

## Recent Developments of Zero ODP, Low GWP Clean Fire Suppression Agents

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### EXTENDED ABSTRACT

In this paper we detail the development of new zero ODP, low GWP clean fire extinguishing agents. A total flooding agent potentially suitable for use in normally occupied areas has been developed and two agents potentially suitable for use in streaming applications or total flooding applications in normally unoccupied areas have been identified.

### TOTAL FLOODING APPLICATIONS

In the area of total flooding applications for normally occupied areas, we discuss in detail the results of recent fire testing, GWP determination, and the physical and toxicological properties of a new clean agent characterized by zero ODP, low GWP, low toxicity, low chemical reactivity and high extinguishing efficiency.

Laboratory scale fire tests were conducted employing the standard cup burner apparatus for Class B fuels and a DuPont-developed laboratory scale Class A test which has been found to accurately replicate results of large scale UL 2166 fire tests. Additional fire testing was performed in a small scale total flooding apparatus. Cardiac sensitization and 4h LC<sub>50</sub> toxicological testing has been completed and indicate this new flooding agent is suitable for use in normally occupied areas containing Class A, B or C fire hazards. The atmospheric lifetime and GWP of this new flooding agent have been determined from its infrared absorption spectrum and experimentally measured rate coefficients for its reaction with hydroxyl radicals. Tables 1 through 4 summarize the physical, chemical, environmental, toxicological and fire suppression properties of this new agent.

**Table 1. Physical and Chemical Properties of Total Flooding Agents for Normally Occupied Areas**

Property	Halon 1301	FM-200®	FK-5-1-12	Flooding Candidate 1
Chemical formula	CF <sub>3</sub> Br	CF <sub>3</sub> CHFCF <sub>3</sub>	CF <sub>3</sub> CF <sub>2</sub> C(O)CF(CF <sub>3</sub> ) <sub>2</sub>	Proprietary
Boiling point (°C)	-58	-17	49	31
Liquid density (g/cm <sup>3</sup> @ 25 °C)	1.54	1.38	1.72	1.3
Chemical reactivity	Low	Low	High	Low

**Table 2. Environmental Properties of Total Flooding Agents for Normally Occupied Areas**

Property	Halon 1301	FM-200®	FK-5-1-12	Flooding Candidate 1
ODP	10	0	0	0
Atmospheric lifetime (y)	65	34.2	0.02	0.10
GWP (100 y ITH)	7140	3660	1	2

**Table 3. Toxicological Properties of Total Flooding Agents for Normally Occupied Areas**

Property	Halon 1301	FM-200®	FK-5-1-12	Flooding Candidate 1
4h LC <sub>50</sub> , ppm	>800,000	>800,000	>100,000	>231,000
CS NOAEL, % v/v	5.0	9.0	10.0	10.0
CS LOAEL, % v/v	7.5	10.5	10.0	12.5

**Table 4. Fire Suppression Properties of Total Flooding Agents for Normally Occupied Areas**

Property	Halon 1301	FM-200®	FK-5-1-12	Flooding Candidate 1
Class A MDC, % v/v	5.0	6.7	4.5	5.6
Class B MDC, % v/v <sup>a</sup>	5.0	8.7	5.9	6.9
Class C MDC, % v/v	5.0	7.0	4.7	6.3
Relative mass efficiency, heptane hazard	0.48	1.00	1.26	1.00
Relative mass efficiency, Class C hazard	0.60	1.00	1.25	1.00

<sup>a</sup> heptane fuel

## **STREAMING APPLICATIONS AND NORMALLY UNOCCUPIED AREAS**

In the areas of streaming applications and total flooding applications in normally unoccupied areas, we report on the development and testing of two new clean agents, one of which exhibits an extinguishing efficiency superior to that of the Halons 1211 and 1301, and discuss the potential of these new agents for the replacement of Halons, for example in commercial aircraft applications including engine nacelle protection and handheld extinguishers. Tables 5 through 7 summarize the physical, chemical, environmental, toxicological and fire suppression properties of these new agents.

**Table 5. Physical, Chemical and Environmental Properties of Streaming or Non-Occupied Area Agents**

Property	Halon 1211	2-BTP	Streaming Candidate 1 (SC1)	Streaming Candidate 2 (SC2)
Chemical Formula	CF <sub>2</sub> BrCl	CF <sub>3</sub> CBr=CH <sub>2</sub>	Proprietary	Proprietary
ODP	3	0.0028	0	0
Atmospheric lifetime (y)	16	0.02	TBD	TBD
GWP (100 y ITH)	1890	0.26	< 20 est.	< 20 est.
Boiling point (°C)	-4	34	31	18
Liquid density (g/cm <sup>3</sup> @ 25 °C)	1.8	1.65	1.38	1.3
Chemical Reactivity	Low	Low	Low	Low

**Table 6. Toxicological Properties of Streaming or Non-Occupied Area Agents**

Property	Halon 1211	2-BTP	Streaming Candidate 1 (SC1)	Streaming Candidate 2 (SC2)
4h LC <sub>50</sub> , ppm	31,300 to 100,000	> 20,000	> 102,900	120,000
CS NOAEL, % v/v	0.5	0.5	1.25	2.50
CS LOAEL, % v/v	1.0	1.0	2.50	> 2.50

**Table 7. Fire Suppression Properties of Streaming or Non-Occupied Area Agents**

Property	Halon 1211	2-BTP	Streaming Candidate 1 (SC1)	Streaming Candidate 2 (SC2)
Class A MDC, % v/v	5.0	?	5.6	4.8
Class B MDC, % v/v	5.0	6.1	7.3	6.2
Class C MDC, % v/v	5.0	?	6.3	5.0
Relative mass efficiency, heptane hazard	1.1	1.3	2.0	1.0
Relative mass efficiency, Class C hazard	1.3	?	1.9	1.0