

Hazard Assessment of Thermal Decomposition Products of Halon Alternatives

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Thermal Decomposition Products Expected in Total Flooding Applications

- Flame temperatures (900 to 1200 C) breakdown agent molecules
- Halogen atoms combine with hydrogen
 - Halogen acids formed (HF, HCl, HBr)
- Other hazardous decomposition products identified in some studies
 - Carbonyl fluoride (COF₂)
 - Elemental halogens (F₂, Br₂)
- *Predominant decomposition product of concern for alternatives is HF*
 - CHF₃, C₃HF₇, C₄F₁₀

Decomposition Product Concentration on D_i

- Fire size at system actuation
 - Fire growth rate
 - Detector sensitivity
 - System discharge delay time
- Enclosure volume
 - Large volumes will dilute concentrations
- Discharge time
 - Exposure time to the fire of sub-extinguishing concentrations of agent
- Other
 - Fuel type and arrangement
 - Vaporization and mixing of agent
 - Preburn time
 - » Presence of hot surfaces
 - Deep seated fires
 - Extinguishment time
 - Design concentration

Threat to Personnel

- Decomposition product concentration
- Exposure time to concentration
- Level of exertion
- Simultaneous exposure to other fire products
- Predisposition to effects
- *Eye and lung irritants*
 - Painful effects
 - Edema and inflammation

Threat to Equipment

- Decomposition product concentration
- Exposure time
- Deposition rate *of* acids on the surface
- Humidity and temperature
- Sensitivity *of* equipment
- Combined effects with smoke

- Corrosion
 - Increased contact resistance
 - Degradation of materials

Toxic Effect Levels of Acid Gases

	HF (ppm)	HCl and HBr (ppm)
30-min LC, in mammals	9003600	1600-6000
Severe irritant in humans	120	100
Dangerous	50350	-
IDLH	30	-
STEL	6	-
Detection	1	-

Effects of Acid Gases on Equipment

- Exposure of printed circuit boards
 - 700 ppm total (HF and HBr)
 - » No failures
 - » Only one board showed appreciable damage
 - 7,000 ppm total (HF and HBr)
 - » Some failures and recoveries during test period
 - » All boards had heavy corrosion
 - 70,000 ppm total (HF and HBr)
 - All boards failed and did not recover
- Recorded magnetic tape
 - For 100's ppm exposures
 - No effects

Estimating HF Concentrations

- Use FPE Tool
 - Standard fire growth rates
 - Smoke detector modeled as heat detector
 - Detection at 13 C above ambient and RTI = 1
 - Closed room
- Scaling factor for HF production to fire size
 - Based on small and moderate scale test data
 - PFC and HFC scaling factors similar
 - PFC and HFC scaling factors greater than 1301

Expected HF Concentrations

35'x35'x8' room with smoke detection

	Fire Growth Rate		
	Slow	Moderate	Fast
immediate Discharge	(88s, 23kW)	(47s, 26kW)	(26s, 32kW)
Alternative 1301	48 ppm 11 ppm	54 ppm 12 ppm	66 ppm 15 ppm
60s Delayed Discharge	(148s, 64kW)	(107s, 134kW)	(86s, 347kW)
Alternative 1301	134 ppm 30 ppm	281 ppm 63 ppm	727 ppm 163 ppm

Expected HF Concentrations

20'x20'x8' room with smoke detection

	Fire Growth Rate		
	Slow	Moderate	Fast
Immediate Discharge	(68s, 14kW)	(37s, 16kW)	(20s, 19kW)
Alternative 1301	92 ppm 21 ppm	105 ppm 24 ppm	124 ppm 28 ppm
60s Delayed Discharge	(128s, 48kW)	(97s, 110kW)	(80s, 300kW)
Alternative 1301	314 ppm 71 ppm	719 ppm 162 ppm	1960 ppm 441 ppm

Automatic Fire Sprinkler (165 F and RTI = 300)

	Slow	Moderate	Fast
35' x 35' x 8'			
Time (s)	312	201	128
Fire Size (kw)	297	473	764
Smoke Height (ft)	3.6	4.1	4.5
Smoke Temp (F)	226	269	330
20' x 20' x 8'			
Time (s)	253	162	104
Fire Size (kw)	122	307	504
Smoke Height (ft)	2.3	2.4	2.7
Smoke Temp (F)	256	306	378

Conclusions

- **Acid gas concentrations**
 - Range from 10's to 1000's ppm
 - Can pose a hazard to personnel
 - May present corrosion problems to equipment
- **Rapid detection and discharge**
 - System actuation at small fire size
- **Estimates of acid gas concentrations**
 - Hazard analysis
 - System design