# Halon Replacement for Airplane Portable Fire Extinguishers - Progress Report

**International Aircraft Systems Fire Protection Working Group Conference**

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# Objective

**Provide a progress report on development of BTP (2-bromo-3, 3, 3-trifluropropene), a promising new environmentally safe Halon replacement fire extinguishing agent**

# Agenda

- Halon Replacement Dates
- Steps to Commercialization
- BTP Performance
- Agent Summary
- Fire Extinguisher Installation
- BTP Risks
- BTP Near-term Steps
- Summary

# Halon Replacement Dates

| | Proposed Requirement | Lavatory | Handheld | Propulsion/ APU | Cargo |
|---|---|---|---|---|---|
| New Design (New TC Application) | EC Cutoff Date | 2011 | 2014 | 2014 | 2018 |
| | ICAO | 2011 | 2016 | 2014 | NA |
| | UL Standard | NA | 2014 | NA | NA |
| Current Production | EC End Date (incl. retrofit) | 2020 | 2025 | 2040 | 2040 |
| | ICAO | 2011 | 2016 | NA | NA |
| | UL Standard | NA | 2014 | NA | NA |

**Notes:**

*EC dates were adopted in March 2010 and published August 18, 2010; to be effective December 31 of the stated year.*

*ICAO proposed halon replacement "resolution" adopted at ICAO General Assembly Meeting on October 6, 2010. Amendments to Annexes 6 & 8 in-work.*

*Underwriters' Laboratory Standard 1093 to be withdrawn September 2014.*

# Steps to Commercialization

- ✓ Cup burner testing - 2002
- ✓ Initial toxicity tests (Ames, cardiotox…) - 2002
- ✓ 2D ODP, GWP and atmospheric lifetime - 2004
- ✓ Prototype extinguisher, near drop-in replacement for Boeing 1211 extinguisher - 2009
- ✓ UL 711 5B pan fire tests - 2009
- ✓ UL 711 cold temperature pan fire test - 2009
- ✓ FAA MPS AR-01/37 hidden fire tests - 2009
- ✓ 3D model analysis of ODP and GWP - 2010
- ✓ FAA MPS AR-01/37 seat fire toxicity tests - 2011
- ✓ ASTM flammability tests (per NFPA 704) - 2011
- ✓ Airplane material compatibility tests - 2011
- ✓ Synthesis of BTP for toxicology testing - 2011
- ❑ Publication of 3D ODP scientific paper
- ❑ Complete toxicology testing
- ❑ PBPK testing and modeling
- ❑ Provide PBPK data to FAA for inclusion in AC 20-42D and FAA/AR-08/3
- ❑ Additional BTP properties testing
- ❑ US EPA TSCA inventory listing
- ❑ US EPA SNAP approval
- ❑ EU REACH approval
- ❑ 3.25” diameter bottle
- ❑ UL 2129 fire extinguisher bottle tests and UL listing
- ❑ ASTM standard for BTP

# BTP Performance

## Initial BTP toxicity test results

| Item | Comments |
|---|---|
| Ames (mutagenic test) | No effects noted |
| Human Lymphocyte (chromosomal aberration) | No effects noted |
| Cardiotoxic Dog Inhalation | NOAEL .5%<br>LOAEL 1.0% |
| Preliminary Limit Test (5% for 30 minutes) | Some potential anesthetic effects noted |

Data from J Grigg & A Chattaway, “The Evaluation of Bromotriflouropropene as a Halon 1211 Replacement”, NIST SP 984, June 2002
http://www.fire.nist.gov/bfrlpubs/fire02/PDF/f02114.pdf

# BTP Performance

**Passed UL 711 5B and UL 2B cold temperature fire tests, December 2009**

# BTP Performance

**Passed FAA MPS AR-01/37 hidden fire tests at UL, December 2009**

# BTP Performance

**Passed FAA MPS AR-01/37 seat fire toxicity tests, February 2011**

# BTP Performance

## FAA MPS seat fire toxicity test results:

| Agent | Test Number | HF 1-Minute Average (200 ppm limit) | HF 4.5-Minute Average (100 ppm limit) | Agent Used (pounds) | Discharge Time (seconds) |
|---|---|---|---|---|---|
| BTP | 1 | 47.8 | 23.9 | 1.85 | 3.2 |
| | 2 | 65.7 | 34.5 | 1.76 | 3.8 |
| | 3 | 88.2 | 47.7 | 1.55 | 2.9 |
| Halon 1211 2011 tests | 1 | 20.5 | 11.7 | .64 | 2.1 |
| | 2 | 20.4 | 11.0 | .64 | 2.4 |
| | 3 | 25.8 | 14.6 | .57 | 2.0 |
| Halon 1211 1999 tests | 1 | 9.28 | 6.01 | 1.2 | 6 |
| | 2 | 21.04 | 13.87 | .8 | 4.5 |
| | 3 | 19.83 | 12.92 | .96 | 4.7 |

Data from FAA test data sheets

**BTP HF levels below the MPS requirements, and FE-36 and FM-200 levels**

# BTP Performance

**Passed NFPA 704 required flammability tests, March 2011**

| Test | Results |
|---|---|
| ASTM D92 Flash point (Cleveland open cup) | None, vapor extinguished flame |
| ASTM E659 Auto ignition Temperature | No ignition |
| ASTM E681 Upper and lower flammability limits | Non-flammable |
| ASTM D6668 Flammability rating | F=0 |

**NFPA 704 flammability rating of zero**

# BTP Performance

**Passed Boeing aircraft materials compatibility testing, March 2011**

- Non-corrosive to standard aircraft metals
- No effect on standard aircraft plastics
- No effect on standard seals or sealants
- No effect on standard aircraft interior materials

**BTP is compatible with typical aircraft materials**

# BTP Performance

**3-D Modeling of BTP by Dr Wuebbles and Ken Patten of University of Illinois (UIUC) completed Dec 22, 2010**

- **Whole Atmosphere Community Climate Model (WACCM) version 3.5.48.**
- **Based on BTP emissions over land areas between 30N and 60N latitude:**
  - **Very short lived compound - 7 days.**
  - **Oxidizes in troposphere, where bromine is rained out.**
  - **0.0028 ODP.**
  - **0.005 GWP (100 year).**

**"BTP should be environmentally safer than other likely choices of agents"** **Dr. Wuebbles**

# Agent Summary

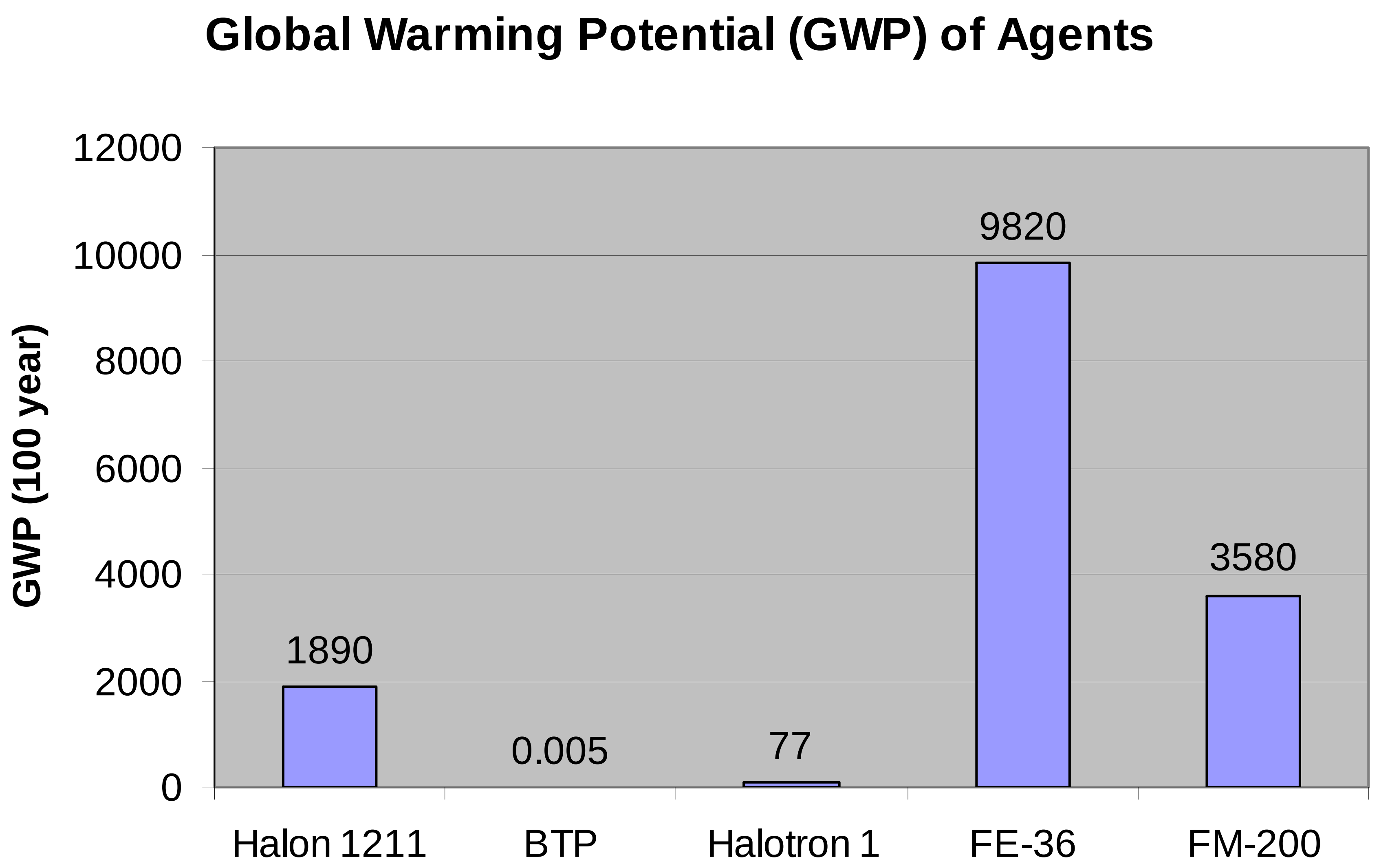
| Agent | UL 711 Rating | Agent Weight (#) | Total Weight (#) | Dimensions (H x W x D) | ODP | GWP (100 year) |
|---|---|---|---|---|---|---|
| Halon 1211 | 5 BC | 2.5 | 3.93 | 17 x 4.8 x 3.25 | 7.9[1] | 1890 [1] |
| **BTP** | **5 BC** | **3.75** | **5.6** | **15.75 x 5 x 3.5** | **0.0028[2] (3D -model)** | **0.005[2]** |
| Halotron 1 (HCFC Blend B) [3] | 5 BC | 5.5 | 9.3 | 15 x 5 x 4.25 | 0.01 [1] | 77 [1] |
| FE-36 (HFC-236fa) | 5 BC | 4.75 | 9.5 | 15.9 x 8 x 4.5 | 0 | 9820 [1] |
| FM-200 (HFC-227ea) | 5 BC | 5.75 | 9.8 | 16.6 x 6.5 x 4.4 | 0 | 3580 [1] |

1. World Meteorological Organization Report No. 52 – "Scientific Assessment of Ozone Depletion: 2010." (Note that Halotron ODP was rounded up from 0.0098).
http://ozone.unep.org/Assessment_Panels/SAP/Scientific_Assessment_2010/index.shtml

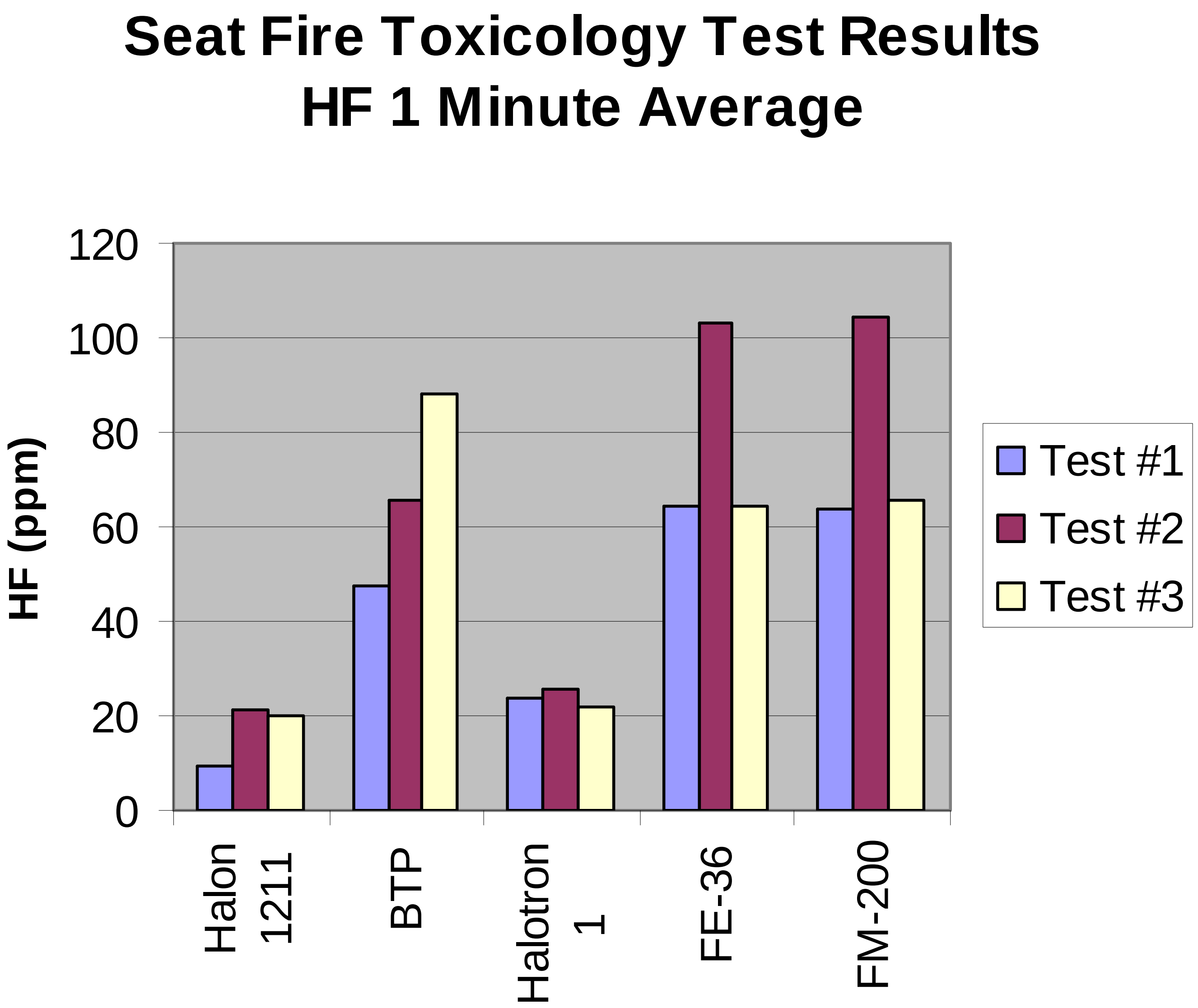
2. University of Illinois at Urbana-Champaign Report "2-Bromo-3,3,3-Triflouropropylene Ozone Depletion Potentials and Global Warming Potentials" dated December 22, 2010, author Kenneth Patten and Donald Wuebbles. (Note that ODP/GWP values vary depending on the assumed geographical distribution of BTP release. The latitudes considered include the U.S. and EU).

3. HCFC -123 (primary constituent of Halotron 1) is subject to US production phase-out in 2015. Supply will be limited to recycling after 2015 unless HCFC-123 is removed from the Montreal Protocol, or the Clean Air Act is amended.

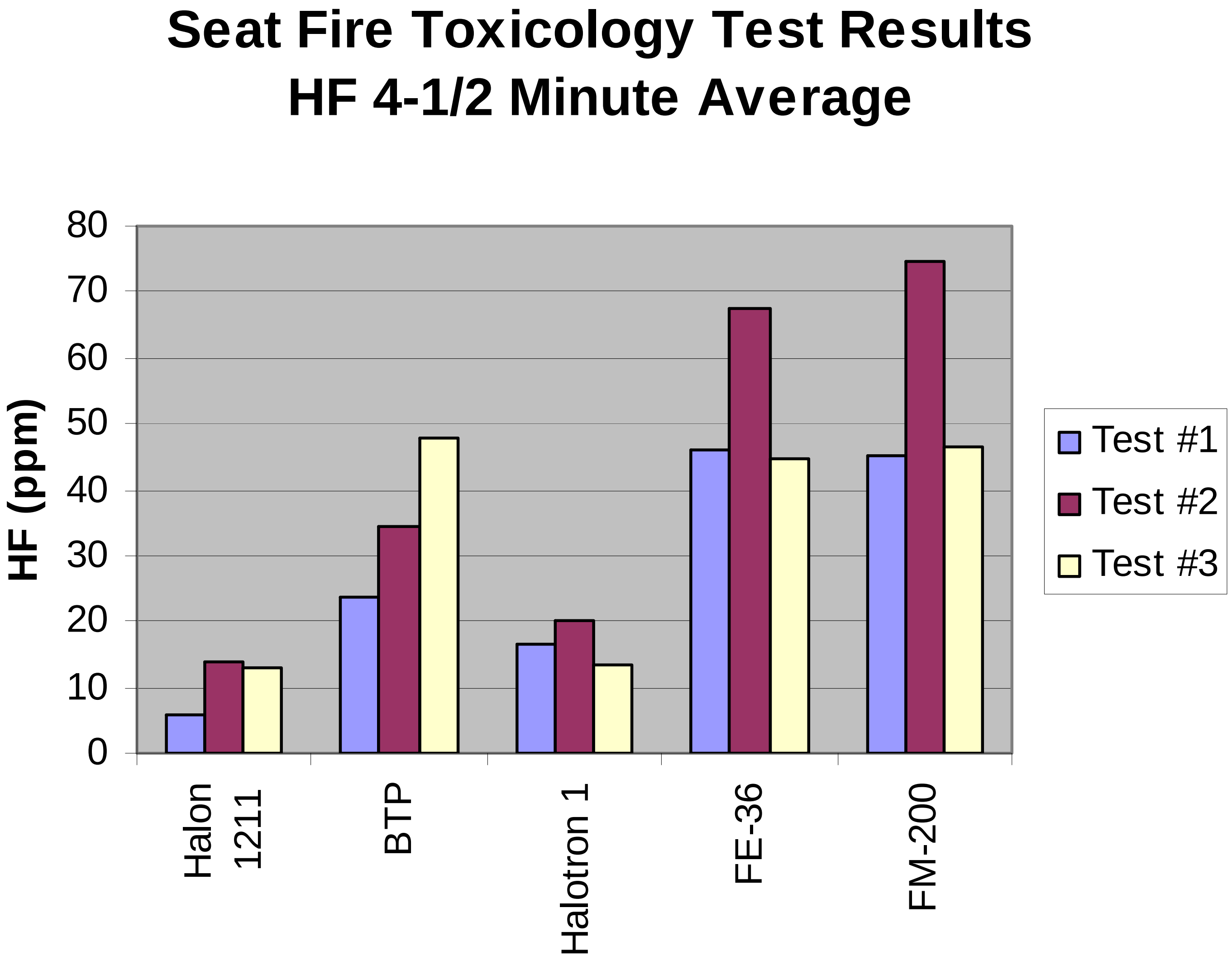
# Agent Summary



# Agent Summary



# Agent Summary



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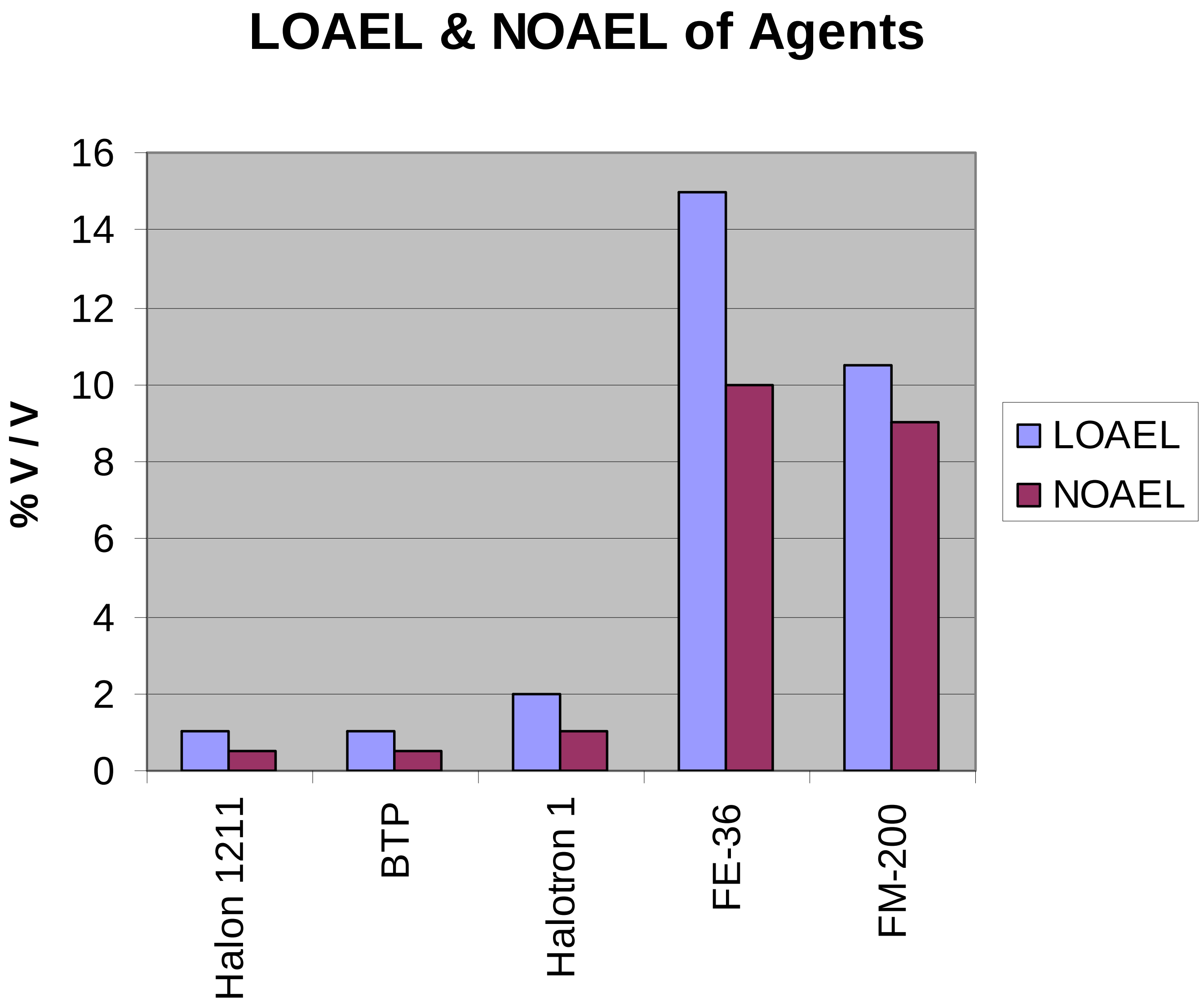

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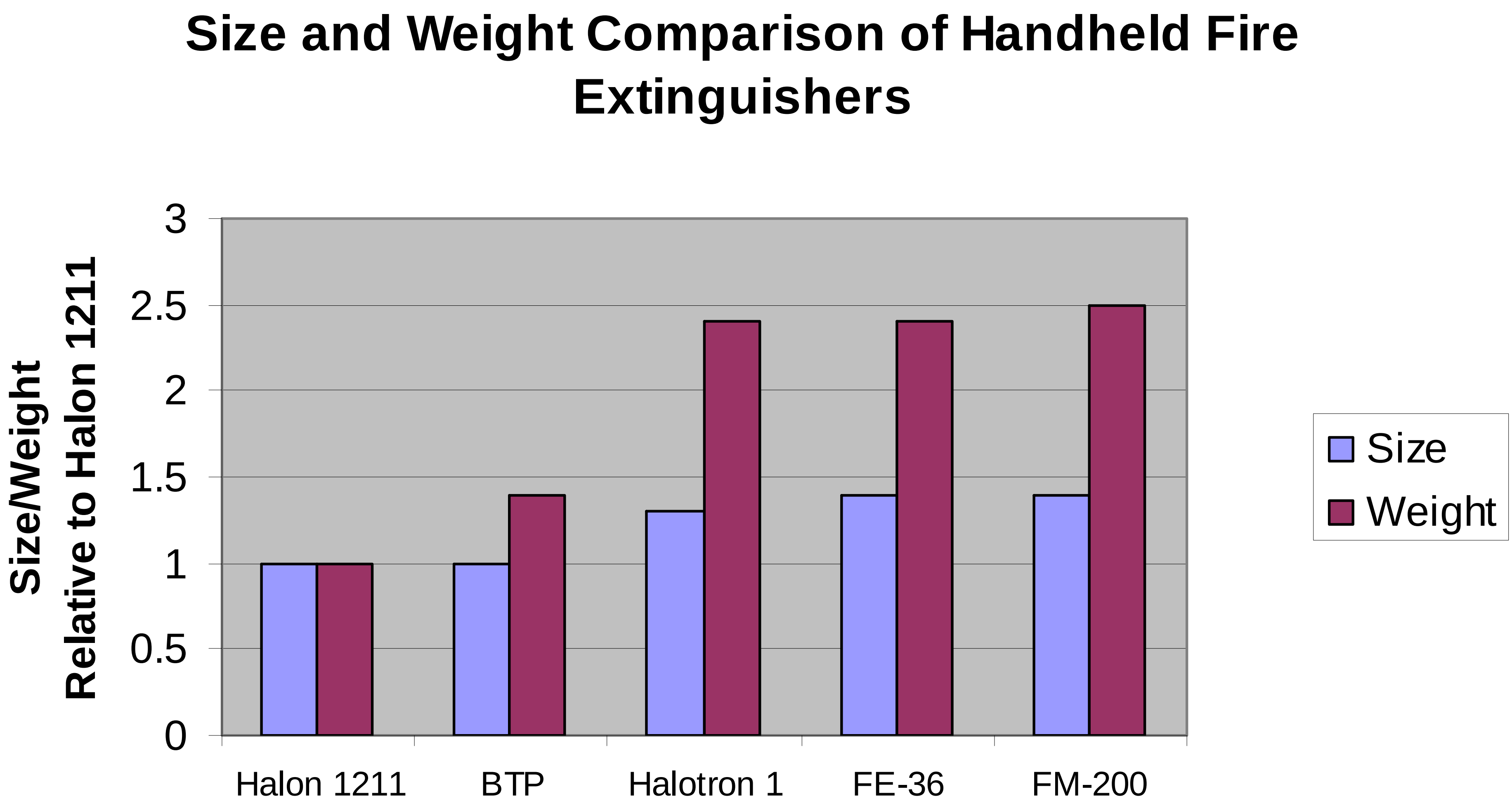
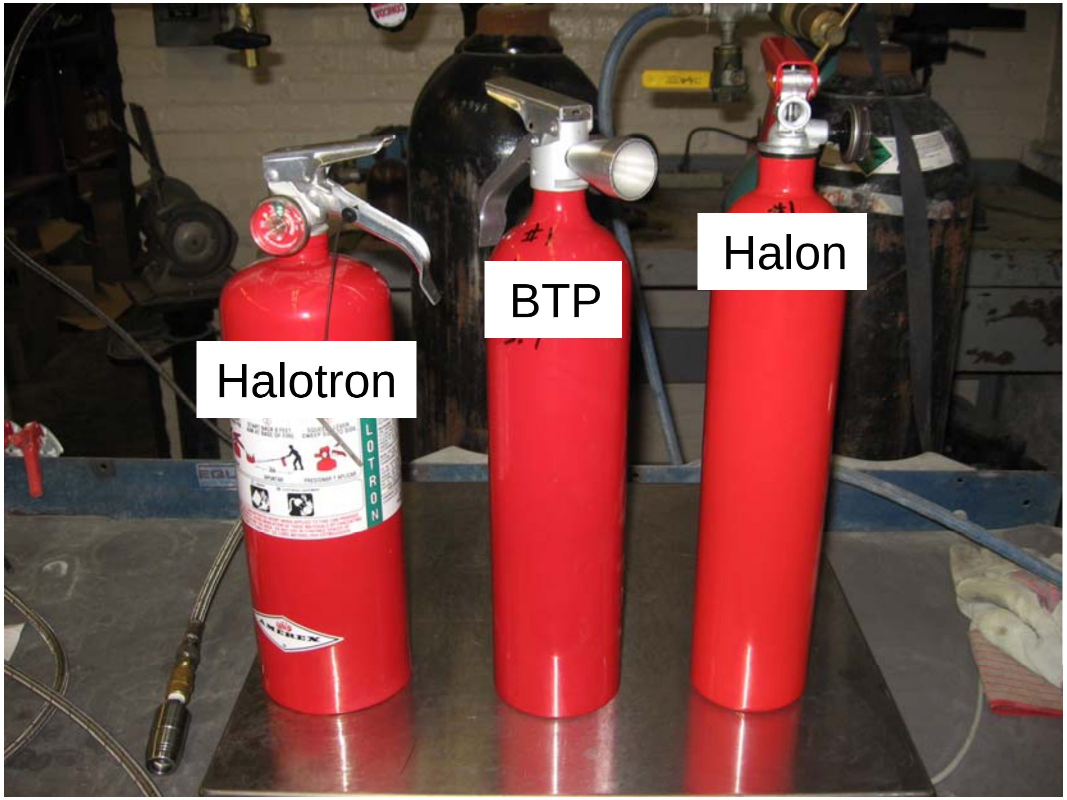


# Fire Extinguisher Installation

**Validation fit-check of 3.5” diameter BTP fire extinguisher was conducted on Boeing production models**

- **Diameter of existing production bottle used for BTP prototype caused Interference on 737 models**
- **Boeing is developing a 3.25” diameter bottle of the same volume**



# Fire Extinguisher Installation

Example of a 737 installation (bracket is removed)

# Fire Extinguisher Installation

Example of a 737 installation

# Fire Extinguisher Installation

Example of a 777 installation

# BTP Near-term Steps

- **Submit paper on 3D atmospheric modeling (ECD 3Q11)**

- **Toxicology testing (ECD 2Q13)**
  - Primarily subchronic, reproductive toxicity, PBPK, irritation

# BTP Risks

- **Must pass all toxicity tests prior to SNAP/REACH approval.**
- **Low volume production cost of BTP is high compared to Halon and alternatives. Expanding BTP market beyond airplane use will lower cost.**

**Boeing considers the higher price acceptable for the following reasons:**

**•Allows retrofit of existing airplanes with minimal impact to airlines**
**•Allows production incorporation with minimal cost and impact**
**•Provides a long term industry solution that is safe for the environment**
**•It is airplane safety equipment**

# BTP Risks

**Per AC20-42D - Halon 1211, Halotron 1, and BTP are unsafe for use in Boeing airplane flight decks and other small volumes.**

- **AC 20-42D, Chapter 4.4b(3), (4) states that concentrations may be adjusted to account for stratification…a report will be published at the FAA Technical Center with method to adjust safe-use concentrations.**

**The report providing necessary guidance to show compliance has not been developed or released.**

**Need to reconvene the Handheld Working Group and develop guidance material based on stratification testing**

# Summary

- **BTP does not have the environmental, size, or weight issues of existing FAA approved halon replacement fire extinguishers/agents.**

- **BTP is a promising, environmentally safe, drop-in replacement.**
  - **3D model validated near zero ODP and GWP.**
  - **Passed UL 711 5B, 2B cold temperature, and FAA MPS tests.**
  - **Passed Boeing aircraft material compatibility tests.**

- **Boeing has funded toxicology testing and is working toward commercialization of BTP.**

***Boeing's goal is to replace Halon portable fire extinguishers just one time, and with an environmentally acceptable agent.***

# Questions?

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