Effectiveness and Thermal Breakdown Products of Fire Suppression Agents

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Introduction
Until recently fluorinated, chlorinated and brominated hydrocarbons such as (CF_3Br) and (CF_2ClBr) were extensively used as fire suppression agents. Unfortunately they have high stratospheric ozone depletion potential and can no longer be used. It is therefore vital to find new agents which have the same good qualities; a substance which is easy to produce, store and transport – an effective extinguishing agent which is not harmful to the humans who use it – the substance must not damage the materials around the fire, which is very important in e.g. aircrafts, computer systems and libraries. Extensive research is conducted on alternative agents that have these good properties without damaging the stratospheric ozone layer. Many of these new agents contain F and can produce HF and other fluorinated compounds when in contact with flames. HF is dangerous to humans so this potential problem must be studied and understood before introducing new agents on the market.
A project aimed at studying the thermal breakdown products from new extinguishing agents is conducted at the Department of fire Safety Engineering at Lund University in cooperation with the Swedish National Testing and Research Institute. Some preliminary results from this project are presented.

Experiments
Experiments haw been conducted with four different extinguishing agents. These are presented in table 1 below.

Three types of experiments were performed in order to find the characteristics of the agents.
❑ 8 litre bombs were used to determine the inerting concentration
❑ Cup burner was used to find the extinguishing concentration
❑ Thermal breakdown was studied in a calorimeter equipment

Analysis of combustion products
❑ Thermal breakdown products with FTIR
❑ CO, CO_2 and O_2 with conventional on-line techniques
❑ HF with ion chromatography
❑ Soot production with a laser – photocell system

Table 1. Tested extinguishing agents

Substance	Chemical Structure	Boiling Point [°C]
Bromotrifluoromethane		-58
Pentafluoroethane		-48.1
Heptafluoropropane		-16.5
Dodecafluoro-2-methylpentan-3-one		49.2

Results
The inerting concentration was determined for the four studied extinguishing agents. An example from one of the experiments is shown in figure 1.

Cup burner tests has so far been performed with Pentafluoroethane, Heptafluoropropane and Dodecafluoro-2-methylpentan-3-one. Results from these tests are presented in table 2.

The main purpose of the project is to determine and compare the thermal breakdown products that are produce from the different extinguishing agents when they are applied in varying proportions to a burning fuel. In order to achieve this the equipment presented in figure 2 was used.

It was found that when the extinguishing agent is introduced into the flame the rate of heat release is increased in some cases this increase is substantial. This is shown in figure 3.

The production of HF is depending of the choice of extinguishing agent as can be seen in figure 4. The HF production per gram extinguishing agent applied is also dependent on the amount of agent per gram fuel.

The FTIR analyses of the thermal breakdown products show that the amounts but also the formed products differ between the agents. This is illustrated in figure 5.

Inerting concentration

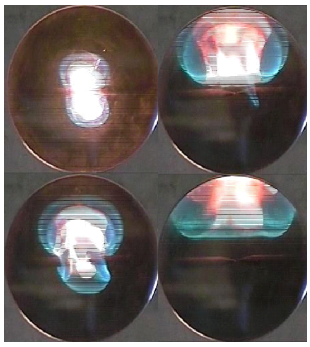

Figure 1. *Photo from an experiment in the 8 litre bombs with 4.2 vol % Propane and 10 vol % Pentafluoroethane (CF_3-CHF_2).*

Table 2. Results from Cup Burner experiments

Substance	Airflow [l/min]	Extinguishing concentration [%]
Pentafluoroethane	10	9.1
Heptafluoropropane	10	7.8
Dodecafluoro-2-methylpentan-3-one	10	5.6
Dodecafluoro-2-methylpentan-3-one	20	6.3

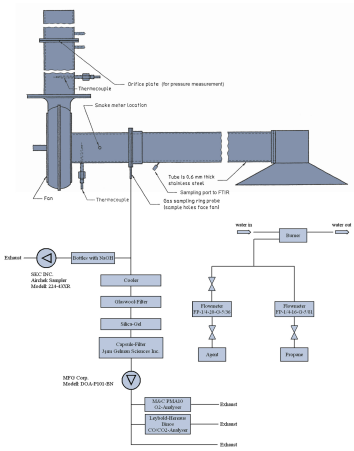

Figure 2. *Calorimeter equipment for determination of combustion products and rate of heat release*

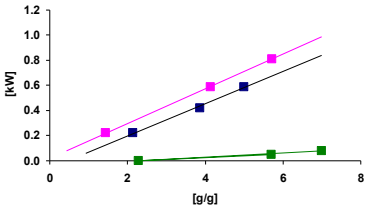

Figure 3. *The contribution from the extinguishing agent to the heat release is presented as a function of the mass of agent added per gram fuel. The flame, in these experiments, hade a rate of heat release of 1 kW.*
Pentafluorethane
Heptafluoropropane
Dodecafluoro-2-methylpentan-3-one

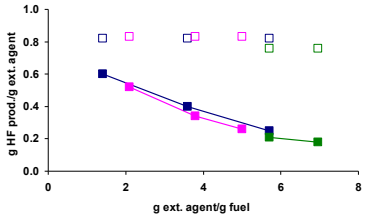

Figure 4. *The diagram shows the mass of HF produced per gram applied extinguishing agent as a function of mass of extinguishing agent applied per gram fuel. The unfilled boxes indicate the maximum theoretical amount of HF for each agent. .*
Pentafluorethane
Heptafluoropropane
Dodecafluoro-2-methylpentan-3-one

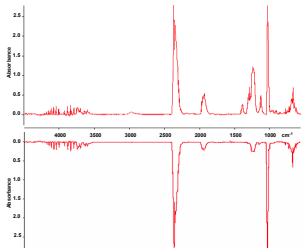

Figure 5. *An example of decomposition products determined by FTIR analysis. The upper spectrogram is from an experiment with Heptafluoropropane and the inversed is from Pentafluoroethane.*

References
1. *"Investigation of Scale Effects on Halon and Halon Alternatives Regarding Flame Extinguishment, Inerting concentration and Thermal Decomposition Products". G. Holmstedt, P. Andersson and J. Andersson. Fourth IAFSS, Ottawa 1994, pp 853-864.*

2. *"Smoke gas analysis by Fourier transform infrared spectroscopy - The SAFIR project" VTT Technical Research Centre of Finland, Research Note 1981 (1999) ISBN 951-38-5481-7.*