Ozone Depletion and Global Warming an Integrated Approach

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Abstract

Halon 1301, which has been used extensively **as a** fire extinguishant, is **a** notorious ozone depleting substance and also has **a** very high global warming potential (GWP). While ozone depletion has largely been controlled through the Montreal Protocol concern about climate change continues to grow. The International Convention on Climate Change (ICCC) in its present form will only slow the rate of increase of greenhouse gases. It is expected that much more stringent controls will be required if we are to stabilize the climate without very significant global warming. In many cases there **are** several available halon replacements. The compound with the lowest GWP will often have **a** small ozone depletion potential (ODP) while **a** zero ODP alternative will often have **a** much higher GWP.

This paper compares potential ozone depletion and global warming for Halon 1301 and **a** variety of Halon 1301 replacements used for fire protection purposes. **A** similar analysis could be carried out for substances in other use categories. For **all** replacements there is **a** considerable saving in terms of ozone depletion; however, for many there is little benefit in terms of global warming and in some cases the global warming effects of **a** halon replacement greatly exceeds the global warming effects of the Halon 1301 which it replaces. In this paper the effects on stratospheric ozone are compared to the contribution to global climate change for **a** number of in-kind Halon 1301 alternatives.

Introduction

The 1994 Scientific Assessment of Ozone Depletion from the World Meteorological Organization [1] has investigated several means to decrease the integrated effective chlorine loading over the next 50 years. It was concluded that the two things which would cause the greatest decrease would be to eliminate emissions of methyl bromide and to not release halons presently contained in existing equipment. In this presentation issues involved in removing Halon 1301 from service and replacing it with various alternatives are discussed.

The Canadian Council of Ministers of the Environment (CCME) [5] developed an inventory of ozone depleting substances (ODS) for 1993 and have tracked consumption of ODS over the period a 10 year period --- 1986 to 1996 for Canada. Consumption has dropped very quickly. On an ODP weighted basis, the 1993 inventory of ODS (65 ODP weighted ktonne) amounted to about 65 years consumption at the 1996 rate. Under these circumstances, in the short term, emissions are going to be governed by inventory rather than consumption. A reduction in inventory should lead to a reduction in emissions. We believe that, in other industrialized nation, the ratio of consumption to inventory for ODS will be similar to that of Canada's.

At the present halon emissions are approximately 8.75% of existing stock per year [2]. Halons are notorious as ozone depleters. Halons are also very strong greenhouse gases. Many of the replacements for halons are also very strong greenhouse gases. When searching for a halon replacement the potential for causing climate change should be weighed against savings in potential ozone destruction. If halon is removed from service and the wrong halon replacement is chosen the impact on the climate will be much greater than if the halon were left in service. On the other hand with the right choice significant savings can be realized both in terms of ozone destruction and climate change. To this end a model has been developed.

Model

The model takes into account both the ODP and GWP. The model was constructed for a number of halocarbon halon alternatives. The halon alternatives selected (NAF S-III, FE-13, FM-200, and CEA-410) are commercialized agents suitable for total flood applications in normally occupied areas. The following assumptions have been made:

Halon 1301 stocks	45,000 tonnes in 1996 [2]
Halon emission rate	8.75% of stock per year [2]
Emission rate for replacements	6.5625% per year *
Amount of halon decommissioned	80%
Time frame for decommissioning	4 years
Weight equivalent for replacements	based design concentration for heptane (NFPA 2001)
Halon 1301 ODP	16
Other ODPs	Scientific Assessment of Ozone Depletion: 1994 [1]
GWPsl	Scientific Assessment of Ozone Depletion: 1994 [1]

* ***see*** discussion below for derivation

Halon 1301 stocks

In the 1994 Montreal Protocol Halon Technical Options Committee **(HTOC)** report [2] there is a figure which shows expected Halon 1301 stocks. For 1996 this figure shows that there are 45,000 tonnes of Halon 1301 world-wide. There are many indications that the HTOC has under estimated halon stocks by a wide margin; however, the HTOC numbers are used in this analysis.

Emission rate for Halon 1301

The 1994 HTOC report **[2]** shows the expected annual emissions of Halon 1301. From this and the amount of Halon 1301 in the bank we calculated the emission rate as a fraction of the bank. The average over the period 1996 to 2030 is calculated to be 8.75%

Emission rate for halon replacements

As Halon 1301 is removed from service and replaced it is expected that systems will be upgraded. New detectors and actuation systems can reduce the incident of accidental discharge. Better valves can also reduce leakage. Overall we have assumed that the emission rate of a halon replacement will be three quarters of the emission rate of Halon 1301 (as determined above).

Amount of Halon 1301 decommissioned

For some critical applications it is unlikely that a Halon 1301 replacement will be utilized in the foreseeable future. Therefore, it is assumed that 20% of the halon bank will be retained for critical applications and thus, 80% can be removed from service and securely stored for future destruction.

Time frame for decommissioning

For the purposes of the model it is assumed that the 80% of the Halon 1301 removed from service will be removed equally over a four year period.

Weight Equivalent for replacement

All halon replacements require more weight than Halon 1301 for the same degree of protection. NFPA 12A [3] sets a minimum design concentration for Halon 1301 at **5** vol.%. Minimum design concentrations for these replacement are 20% over the cup burner concentration as discussed in NFFA 2001 [4]. For the model, the design concentration is based on the cup-bumer value for heptane recognized by the manufacturer of the agent, for other fuels other concentrations might be appropriate.

Halon 1301 ODP

It has been suggested that bromine is more damaging to the ozone layer than previously believed. The ODP for Halon 1301 is 16, this value has been widely accepted. Using a lower ODP, such as the value of 10 recognized by the Montreal Protocol, for Halon 1301 would not substantially change the results of this model and would not change the resulting conclusions.

ODP for the current halon replacements

The ODPs for the halon replacements were taken from the Scientific Assessment of Ozone Depletion [1].

GWPs

100 year time horizon GWPs relative to CO_2 [1] are used.

Results and Discussion

Ozone Depletion

There is a clear and significant advantage, in terms of ozone depletion to remove Halon 1301 from service and replace it with any one of the replacements discussed here. **As** can be seen from Figure 1 it makes very little difference whether Halon 1301 is replaced with a zero ODP (FE-13, FM-200, or CEA-410) replacement or with NAF S-III which is a non-zero ODP replacement. Over a period of 40 years the difference ozone depletion is less than 1%.

On Figure 1, which shows the case for no decommissioning, as well **as** the case where Halon 1301 is replaced either with NAF **S-III** or a zero ODP replacement, it is very difficult to see the difference between the NAF S-III line and the zero ODP line. This is because the ODP of NAF S-III is very close to zero relative to the ODP for Halon 1301. **The** cumulative ODP emissions **are** almost entirely controlled by the decommissioning scenario selected. More rapid decommissioning (destruction) leads to lower emissions while no decommissioning eventually leads to total emission of the Halon 1301 bank; an amount in **excess** of 600,000 ODP tonne. If one chooses to keep the existing stock of Halon 1301 in service, then there is not a rational for preventing the use of HCFC based (near zero ODP) halon replacements, such as NAF **S-III.**

Climate Change

Table 1 shows the cumulative global warming potential (CO_2 tonnes: 100 year time horizon) emissions for a period of 40 years. Figure **2** shows the cumulative emissions as they build up over that period. As can be seen the lowest impact on the climate would result from removing Halon 1301 from service and replacing it with **NAF** S-III. There is a cumulative emission drop from **247** million tonnes CO_2 equivalent to 112 million tonnes CO_2 equivalent when Halon 1301 is replaced with NAF S-III.

Figure 1: Cumulative ODP Emissions (in ODP tonnes)

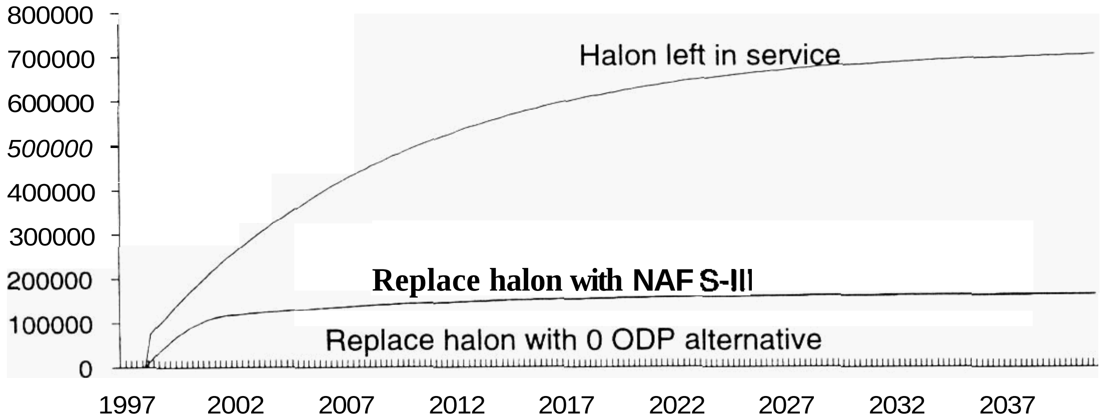
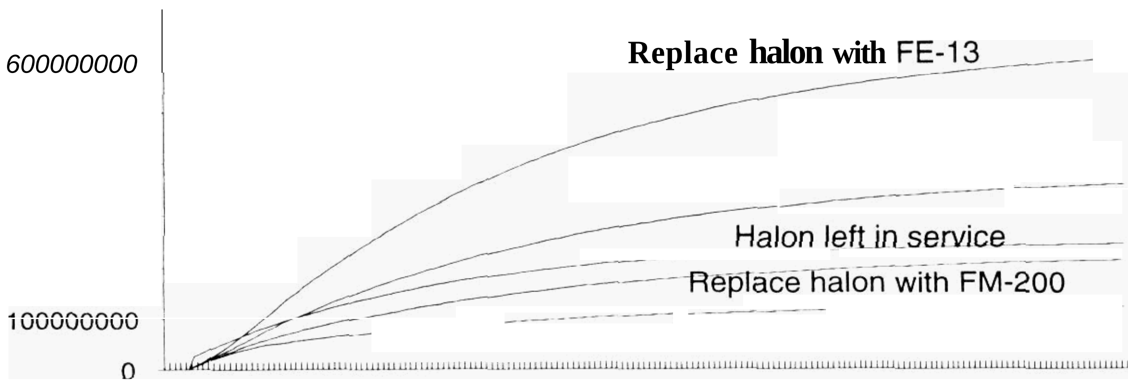


Table 1. Cumulative Emissions.

Emission Scenario	40 year cumulative GWP emissions (CO_2 tonnes, 100 year time horizon)	40 year cumulative ODP emissions (ODP tonne)
Halon 1301 no decommissioning	$2.45*10^8$	$7.01*10^5$
NAF S-III replaces halon 1301	$1.22*10^8$	$1.64*10^5$
FM-200 replaces halon 1301	$2.12*10^8$	$1.63*10^5$
CEA-410 replaces halon 1301	$3.55*10^8$	$1.63*10^5$
FE-13 replaces halon 1301	$5.95*10^8$	$1.63*10^5$



There is a slight advantage to removing Halon 1301 from service and replacing it with FM-200. The advantage arises largely from reductions in emissions caused by improvements in equipment, assuming that equipment (valves, seals, etc.) will improve when systems are replaced.

The replacement of halon 1301 with either FE-13 or CEA-410 causes **a** greater impact on the climate than retention of Halon 1301. The total emitted GWP increases dramatically if either of these is substituted for Halon 1301 as is shown in Figure **2 and** Table 1. Clearly in terms of climate change the best halocarbon replacement for Halon 1301 is NAF **S-III.**

Conclusions

Halon 1301 should be removed from service wherever practical as this will provide a significant environmental benefit both to the ozone layer and to preserving the earth's climate. NAF **S-III** is the best replacement for Halon 1301 in terms of potential climate change and it is the only replacement considered here that actually provides **a** significant net benefit. The large net benefit to the environment in terms of climate change provided by NAF S-III outweighs the minor penalty associated with its very small near-zero ODP, provided Halon 1301 continues to remain in service.

References

[1] ***Scientific Assessment of Ozone Depletion: 1994*** World Meteorological Organization Global Ozone Research and Monitoring Project - Report No. 37: Geneva Switzerland.

[2] ***Montreal Protocol on Substances that Deplete the Ozone Layer: Report of the Halon Fire Extinguishing Agents Technical Options Committee:*** UNEP December 1994.

[3] ***NFPA 12A Halon 1301 Fire Extinguishing Systems 1989 Edition*** National Fire. Protection Association, Quincy, MA.

[4] ***NFPA 2001 Standard** on **Clean Agent Fire Extinguishing Systems 1996 Edition*** National Fire Protection Association, Quincy, MA.

[5] ***National Action Plan for the Environmental Control of Ozone-Depleting Substances and their Halocarbon Alternatives.*** Federal Provincial Working Group on Controls Harmonization (ODS): Canadian Council of Ministers of the Environment, Draft Report March 1997.