Congo	Kuwait	Papua New Guinea	Vanuatu
Democratic Republic of Congo	Lao People's Democratic Republic	Paraguay	Venezuela
Costa Rica	Lebanon	Peru	Viet Nam
Côte d'Ivoire	Lesotho	Philippines	Yemen
Croatia	Liberia	Qatar	Yugoslavia
Cuba	Libyan Arab Jamahiriya	Romania	Zambia
Cyprus	The Former Yugoslav Republic of Macedonia	Saint Kitts & Nevis	Zimbabwe
Djibouti	Madagascar	Saint Lucia	
Dominica		Saint Vincent and the Grenadines	
Dominican Republic		Samoa	



As per status of ratification, 20 August 1999

## Annex 3: About the UNEP TIE OzonAction Programme

Nations around the world are concerned about the emissions of man-made CFCs, halons, carbon tetrachloride, methyl chloroform, methyl bromide and other ozone-depleting substances (ODS) that have damaged the stratospheric ozone layer — a shield around the Earth which protects life from dangerous UV radiation from the Sun. 170 countries have committed themselves under the Montreal Protocol to phase out the use and production of these substances. Recognizing the special needs of developing countries, the Parties to the Protocol also established a Multilateral Fund and appointed implementing agencies to provide technical and financial assistance to enable them to meet their commitments under the treaty. UNEP is one of the Fund's implementing agencies; the others are UNDP, UNIDO and the World Bank.

Since 1991, the UNEP TIE OzonAction Programme in Paris has been strengthening the capacity of governments (especially National Ozone Units) and industry in developing countries to make informed decisions on technology and policy options that will result in cost-effective ODS phase-out activities with minimal external intervention. The Programme accomplishes this by delivering a range of need-based services, including:

### Information Exchange

to enable decision makers to take informed decisions on policies and investments. Information and management tools already provided for developing countries include the OzonAction Information Clearinghouse (OAIC) diskette and World Wide Web site, a quarterly newsletter, sector-specific technical publications for identifying and selecting alternative technologies, and policy guidelines.

### Training and Networking

that provide platforms for exchanging experiences, developing skills, and tapping the expertise of peers and other experts in the global ozone-protection community. Training and network workshops build skills for implementing and managing phase-out activities, and are conducted at the regional level (support is also extended to national activities). The Programme currently operates eight regional and sub-regional Networks of ODS Officers involving 95 countries, which have resulted in member countries taking early steps to implement the Montreal Protocol.

### Country Programmes and Institutional Strengthening

that support the development of national ODS phase-out strategies and programmes, especially for low-volume ODS-consuming countries. The Programme currently assists 79 countries in the development of their Country Programmes and implements Institutional-Strengthening projects for 67 countries.

For more information about these services please contact:

UNEP Division of Technology, Industry and Economics  
OzonAction Programme  
39-43 quai André Citroën  
75739 Paris Cedex 15  
France  
phone: +33 1 44 37 14 50, fax: +33 1 44 37 14 74  
email: ozonaction@unep.fr  
<http://www.uneptie.org/ozonaction.html>

## About the UNEP Division of Technology, Industry and Economics

The mission of the UNEP Division of Technology, Industry and Economics is to help decision makers in government, local authorities, and industry develop and adopt policies and practices that:

- are cleaner and safer;
- make efficient use of natural resources;
- ensure adequate management of chemicals;
- incorporate environmental costs; and
- reduce pollution and risks for humans and the environment.

The UNEP Division of Technology, Industry and Economics (UNEP TIE) located in Paris, is composed of one centre and four units:

**The International Environmental Technology Centre (Osaka)**, which promotes the adoption and use of environmentally sound technologies with a focus on the environmental management of cities and freshwater basins in developing countries and countries with economies in transition.

**Production and Consumption (Paris)**, which fosters the development of cleaner and safer production and consumption patterns that lead to increased efficiency in the use of natural resources and reductions in pollution.

**Chemicals (Geneva)**, which promotes sustainable development by catalysing global actions and building national capacities for the sound management of chemicals and the improvement of chemical safety worldwide, with a priority on Persistent Organic Pollutants (POPs) and the Prior Informed Consent procedure (PIC, run jointly with the Food and Agriculture Organization of the United Nations).

**Energy and OzonAction (Paris)**, which supports the phase-out of ozone depleting substances in developing countries and countries with economies in transition, and promotes good management practices and use of energy, with a focus on atmospheric impacts. The UNEP/RISØ Collaborating Centre on Energy and Environment supports the work of the Unit.

**Economics and Trade (Geneva)**, which promotes the use and application of assessment and incentive tools for environmental policy and helps improve the understanding of linkages between trade and environment and the role of financial institutions in promoting sustainable development.

UNEP TIE activities focus on raising awareness, improving the transfer of information, building capacity, fostering technology cooperation, partnerships and transfer, improving understanding of the environmental impact of trade issues, promoting the integration of environmental considerations into economic policies, and catalysing global chemical safety.

For more information contact:  
UNEP Division of Technology, Industry and Economics  
39-43, quai André Citroën  
75739 Paris Cedex 15, France  
phone: +33 1 44 37 14 50, fax: +33 1 44 37 14 74  
e-mail: [unepie@unep.fr](mailto:unepie@unep.fr)  
<http://www.unepie.org>

# Annex 4: Glossary and acronyms

## Absorption

A process by which a material (the absorbent) extracts one or more substances (absorbates) from a liquid or gaseous medium with which it is in contact and changes it chemically, physically, or both. The process is accompanied by a change in entropy which makes it a useful mechanism for a refrigeration cycle. Water-lithium bromine and ammonia-water chillers are examples of absorption chillers.

## Aerosol

A suspension of very fine solid or liquid particles in a gas. Aerosol is also used as a common name for a spray (or 'aerosol') can: a container filled with a product and a propellant, and pressurized so as to release the product in a fine spray.

## Aqueous cleaning

Cleaning parts with water to which may be added suitable detergents, saponifiers, or other additives.

## Article 5 Country

A developing country which is a Party to the Montreal Protocol and has, on the date of the entry into force of the Montreal Protocol or at any time thereafter, an annual calculated level of consumption less than 0.3 kg per capita of the controlled substances listed in Annex A, and less than 0.2 kg per capita of the controlled substances listed in Annex B. Such countries are permitted a ten-year grace period in respect of the phase-out schedule laid down by the Montreal Protocol for developed countries.

## Atmospheric lifetime

A measure of the average time that a chemical remains intact once released into the atmosphere.

## Azeotrope

A blend consisting of one or more refrigerants of different volatilities that does not appreciably change in composition or temperature as it evaporates (boils) or condenses (liquefies) under constant pressure (compare zeotrope). Refrigerant blends assigned an R-500 series number by ANSI/ASHRAE 34 are azeotropes.

## Blends/mixtures

A blend is a mixture of two or more pure fluids (a ternary blend contains three such fluids). Given the right composition, blends can achieve properties to fit almost any refrigeration purpose. For example, a mixture of flammable and non-flammable components can result in a non-flammable blend. Blends can be divided into three categories: azeotropic, non-azeotropic, and near-azeotropic blends.

## Carbon dioxide (CO<sub>2</sub>)

A gaseous compound (CO<sub>2</sub>) formed by, for example, the combustion of carbon. Carbon dioxide contributes to the greenhouse effect.

## Carbon tetrachloride

A chlorocarbon solvent (CCl<sub>4</sub>) with an ODP of approximately 1.1 that is controlled under the Montreal Protocol. It is considered toxic and a probable human carcinogen as classified by the International Agency for Research on Cancer. Its use is strictly regulated in most countries and it is employed primarily as a feedstock material for the production of other chemicals.

## CFCs

See Chlorofluorocarbons.

## Chlorofluorocarbons (CFCs)

A family of organic chemicals composed of chlorine, fluorine, and carbon atoms, usually characterized by high stability contributing to a high ODP. These fully halogenated substances are commonly used in refrigeration, foam blowing, aerosols, sterilants, solvent cleaning, and a variety of other applications. CFCs have the potential to destroy ozone in the stratosphere.

## CO<sub>2</sub>

See Carbon dioxide.

## Controlled substance

Under the Montreal Protocol, any ozone-depleting chemical that is subject to control measures, such as a phase-out requirement.

## Country Programme (CP)

A national strategy prepared by an Article 5 country to implement the Montreal Protocol and phase out ODS. The Country Programme establishes a baseline survey on the use of the controlled substances in the country and draws up a policy, strategies for its implementation, and a phase-out plan for ODS replacement and control. It also identifies investment and non-investment projects for funding under the Multilateral Fund.

## CP

See Country Programme.

## Dimethyl ether (DME)

A flammable aerosol propellant (CH<sub>3</sub>OCH<sub>3</sub>) used in some European, Japanese, and US aerosol formulations, for air-freshener sprays, hair sprays, and insecticides.

## DME

See Dimethyl ether.

## DoD

US Department of Defence

## Drop-in replacement

The procedure when replacing CFC refrigerants with non-CFC refrigerants in existing refrigeration, air-conditioning and heat pump plants without any plant modifications. However, drop-in replacement is normally referred to as retrofitting because minor modifications, such as a change of lubricant and/or the replacement of the expansion device and desiccant material, are needed.

## Environmental management programme

The actions, steps, resources, schedules, and responsibilities required to achieve environmental objectives.

## Environmental policy

A statement issued by a company setting out its principles and intentions in relation to its overall environmental performance. It establishes a framework for action and for setting environmental objectives and targets.

## Ethylene oxide (EtO)

A substance used extensively by health care providers, such as hospitals and clinics, and by industrial users (device manufacturers, contract sterilization services, and so on) to sterilize products that are heat-sensitive and/or moisture-sensitive.

## EtO

See Ethylene oxide.

## Global warming

The warming of the earth due to the heat-trapping action of natural and man-made greenhouse gases. Greenhouse gases emitted by human activities, including CFCs and HCFCs, are believed to warm the Earth's atmosphere, leading to climate change.

## Global warming potential (GWP)

The relative contribution of certain substances (or greenhouse gases) such as carbon dioxide, methane, CFCs, HCFCs, and halons, to global warming when released into the atmosphere by the combustion of oil, gas, and coal (CO<sub>2</sub>), by direct emission, leakages from refrigeration plants, and so on. The standard measure of GWP is one which is consistent with the approach to indexing promoted by the Intergovernmental Panel on Climate Change (IPCC) and is expressed in terms of a comparison with carbon dioxide, which has a GWP of 1.0. GWP can be expressed in relation to a time horizon for integration of 20, 100, or 500 years. There is no agreement within the scientific community on which of these is the proper time horizon, but 100 years is the period most commonly used.

**GPS**

Global positioning system.

**Greenhouse effect**

A thermodynamic effect whereby energy absorbed at the Earth's surface, which is normally able to radiate back out to space in the form of long-wave infra-red radiation, is retained by gases in the atmosphere, thereby causing a rise in temperature. The gases in question are partially natural, but man-made pollution is thought to be contributing increasingly to the effect. The same CFCs that cause ozone depletion are known to be greenhouse gases, with a single CFC molecule having the same estimated effect as 10 000 carbon dioxide molecules. See also Global warming and Global warming potential.

**Greenhouse gas**

A gas, such as water vapour, carbon dioxide, methane, a CFC or an HCFC, that absorbs and re-emits infra-red radiation, warming the Earth's surface and contributing to climate change.

**GWP**

See Global warming potential.

**Halocarbons**

Compounds derived from methane (CH<sub>4</sub>) and ethane (C<sub>2</sub>H<sub>6</sub>), in which one or several of the hydrogen atoms are substituted with chlorine (Cl), fluorine (F), and/or bromine (Br). Such compounds are so called 'partly halogenated halocarbons'. When all the hydrogen atoms are substituted the compound is said to be fully halogenated. The ability of halocarbons to deplete ozone in the stratosphere varies with their chlorine and/or bromine content and their chemical stability. Fully halogenated halocarbons have a much higher chemical stability (a typical atmospheric lifetime of 100–500 years) than partly halogenated halocarbons (which have a typical atmospheric lifetime of 1–20 years). CFCs, HCFCs, and HFCs are examples of halocarbons.

**Halon**

A bromochlorofluorocarbon (BCFC) consisting of one or more carbon atoms surrounded by fluorine, chlorine, and bromine. Halons are commonly used as flame retardants and fire-extinguishing agents. Halons have high ODPs.

**HAP**

See Hydrocarbon aerosol propellant.

**HBFCs**

See Hydrobromofluorocarbons.

**HCs**

See Hydrocarbons.

**HCFCs**

See Hydrochlorofluorocarbons.

**HFCs**

See Hydrofluorocarbons.

**Hydrobromofluorocarbons (HBFCs)**

A family of hydrogenated chemicals related to halons and consisting of one or more carbon atoms surrounded by fluorine, bromine, at least one hydrogen atom, and sometimes chlorine. HBFCs have lower ODPs than halons.

**Hydrocarbons (HCs)**

Chemical compounds consisting of one or more carbon atoms surrounded only by hydrogen atoms. Examples of hydrocarbons are propane (C<sub>3</sub>H<sub>8</sub>, HC-290), propylene (C<sub>3</sub>H<sub>6</sub>, HC-1270) and butane (C<sub>4</sub>H<sub>10</sub>, HC-600). HCs are commonly used as substitutes for CFCs in aerosol propellants and refrigerant blends. They have an ODP of zero. Hydrocarbons are volatile organic compounds, and their use may be restricted or prohibited in some areas. Although they are used as refrigerants, their highly flammable properties normally restrict their use as low-concentration components in refrigerant blends.

**Hydrocarbon aerosol propellant (HAP)**

A flammable but non-ozone-depleting aerosol propellant widely used throughout the world.

**Hydrochlorofluorocarbons (HCFCs)**

A family of chemicals related to CFCs and containing hydrogen, chlorine, fluorine, and carbon atoms. HCFCs are partly halogenated and have much lower ODPs than do CFCs. Examples of HCFC refrigerants are HCFC-22 (CHClF<sub>2</sub>) and HCFC-123 (CHCl<sub>2</sub>CF<sub>3</sub>).

**Hydrofluorocarbons (HFCs)**

A family of chemicals related to CFCs and consisting of one or more carbon atoms surrounded by fluorine and hydrogen atoms. Since no chlorine or bromine is present, HFCs do not deplete the ozone layer. HFCs are widely used as refrigerants. Examples of HFC refrigerants are HFC-134a (CF<sub>3</sub>CH<sub>2</sub>F) and HFC-152a (CHF<sub>2</sub>CH<sub>3</sub>).

**Hydrofluoroether**

A chemical composed of hydrogen, fluorine and ether, closely resembling the performance characteristics of an ODS.

**ICEL**

International Cooperative for Environmental Leadership.

**ICOLP**

International Cooperative for Ozone Layer Protection (now called ICEL).

**Implementing Agency**

Under the Montreal Protocol, four international organizations are designated to implement the Multilateral Fund: UNDP, UNEP, UNIDO, and the World Bank.

**Low volume ODS-consuming countries (LVC countries)**

Defined by the Multilateral Fund's Executive Committee as Article 5 countries whose annual ODS consumption is calculated as being less than 360 ODP tonnes.

**LOX**

Liquid oxygen.

**LVC**

See Low volume ODS-consuming countries (LVC countries).

**MCF**

Abbreviation for methyl chloroform. See 1,1,1-trichloroethane.

**MeCl**

See Methylene chloride.

**MEK**

See Methyl ethyl ketone.

**Methyl bromide**

A colourless, odourless, highly toxic gas composed of carbon, hydrogen, and bromine, and used as a broad-spectrum fumigant in commodity, structural, and soil fumigation. Methyl bromide has an ODP of approximately 0.6.

**Methyl chloroform (MCF)**

See 1,1,1-trichloroethane.

**Methylene chloride (MeCl)**

A non-ozone-depleting chlorinated chemical (CH<sub>2</sub>Cl<sub>2</sub>) commonly used in a variety of metal, electronic, and precision cleaning applications, and as an alternative blowing agent.

**Methyl ethyl ketone (MEK)**

An organic solvent which is a potential substitute for carbon tetrachloride in a variety of hand-wipe and aerosol cleaning applications.

**Montreal Protocol**

An international agreement limiting the production and consumption of chemicals that deplete the stratospheric ozone layer, including CFCs, halons, HCFCs, HBFCs, and methyl bromide. Signed in 1987, the Protocol commits Parties to take measures to protect the ozone layer by freezing, reducing, or ending production and consumption of controlled substances. This agreement is a protocol to the Vienna Convention.

**Multilateral Fund**

Part of the Financial Mechanism under the Montreal Protocol. The Multilateral Fund for Implementation of the Montreal Protocol was established by the Parties to provide financial and technical assistance to Article 5 countries.

**National Ozone Unit (NOU)**

The government unit in an Article 5 country responsible for managing the national ODS phase-out strategy as specified in the Country Programme. NOUs are responsible for, among other things, fulfilling data-reporting obligations under the Montreal Protocol.

**NATO**

North Atlantic Treaty Organization.

**Natural refrigerants**

Naturally existing substances already circulating in the biosphere which can be used as refrigerants. Examples of natural refrigerants are ammonia (NH<sub>3</sub>), hydrocarbons (such as propane), carbon dioxide (CO<sub>2</sub>), air, and water.

**NOC**

Navy oxygen cleaner.

**NOU**

See National ozone unit.

**ODP**

See Ozone depletion potential.

**ODS**

See Ozone depleting substance.

**ODS Officer**

A member of a National Ozone Unit.

**Ozone**

A reactive gas consisting of three oxygen atoms, formed naturally in the atmosphere by the association of molecular oxygen (O<sub>2</sub>) and atomic oxygen (O). It has the property of blocking the passage of dangerous wavelengths of ultraviolet radiation in the upper atmosphere. Whereas it is a desirable gas in the stratosphere, it is toxic to living organisms in the troposphere.

**OzonAction programme**

UNEP TIE's OzonAction programme provides assistance to developing country Parties under the Montreal Protocol through information exchange, training, networking, country programmes, and institutional-strengthening projects.

**Ozone depleting substance (ODS)**

Any substance with an ODP greater than zero that can deplete the stratospheric ozone layer. Most ODS are controlled under the Montreal Protocol and its Amendments, and include CFCs, HCFCs, halons, and methyl bromide.

**Ozone depletion**

The accelerated chemical destruction of the stratospheric ozone layer by the presence of substances produced, for the most part, by human activities. The substances that deplete the ozone layer most acutely are the chlorine-free and bromine-free radicals generated from relatively stable chlorinated, fluorinated, and brominated products by ultraviolet radiation.

**Ozone depletion potential (ODP)**

A relative index indicating the extent to which a chemical product may cause ozone depletion. The reference level of 1 is fixed at the potential of CFC-11 and CFC-12 to cause ozone depletion. If a product has an ODP of 0.5, a given weight of the product in the atmosphere would, in time, deplete half the ozone that would be depleted by the same weight of CFC-11. ODP is calculated using mathematical models that take into account factors such as the stability of the product, the rate of diffusion, the quantity of depleting atoms per molecule, and the effect of ultraviolet light and other radiation on the molecules. The substances implicated generally contain chlorine or bromine.

**Ozone layer**

An area of the stratosphere, approximately 15 to 60 kilometers (9 to 38 miles) above the earth, where ozone is found as a trace gas (at higher concentrations than other parts of the atmosphere). This relatively high concentration of ozone filters out most ultraviolet radiation, preventing it from reaching the earth.

**Ozone Secretariat**

The Secretariat to the Montreal Protocol and the Vienna Convention, staffed by UNEP and based in Nairobi, Kenya.

**Party**

A country that signs and/or ratifies an international legal instrument (e.g. a protocol or an amendment to a protocol), indicating that it agrees to be bound by its rules. Parties to the Montreal Protocol are countries that have signed and ratified the Protocol.

**PERC**

See Perchloroethylene.

**Perchloroethylene (PERC)**

A non-ozone-depleting chlorinated solvent commonly used in a variety of metal, electronic, and precision cleaning applications. There are potential health problems associated with its use, which makes it important to enact strict health and safety measures to prohibit excessive exposure to the chemical.

**Perfluorocarbons (PFCs)**

A group of synthetically produced compounds in which the hydrogen atoms of a hydrocarbon are replaced with fluorine atoms. The compounds are characterized by extreme stability, non-flammability, low toxicity, zero ODP, and high GWP.

**PFCs**

See Perfluorocarbons.

**Phase-out**

The ending of all production and consumption of a chemical controlled under the Montreal Protocol.

**Phase-out plan**

Part of the Country Programme based on the strategy declared by the government and defining the phase-out calendar for each controlled substance as well as the government actions to be taken for achieving phase-out. It contains a prioritized list of projects to be undertaken and takes into account the specific industrial, political, and legislative situation of the country concerned.

**R&D**

Research and development.

**Reclamation**

Reprocessing and upgrading of a recovered controlled substance through such mechanisms as filtering, drying, distillation, and chemical treatment in order to restore that substance to a specified performance standard. Chemical analysis, often involving processing off site at a central facility, is required to determine that appropriate product specifications are met.

**Recovery**

The collection and storage of controlled substances from machinery, equipment, containment vessels, and so on, during servicing or prior to disposal without necessarily testing or processing it in any way.

**Recycling**

Re-use of a recovered controlled substance following a basic cleaning process such as filtering and drying. For refrigerants, recycling normally involves reinstallation, and often occurs on site.

**Refrigerant**

A heat-transfer agent, usually a liquid, used in equipment such as refrigerators, freezers, and air-conditioners.

**Refrigerant management plan (RMP)**

A country-level plan involving the study and evaluation of all the alternative technical and policy options and the design and implementation of an integrated global strategy for the cost-effective phase-out of ODS refrigerants. Projects previously implemented in isolation from one another thus become part of an overall approach designed and structured to obtain the best possible results. The RMP concept may also be used as a management tool at company level.

**Retrofit**

The upgrading or adjustment of equipment so that it can be used under altered conditions; e.g. of refrigeration equipment to use a non-ODP refrigerant in place of a CFC.

**RMP**

See Refrigerant management plan.

**Semi-aqueous cleaning**

Cleaning with a non-water-based cleaner, followed by a water rinse.

**Servicing**

In the refrigeration sector, all kinds of work undertaken by a service technician, from the installation, operation, inspection, repair, retrofitting, redesign, and decommissioning of refrigeration systems to the handling, storage, recovery, and recycling of refrigerants as well as record keeping.

**Solvent**

Any product (aqueous or organic) designed to clean a component or assembly by dissolving the contaminants present on its surface.

**Stratosphere**

That part of the Earth's atmosphere above the troposphere, at a height of about 15 to 60 kilometers (9 to 38 miles). The stratosphere contains the ozone layer.

**TCA**

See 1,1,1-trichloroethane.

**TEAP**

Technology and Economic Assessment Panel.

**Transitional substances**

Under the Montreal Protocol, a chemical, such as an HCFC, whose use is permitted as an ODS replacement short-term but which, because of its own ODP or toxicity, will have to be replaced in the longer term.

**1,1,1-Trichloroethane (TCA)**

A hydrochlorocarbon commonly used as a blowing agent and as a solvent in a variety of metal, electronic, and precision cleaning applications. Also known as methyl chloroform, it has an ODP of approximately 0.11.

**Ultraviolet radiation (UV)**

Radiation from the Sun with wavelengths between visible light and X-rays. UV-B (280–320 nm) is one of three bands of UV radiation, is harmful to life on the Earth's surface, and is mostly absorbed by the ozone layer.

**UNDP**

See United Nations Development Programme.

**United Nations Development Programme (UNDP)**

One of the Multilateral Fund implementing agencies.

**UNEP**

See United Nations Environment Programme.

**UNEP TIE**

United Nations Environment Programme, Division of Technology, Industry and Economics (Paris, France).

**United Nations Environment Programme (UNEP)**

One of the Multilateral Fund implementing agencies through its UNEP TIE OzonAction Programme.

**UNIDO**

See United Nations Industrial Development Organization.

**United Nations Industrial Development Organization (UNIDO)**

One of the Multilateral Fund implementing agencies.

**USEPA**

United States Environmental Protection Agency.

**UV**

See Ultraviolet radiation.

**Vienna Convention**

The 1985 international agreement setting a framework for global action to protect the stratospheric ozone layer. The convention is implemented through its Montreal Protocol.

**VOCs**

See Volatile organic compounds.

**Volatile organic compounds (VOCs)**

Compounds that will evaporate at their temperature of use and which, by a photochemical reaction, will cause atmospheric oxygen to be converted into potentially smog-promoting tropospheric ozone under favourable climatic conditions.

**World Bank**

Formally known as the International Bank for Reconstruction and Development and one of the Multilateral Fund implementing agencies.

**Zeotrope**

A blend consisting of several refrigerants of different volatilities that appreciably changes in composition or temperature as it evaporates (boils) or condenses (liquefies) at a given pressure (compare azeotrope). A refrigerant blend assigned a R-400 series number in ANSI/ASHRAE 34 is a zeotrope.





# **MAINTAINING MILITARY READINESS BY MANAGING OZONE DEPLETING SUBSTANCES**

## Guidelines for armed forces in developing countries

Most military systems – weapons systems, support systems, and facilities – rely on ozone depleting substances (ODS) such as CFCs and halons and cannot function effectively without them. Accordingly, the use of these chemicals is directly linked to military readiness and national security.

Because ODS are being phased out worldwide under the Montreal Protocol, armed forces should accord a high priority to ensuring that their ODS use is properly managed and that the transition to alternatives is a smooth process.

This guide has been developed to help armed forces in Article 5 countries meet this challenge. It explains step by step how to establish and implement an ODS management programme in line with national obligations under the Montreal Protocol. Based on the lessons learned by developed countries' armed forces, the guide is written for personnel involved in environmental compliance/protection issues, as well as chiefs and managers.

The guide has been developed as part of UNEP's Work Programme under the Multilateral Fund for the Implementation of the Montreal Protocol.

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