HALON ISSUES IN DEVELOPING COUNTRIES

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INTRODUCTION

In January **1991,** the Interium Multilateral Ozone Fund was created by the Parties to the Montreal Protocol on Substances that Deplete the Ozone Layer (1987), for the purpose of providing financial and technical assistance for eligible developing countries to meet the requirements of the Protocol. In particular, the Fund was established to phaseout the consumption of controlled ozone-depleting substances. The United Nations Environment Program (UNEP), the United Nations Development Program (UNDP), and the World Bank were chosen to be the Funds implementing agencies, with UNEP being assigned the responsibility of conducting research, gathering data, and providing a clearinghouse function.

Through this endeavor, the OzonAction work program has been established under the Fund to disseminate information throughout the world. The program includes training workshops, the OzonAction Newsletter dedicated to ozone protection, and the implementation of the Montreal Protocol and the OzonAction Information Clearinghouse (OAIC). The OAIC is a free on-line data system containing information on a wide range of technical and programmatic issues relating to the phaseout of controlled substances. The following contacts are available for additional assistance:

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The following paper discusses the special needs of the developing countries with respect to halons and what some to the possible options might be as they are phased out. The approach for eliminating halon use in developing countries will be to remove the agent and applicable extinguishing hardware and replace it with redesigned and engineered fire protection systems, including new agents, early detection and other warning systems, and trained personnel. The cost effective approaches will be to begin elimination now, and not to install new halon systems.

SPECIAL NEEDS OF DEVELOPING COUNTRIES

Table 1 is a list of the developing countries of the world operating under Article 5 Paragraph 1 of the Montreal Protocol as of September 1991.

TABLE 1. LIST OF DEVELOPING COUNTRIES.[a]

Country	Country	Country
Argentina	Bangladesh	Brazil
Burkina Faso	Cameroon	Chile
costa Rica	Ecuador	Egypt
Fiji	Gambia	Ghana
Guatemala	Iran (Islamic Republic of)	Jordan
Kenya	Libyan Arab Jamahiriya	Malawi
Malysia	Maldives	Mexico
Nigeria	Panama	Phillipines
Sri Lanka	Syrian Arab Republic	Thailand
Togo	Trinidad and Tobago	Tunisia
Turkey	Uganda	Uruguay
Venezuela	Yugoslavia	Zambia

[a]Listed under Article 5 Paragraph 1 of the Montreal Protocol.

While industrialized counmes have been the major consumer of halons in the past, developing counmes trying to improve their standard of living are increasingly using these chemicals to protect valuable resources. Halon uses in developing countries generally parallel those of the developed world. These uses include: portable extinguishers for fixed facilities, marine applications, transportation, some electronics protection (usually in assembly operations), oil production and handling facilities (Middle East), military, and training and testing.

The special needs of developing countries are several fold when it comes to halons. Generally, the water supply infrastructure is not available or it is inadequate to meet fire protection requirements (Reference 1). Therefore, the self contained feature of a halon system becomes very important for tire protection. The halon quantities which exist in developing counmes is generally inadequate to provide a future halon bank upon which to draw. Fire protection personnel in the developing countries have inadequate funding to keep track of halon developments. Funding is required for technology transfer. Assistance is needed in the developing world to upgrade existing fire protection systems and install new alternative systems. It is a financial disadvantage for developing countries to continue to install halon systems when alternative protection strategies would suffice. The halon community in the developed world could support the developing counmes by providing halon recovery and recycling technology and information on halon substitutes.

THE FUND

The Parties to the Montreal Protocol established the Interim Multilateral Ozone Fund to assist qualified signatory developing countries to meet their incremental costs so as to enable their compliance with the phaseout provisions of the Protocol. The costs of substitute technologies will be high and the objective of the Fund is to help compensate developing counties for the technical and financial costs **of** switching to substitute CFCs and halons and the resulting costs of abandonment of existing plant and equipment (Reference 2).

The Fund **was** established under Article 10 of the Montreal Protocol, at the London Meeting in June, 1990. A 14 member Executive Committee, equally split between developed and developing member counmes, supervises, administers, and operates the Fund. A Fund Secretariat, led by a Chief Officer, assists and supports the Executive Committee in its work. The agencies implementating the fund **are** the United Nations Development Programme (UNDP), the United Nations Environment Program (UNEP), and the World Bank. The Executive Committee and the Secretariat operate out of Montreal, Canada.

The role of UNEP is to act as the treasurer of the Fund. UNEP is responsible for research, data gathering, and clearinghouse functions. UNEP studies and identifies the needs of developing countries and facilitates ways to respond to these needs. UNEP also collects, analyses, and distributes information, and holds workshops and training sessions. The UNDP is tasked with assisting in feasibility and pre-investment studies through its resident representatives in 112 field offices. The main responsibility of the World Bank is to help with the implementation of investment projects (Reference **3).**

Parties at the London Meeting established the Fund as $240 million for 3 years. Thirty four countries have pledged to provide funding, either through real dollars or in the form of experts or training, technology transfer, and/or provisions of substitutes for CFCs or halons.

In order to obtain assistance under the Fund, the country must first be listed under Article 5 Paragraph 1 of the Protocol, these are countries which have signed and will ratify the Protocol. Next, the ozone depletion potential (ODP) weighted consumption Of Annex A controlled substances (i.e., CFCs and halons) must be less than 0.3 kg/capita (0.67 lbs/capita). If these provisions are met, then consultation and agreement between the bank and appropriate government officials on the necessary assistance is established. A follow up is then established in which a questionnaire is completed on the ozone depleting substances (ODSs) consumed in the country, applicable institutions within the country are defined, and a phaseout schedule is outlined.

Typical projects include ODS assessments and country programs. The ODS assessment consists of classifying ODS supply and demand. This entails quantifying imports and exports with specific use sectors identified Technology requirements are identified. Specific project proposals are also identified, such as recovery/recycle needs, substitute technologies, substitute chemicals, and methods to improve local resources. Typically, ODS assessment results indicate: (1) comprehensive national studies should be undertaken by each developing country to evaluate the impact of an ODS phaseout on socioeconomic and financial conditions, (2) short and long term strategies and action plans should be developed, and (3) phaseouts should begin as soon as possible, through information technology exchange, implementation of demonstration projects, and improving and strengthening institutional capacity within the developing country (Reference 3).

The second typical project which has been funded includes the country programs. The country program is used to develop phaseout methodologies, identify country frameworks including institutional and policy, identify technical options, identify optional strategies, perform cost analysis, and recommend phaseout strategies, new policies, and projects. The country program is used to develop an ODS action plan for the developing country. Results from various country programs indicate that a prompt and orderly phaseout of ODSs will minimize the economic impact. The incremental capital costs are small when compared to the incremental operational costs and early replacement costs. The key for developing countries will be to minimize the early replacement costs, and thus, minimize the total economic costs of phaseout. As with the developed countries, recovery and recycling practices offer the most direct cost savings. Table 2 shows proposed activities which have been or are proposed for funding related to halon use in developing countries.

TABLE 2. ACTIVITIES FUNDED OR PROPOSED FOR FUNDING RELATED TO HALONS IN DEVELOPING COUNTRIES.[a]

Proposed Activity	Countries
ODS Assessments	Argentina, Bangladesh, Costa Rica, Iran, Jordan Uruguay
Training of government and others	Bangladesh, Egypt, Thailand, Bangladesh, Jordan, Kenya, Nigeria, Philippines, Sri Lanka, Turkey
In-country training seminars	Nigeria, Venezuela
General technical assistance	Mexico, Trinidad, Tobago
Prefeasibility Studies	Egypt
Detailed country programs	Asia: Bangladesh, China, Philipines, Sir Lanka, Thailand, Africa: Ghana, Kenya, Nigeria; Middle East: Egypt, Jordan, Turkey; Latin America/Caribbean: Argentina, Brazil, Chile, Costa Rica, Ecuador, Mexico, Trinidad, Tobago, Uruguay, Venezuela
Workshops on recycling of halons	Chile, Costa Rica, Kenya, Mexico (includes inventory), Turkey
Preparatory studies on halon controls	China, Venezuela
Training/demonstration programs to reduce and substitute halon use in non-essential applications	Mexico, Venezuela
Setup/support ozone offices or technical information centers	Brazil, China, Ghana, Thailand
Public awareness/education programs	Argentina, Bangladesh, Brazil, Chile, Nigeria, Philippines, Sri Lanka, Thailand, Turkey, Venezuela

[a]Reference 2.

WORKSHOPS FOR DEVELOPING COUNTRIES

Two training/networking workshops for developing countries have been held. The first was in Jomtien, Thailand (November 1991) and the second was in Heliopolis/Cairo, Egypt (December 1991). The workshops were attended by regional participants at senior levels, from governments, industry associations, academia, as well as non-governmental organizations. Countries that are parties to the Montreal Protocol as well as non-Party countries were represented. Resource persons from countries around the world participated as speakers and technical experts at these workshops.

Participants emphasized the need for increased information exchange and wide information dissemination to developing countries. The decision makers in both government and industry need infomation with respect to policies, strategies, and activities to be undertaken for phasing out ODSs; increased training and new technology for substitutes and their use; establishment of permanent regional/sub-regional networks to share information and experiences, as well as, to monitor and encourage progress; and increased research on environmental and economic impacts of ozone layer depletion and a greater involvement of developing countries in such research.

Generally, representatives from the Montreal Protocol Technical Assessment Committees made presentations on the available/alternative technologies in the various industrial use sectors. Costs and appropriate actions which developing countries should be taking were presented.

Results of the workshops were positive. Changes are possible in many use sectors especially when supported by country programs. Recovery/recycling and management of the bank of existing chemicals will substantially reduce the need for importing ODSs. Developing countries are willing to adopt new technologies provided "some" funding is made available.

Interestingly, in the aerosol, solvent, refrigeration, and foams use sectors substitute technologies are in place or emerging rapidly. However, information and technology needs to be disseminated to developing countries through cooperative projects and information networks (Reference 4). For halons there are no definite solutions like there are for the other use sectors. Many replacement chemicals are under development and investigations are still in process. The key to reducing halon uses in developing countries is minimization and use of halons only where they are really needed. Recovery/recycling and bank management are key. Information dissemination to key representatives in the developing countries on available substitute technologies is critical.

Three terms need to be defined at this point: (1) a halon "replacement" agent is a halon-like, gaseous or volatile, clean fire extinguishant, explosion suppression agent, and/or inertion agent; (2) a halon "alternative" agent is defined as a not-in-kind, non-halon-like agent (e.g., carbon dioxide, water, foam, and powders); and (3) a halon "substitute" encompasses both halon replacement and alternative technologies (Reference 1). This section will discuss the status of the halon substitutes available to developing counmes at this time.

Halon Replacements --- All of the halon replacements announced thus far have significant tradeoffs in one or more of the following: environmental acceptability (ODP, GWP, atmospheric lifetime), toxicity, and/or effectiveness. There is every indication that the lower ODP compounds (HCFCs, HFC, and perfluorocarbons) may be suitable for use in small portable fire extinguishers; however, their suitability in other applications remains to be demonstrated. The announced replacements are: HCFC-123 also known as FE-232 by one company and blends thereof, HCFC-124 also known as FE-241, HFC-125 also known as FE-25, HFC-23 also known as FE-13, HBFC-22B1 also known as FM-100, HFC-227ea also known as FM-200, HBFC-124B1, perfluorocarbons also known as PFC products, CFC blends, and proprietary HCFC blends (North American Fire Guardian (NAF) and Halotron) (Reference 6). The ODPs of these compounds range from 0.0 to 1.4 times higher than CFC-11, compared to 3 to 16 times for halons. Their atmospheric lifetimes range from 2 to over 500 years, compared to 12 to 100 years or so for halons.

In reference to "essential use," these compounds should, nevertheless, be considered as transitional agents. The properties of these halon replacements are such that they could be used to replace halons in some existing "essential" applications. Minor system modifications, such as increasing the number of storage containers, different nozzles, seals, and other miscellaneous component changes would have to be made.

In conclusion, all announced candidates have significant tradeoffs. However, additional time is required to develop advanced halon replacements. Halon minimization, conservation, and alternatives approaches to fire protection should be used. The key for all counmes is to restrict the installation of new halon systems through the implementation of alternative technologies where possible. The halon alternatives available to developing countries are discussed in the following section.

Halon Alternatives --- For both portable extinguishers and fixed systems, the greatest scope for elimination of halon use arises from the use of alternative extinguishing agents. In practice, the suitability of any agent will depend on the application. Reference 5 suggests that, at present, two-thirds of fixed halon systems users could eliminate some if not all of their demand by the use of alternative agents. The available halon alternatives include water, foams, dry chemical, and inert gases. The inert gases are carbon dioxide, nitrogen, argon, helium, and most recently being investigated INERGEN (Reference 7).

Water is a very effective extinguishing agent because of its unusually high specific heat and heat of vaporization. Testing has shown that fine water sprays (misting systems) can be very effective fire extinguishants and have the additional benefit of cooling to prevent reignition. The quantity of water required is, in some installations, less than the equivalent amount of halon needed for the same fire scenario. Automatic sprinkler systems were first developed in the last century and are well-proven, highly reliable form of fire protection. This is particularly true in general industrial and commercial premises, in which none of the disadvantages listed below are of major practical significance. Automatic sprinklers may be used for protection of many of the hazards for which halon is traditionally used. As an extinguishing agent, water has a number of disadvantages compared with halons: (1) secondary damage, (2) clean-up problems, (3) conducts electricity, making it unsuitable for discharge onto live elecmcal equipment, (4) does not penetrate into enclosures as well as gaseous agents, (5) discharge normally takes longer than a gaseous agent, (6) unsuitable for Class B fires involving flammable liquid hazards (this may be overcome by misting systems), and (7) not suitable in extreme temperature environments. Systems that use small quantities of water, projected as a "mist" of fine droplets are under development. Possible applications include the extinguishment of Class B fires, explosion suppression, and in-cabinet protection for electronic equipment. Another application for such systems may be in aircraft cabins (Reference 8).

Foam is a suitable alternative to a number of halon systems, particularly those involving flammable liquids. Foams extinguish flames by establishing a barrier between the fuel and air. Drainage of water from the foam also provides a cooling effect, which is particularly important for fires where glowing embers are a problem. Foam systems are usually found in four basic configurations: (1) fixed systems (like total-flood halon systems), (2) semi-fixed systems (fixed hose reels), (3) mobile systems (vehicle mounted), and (4) portable extinguishers. Foams are found in three types low-, medium-, and high-expansion. Example foam applications include areas between floors, in which a small number of high expansion foam systems have recently been used in preference to halon and engine rooms on ships (Reference 5). Disadvantages of foam systems include: (1) greater weight and space requirements, (2) the need for a suitable water supply, (3) relatively long extinguishing time, and (4) cleanup problems. Also, the use of high expansion foams can be dangerous in large enclosures where people might be present, due to visibility concerns. Toxicity and asphyxiation are not considered to be problem with high expansion foam total flood systems. Additional disadvantages of foams are similar to water.

Certain finely ground powders can be used as extinguishing agents. The extinguishing mechanism is complex and not fully understood Powders generally provide very rapid flame knockdown and are considered to be more effective than halons. The main disadvantages of powder include: (1) poor penetration behind obstacles, (2) does not provide an inhibiting atmosphere after discharge, (3) no cooling effect, (4) possible secondary damage to electronic, electromechanical, and mechanical equipment (5) cleanup problems, and (6) can result in temporary loss of visibility if discharged in a confined space. Fixed powder systems are very uncommon and uses are normally limited to "localized applications," such as with textile machines or deep fat fryers, for which halons would not normally be used. These system should be considered for engine space protection. Powder extinguishers are suitable for most types of fires, depending on the type of powder used. They are also suitable for situations where a range of different fires can be experienced (e.g., electrical fires, flammable liquid fires, and fires in solids).

Combustion cannot occur when the oxygen content of air at normal pressures (1 atmosphere) is reduced below approximately 15 percent. Thus the addition of a sufficient amount of an inert gas such as carbon dioxide, nitrogen, argon can extinguish a fie by diluting the air such that the oxygen concentration is below that required to sustain a fie. Unfortunately, health problems can occur at low oxygen concentrations.

In terms of technical performance, the alternative agent which most closely emulates halons is carbon dioxide. It is the major alternative agent that, like halons, is a gas at normal ambient temperature and pressure. It shares many of the advantages of halons in that it is a clean, non-conducting agent with good penetrating capability. Before the current popularity of halons, carbon dioxide systems were used for many of the applications for which halon systems are now installed. This includes the protection of early generation computer installations and engine spaces. The safety record of such systems is good. Fixed carbon dioxide systems remain in popular use for a number of applications, particularly unmanned areas. Carbon dioxide is, however, less efficient than halons and, therefore, the size and weight of the storage requirements are greater. On existing industrial and commercial premises, weight and space considerations are more relevant in retrofitting than with new installations, but do not appear to be generally perceived as major obstacles. A fixed carbon dioxide system could cost two to three times as much as a fixed halon system. Carbon dioxide portable extinguishers have also been available for many years and are in common usage. They have certain disadvantages compared with halons, including larger size, greater weight, lower efficiency, shorter agent throw, no Class A rating, and less "user friendly" characteristics. However, seventy-one percent of users surveyed in the 1991 UK study considered carbon dioxide portable extinguishers to be a suitable replacement for many or all of their halon extinguishers (Reference 5). Carbon dioxide extinguishers are not drop-in alternatives for halon extinguishers. Since replacing halon extinguishers with carbon dioxide extinguishers may leave a building devoid of sufficient Class A extinguishers, a combination of carbon dioxide, water, and/or foam may be required as the most suitable halon alternative.

Nitrogen. argon, and helium have been used as fire extinguishants in relatively rare cases involving totally enclosed unoccupied spaces. System and chemical costs generally prohibit their use.

A proprietary inert gas known as INERGEN is beginning to receive attention as a halon alternative. Information on INERGEN is to be provided by other authors within these proceeding, therefore, it is only briefly mentioned herein.

ALTERNATIVE FIRE PROTECTION APPROACHES

None of the currently available halon alternatives and replacement agents are suitable for use as "drop in" extinguishants in existing halon systems and equipment. When replacing halons, redesign and new construction will be required. Generally, at costs greater than the initial installation. Thus, from a cost effectiveness standpoint the installation of halon systems must be halted and alternative technologies put in their place. In this light, the following additional approaches to fire protection are presented.

Precautionary Option to Fire Protection --- A fire detection and suppression scheme is only one part of an adequate fire protection system for an installation or facility. Fire protection is not simply the provision of fire extinguishers or fixed extinguishing systems. In assessing the scope for halon replacements and alternatives, it is necessary to consider not only direct extinguishing agent substitutes, but also other approaches to achieving a suitable level of protection against fire. This involves a combination of measures to mitigate the loss potential. Precautionary measures include: (1) early detection and early warning through increased surveillance of key installations; (2) good fire prevention practices (such as "designing out" the potential for ignition and minimization of unnecessary combustible materials and ignition sources); **(3)** use of materials that prevent fire spread and damage, such as installation of less flammable cables and cables that produce less smoke and toxic gases; **(4)** protection of individual electronic equipment cabinets, rather than the entire volume of the room in which they are housed (Reference 9); ***(6)*** isolation of the equipment at risk in a smaller area separated by fire-resistant construction; and **(7)** contingency planning such as duplication of records and equipment redundancy.

Major cost implications are involved in the provision of some of the above measures. But, there is general consensus amongst halon users, fire insurers and regulatory authorities that the alternative approaches option will significantly reduce fixed halon extinguishing installations. The extent to which this is possible depends very much on the application. However, nearly half the users surveyed in the Reference 5 stated that this approach could eliminate at least some of their demand for halon systems.

Zero Protection Option --- Another option is to eliminate halon-based fire protection equipment, without replacement by an alternative method of fire extinguishment (known as the "zero protection option"). This might be appropriate in situations where the fire hazard to common electrical appliances such as electronic typewriters and personal computers has been overemphasized. Overemphasis has resulted in the provision of more halon fixed systems and extinguishers than is necessary. Thus a reduction in the number of halon extinguishers provided has occurred in some companies. The zero protection option, however, has only limited application and would be a route for eliminating only a small propomon of existing halon systems and extinguishers (Reference 5).

Alternative Strategy Option --- Another option is the alternative strategy option. An example is in the case of desktop electrical equipment which, if ignited due to an elecmcal fault, may cease to bum if the power is switched off. If the equipment then continues to bum, the use of water or foam, for example, would generally create no hazard, provided there was no significant storage of electrical charge within the item in question. Alternative strategies could eliminate only a small proportion of existing halon systems and extinguishers.

CONCLUDING REMARKS

A fund has been established under the auspices of the Montreal Protocol to help signatory developing countries of the world meet the requirement of phasing out the consumption of controlled ozone depleting substances. The Fund was established under Article 10 of the Protocol, at the London Meeting in June, 1990 as $240 million for 3 years. Thirty four countries have pledged to support the Fund which is administered by an Executive Committee, and a Fund Secretariat whom is led by a Chief Officer, UNEP, UNDP, and the World Bank are the Fund's implementing agencies.

Developing countries require information exchange and wide information dissemination. The decision makers of the developing country in both government and industry need information with respect to policies, strategies, and activities to be undertaken for phasing out ODSs; increased training and new technology for substitutes and their use; establishment of permanent regional/sub-regional networks to share infomation and experiences as well as to monitor and encourage progress; and increased research on environmental and economic impacts of ozone layer depletion and a greater involvement of developing countries is such research.

From the halon perspective, the conclusions are that the available halon substitutes have significant tradeoffs. Additional time is required to develop superior halon replacements. Halon minimization, conservation, and alternatives approaches to fire protection should be used. The key is to restrict the installation of new halon systems through the implementation of alternative technologies where possible. Halon alternatives are available for use in developing countries.

The most effective approach for eliminating halons is to remove the agent and applicable extinguishing hardware and replace it with a redesigned and engineered fire protection system, including early detection and other warning systems, new agent, and trained personnel. The most cost effective approach is to not install halon systems in the first place.

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