BTP on Track to Replace 1211 in Commercial Aviation

Halon Replacement for Aircraft Portable Fire Extinguishers – Progress Report

PRESENTATION TO:

7th Triennial International Aircraft Fire and Cabin Safety Research Conference

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Overview

- Three halon 1211 alternatives are currently FAA and UL approved
  - HCFC Blend B
  - HFC-236fa
  - HFC-227ea

- 2-Bromo-3,3,3-trifluoropropene (2-BTP or BTP) in development
  - Boeing supporting research
  - SNAP application was expected earlier in the year
    - Just recently filed
    - Additional testing ongoing
### Property Comparison

<table>
<thead>
<tr>
<th></th>
<th>HALON 1211</th>
<th>HCFC Blend B</th>
<th>HFC-236fa</th>
<th>HFC-227ea</th>
<th>BTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Formula</td>
<td>CF₂Br</td>
<td>CF₃CHCl₂ +</td>
<td>CF₃CH₂CF₃</td>
<td>CF₃CHFCF₃</td>
<td>CF₃CBrCH₂</td>
</tr>
<tr>
<td>Molecular Weight</td>
<td>185.4</td>
<td>190.7</td>
<td>162.0</td>
<td>170.0</td>
<td>174.3</td>
</tr>
<tr>
<td>Boiling Point @ 1 Atm.</td>
<td>26°F (-3°C)</td>
<td>61°F (27°C)</td>
<td>30°F (-1°C)</td>
<td>2°F (-19°C)</td>
<td>93°F (34°C)</td>
</tr>
<tr>
<td>Specific Gravity, Liquid</td>
<td>1.83</td>
<td>1.46</td>
<td>1.38</td>
<td>1.60</td>
<td>1.65</td>
</tr>
<tr>
<td>Atmospheric Lifetime</td>
<td>16 years</td>
<td>1.3 years ¹</td>
<td>242 years</td>
<td>36 years</td>
<td>7 days</td>
</tr>
<tr>
<td>LC 50 (4 hr rat), ppm</td>
<td>31,000 – 100,000</td>
<td>30,000 – 35,000</td>
<td>&gt;189,000</td>
<td>&gt;800,000</td>
<td>&gt;20,000</td>
</tr>
<tr>
<td>Cardio-Tex LOAEL, %vol.</td>
<td>1%</td>
<td>2%</td>
<td>15.0%</td>
<td>10.5%</td>
<td>1%</td>
</tr>
<tr>
<td>Cardio-Tex NOAEL, %vol.</td>
<td>0.5%</td>
<td>1%</td>
<td>10%</td>
<td>9%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Cup Burner, heptane, %vol.</td>
<td>2.2%</td>
<td>6.5%</td>
<td>0.3%</td>
<td>6.1%</td>
<td>4.7%</td>
</tr>
</tbody>
</table>

¹ Value based on HCFC-123. Also contains one PFC in small proportion.

### Bottle Details – UL/FAA Approved 5B:C

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<th>BTP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bottle Dimensions, in.</td>
<td>17 x 4.8 x 3.25</td>
<td>15 x 5 x 4.25</td>
<td>15.9 x 8 x 4.5</td>
<td>16.5 x 6.5 x 4.4</td>
<td>~17 x 5 x 3.25</td>
</tr>
<tr>
<td>Agent Weight, Lb.</td>
<td>2.5</td>
<td>5.5</td>
<td>4.75</td>
<td>5.75</td>
<td>3.75</td>
</tr>
<tr>
<td>Gross Weight, Lb.</td>
<td>3.93</td>
<td>9.3</td>
<td>9.5</td>
<td>9.8</td>
<td>5.6</td>
</tr>
<tr>
<td>Bottle Construction</td>
<td>Aluminum</td>
<td>Carbon Steel</td>
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<td>Carbon Steel</td>
<td>Aluminum</td>
</tr>
</tbody>
</table>

- Current approved alternatives gross weight based on carbon steel bottles
  - Reductions possible
- BTP bottle is a drop-in for current Boeing Halon 1211 unit
  - May be different in size than other airframe manufacturers
Environmental Profile - ODP

Ozone Depletion Potential \((CFC-11 = 1)\)

Source: Scientific Assessment of Ozone Depletion, 2010

Environmental Profile - GWP

Global Warming Potential \((100\text{yr CO}_2 = 1)\)

Source: Scientific Assessment of Ozone Depletion, 2010

HCFC Blend B value based on HCFC-123, also contains small proportion PFC
Balancing ODP and GWP

• Korean Green Mark
  • Criteria
    • ODP less than 0.055
    • GWP less than 3000

• BTP meets criteria

• Mark has been issued for HCFC Blend B

• HFCs do not meet criteria

BTP Development – FAA/UL

• AC20-42D, Hand Fire Extinguishers for Use In Aircraft
  • Requires
    • UL listing for 5B:C

    • FAA Hidden Fire Test
      • Conducted at UL

    • FAA Seat Fire / Toxicity Test
**BTP Development**

- Extensive Toxicity Test Program Required for SNAP/STCA, REACH, and FAA
  - Rat Micronucleus
  - Eye Irritation
  - Skin irritation
  - Acute Dermal
  - 90-day Sub-Chronic Inhalation
  - Reproductive and Development Screen
  - Acute Fish Toxicity
  - Activated Sludge Respiration Inhibition
  - Biodegradation
  - Partition Coefficients
  - Physiologically Based Pharmacokinetic (PBPK) Modeling

- All testing in this series complete

**BTP REPRODUCTIVE AND DEVELOPMENTAL**

- **Initial Reproductive and Developmental Screen (COMPLETE)**
  - 6 hours/day, 7 days/week exposure
  - Not mutagenic and no birth defects noted
  - Effects to reproductive cycle observed
  - NOAEL not determined

- **Second Reproductive and Developmental Screen (ONGOING)**
  - Testing underway
  - Desire to find NOAEL and evaluate short term effects, if any, from exposure to discharge
  - 6 hours/day, 7 days/week exposure
    - Lower exposure levels than initial test
  - 5 minutes/day, 7 days/week exposure
    - Discharge exposure (1% for 5-minutes)
  - Report Tentative Completion - 1Q2014
BTP PBPK Model Results

30.6 mg/L

Allowable Blood Concentration
1.0% - LOAEL
0.95% - 5-Min PBPK Allowable
0.25% - NOAEL

Time, Minutes

Air Exchange Rate (Tsu), Minutes Per Air Exchange

Maximum Initial Concentration

Unintended Case
(5min PBPK Allowable) Concentration
BTP Schedule

- US EPA SNAP and EU ECHA REACH submittals should have been made
  - Additional reproductive test report will be filed toward end of 1Q2014

- UL fire performance complete

- UL hardware tests ongoing
  - 1 year leak
  - Misc. hardware tests

- Regulatory review anticipated to be complete by end of 2014
  - US Federal Register notice may take longer

- Commercialization to support airplane manufacturer's implementation dates to meet ICAO's December 31, 2015 date