Handheld Fire Extinguisher MPS Update

Systems Working Group Meeting
Koeln, Germany

By: Robert Morrison

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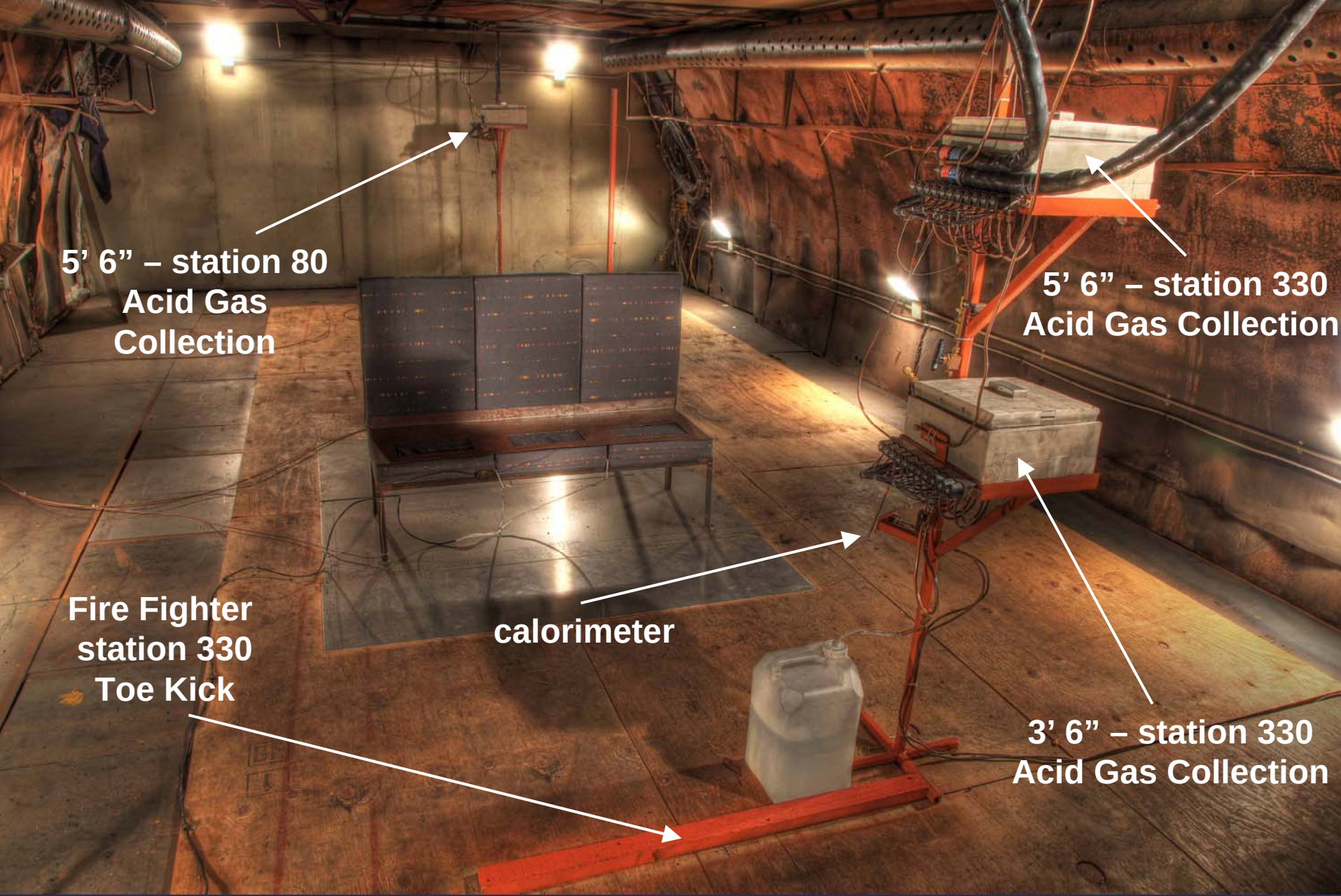
Federal Aviation Administration

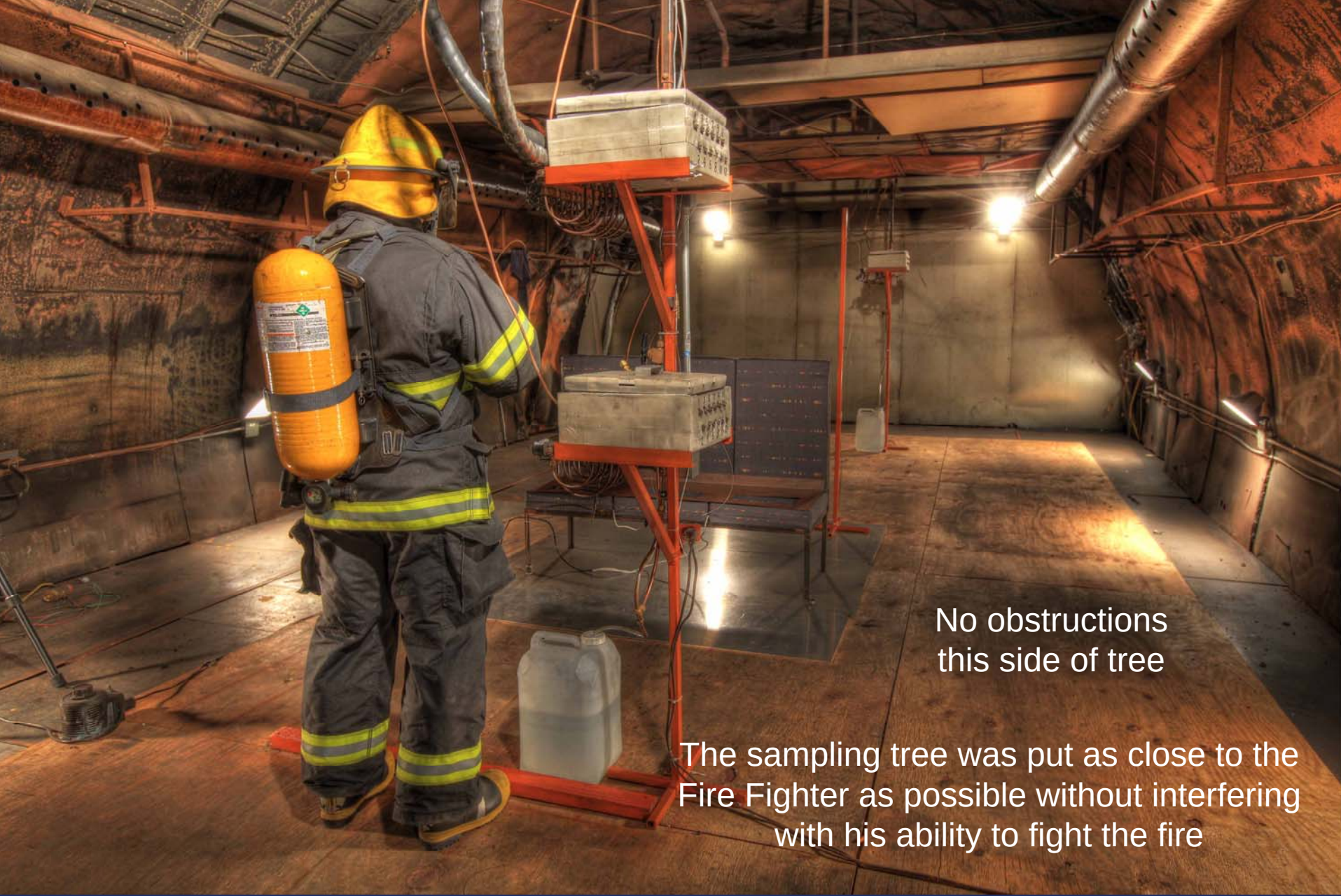
Topics

- **Recreating the 1999 MPS seat test setup**
- **Achieving hydrogen fluoride (HF) numbers**
- **Replacing gasoline as a test fuel**
- **Comparing test data**
- **Future Work**
  - Fire Extinguisher Market Survey

Recreating MPS Seat Fire Test Setup

- **Started collecting as many of the original test setup parts**
  - We recovered all 3 acid gas collection ice bath boxes with control system solenoids and sample pumps
- **The original components were overhauled or replaced**
  - All 3 acid gas boxes were reinsulated, leak checked, and reused
  - Reused one sample pump
  - Discarded the old solenoids in favor of newer more compact ones
- **Acid gas sampling**
  - 3mm Glass beads are coated with a sodium hydroxide solution and loaded into 4mm ID sample tubes
  - Sample tubes are loaded into an ice water bath and connected to a sample pump, flowmeter, and control solenoid
  - Sampling system control solenoids activate each consecutive sample tube for 30 seconds for a duration of 5 minutes
  - Ion Chromatography (IC) Gradient Elution method is used for analysis


5’ 6” – station 80
Acid Gas
Collection
5’ 6” – station 330
Acid Gas Collection
Fire Fighter
station 330
Toe Kick
calorimeter
3’ 6” – station 330
Acid Gas Collection


No obstructions
this side of tree
The sampling tree was put as close to the Fire Fighter as possible without interfering with his ability to fight the fire

Fire fighter positioned behind the 6’ toe kick board

Recreating MPS Seat Fire Test Setup

- **New testing area**
  - Original MPS test area is no longer available
  - Front of TC-10 has been redesigned, so we moved the test to back of TC-10.
  - New test area works out to be 7,935.4 ft^3 and uses the original ventilation ducts
- **Updated instrumentation and data acquisition system**
  - Rosemont infrared analyzers are used to collect Agent, CO, CO_2, and O_2 concentrations
  - 900 channel Adwin data acquisition system for storage
  - Total Hydrocarbon (THC) analyzer added to collect support data
  - Fourier Transform InfraRed (FTIR) analyzer added to collect support data
- **Cabin air exchange rate set to 1 every 5 minutes**

Achieving HF Numbers

- **Reproducing the 1999 HF numbers was elusive**
- **It took 8 tests to find the best combination of fuel pour rate, fuel soak time, and position of template on the seat cushions without sacrificing seat fire intensity**
- **Types of adjustments made while working inside the MPS guidelines to achieve the 1999 HF numbers**
  - Gasoline template pour size (minimal effect on fire intensity)
    - Ranged from 12” x 6” to 16” x 14” (full seat bottom)
  - Gasoline template position on seat cushion (no effect on fire intensity)
    - Ranged from 2” to 3 “ from each seat cushion edges
  - Gasoline pour rate (large effect on fire intensity)
    - Ranged from 30 seconds to 1 minute
  - Gasoline soak time to ignition (large effect on fire intensity)
    - Ranged from 1 minute to 4 minutes

Achieving HF Numbers

- **We went as far as we could using gasoline as a test fuel and couldn't achieve the 1999 HF numbers**
  - We were shooting for 20 ppm (1 min) and 13 ppm (4.5 min)
    - This was the average of the 2 highest tests out of the 3 1999 tests
  - Lowest gasoline HF value we achieved was 32 ppm (1 min) and 14 ppm (4.5 min)
  - Worst value was 55 ppm (1 min) and 26 ppm (4.5 min)
- **MPS test fuel**
  - Ethanol wasn't present in the 1999 fuel blends and the fuel used in the 1999 tests wasn't tested
  - Today's gasoline blend is allowed to go up to the posted 10% ethanol on the pumps, but usually is found to have around 3%.
  - The EPA is now endorsing E15 (15% ethanol/ 85% Gasoline)
  - We either had to scale our test data or change our test fuel
- **Because of the variability in gasoline blends, we started running tests using N-Heptane**

Achieving HF Numbers

Test No.	1999 #1	1999 #2	1999 #3	2011 #7	2011 #9	Comments
Agent Tested	Halon 1211	Halon 1211	Halon 1211	Halon 1211	Halon 1211	
Highest HF 1 minute (ppm) 4.5 minute (ppm)	**9.28 6.01**	**21.04 13.87**	**19.83 12.92**	**33.4 20.4**	**21.6 11.1**	HF<200 1 min HF<100 4.5 min
Agent Used (lbs)	1.2	0.8	0.96	0.616	.652	
Discharge Time (sec)	6	4.5	4.7	1.96	1.85	
BTU	0.35	0.45	0.36	0.548	0.437	
Peak H1211 10s avg (%)	0.065	0.054	0.058	0.0226	0.022	
Peak CO (%)	0.01	0.035	0.055	0.15	0.401	
Peak CO2 (%)	0.06	0.18	0.16	0.282	Bad Data	
Peak Cabin Temp (°F)	85	82	80	110	113	
Template				12” x 6”	12” x 6”	

Comparing Halon 1211 Test Data

Test No.	1999 #1	1999 #2	1999 #3	2011 #15	2011 #16	2011 #17	
Agent Tested	Halon 1211	Halon 1211	Halon 1211	Halon 1211	Halon 1211	Halon 1211	
Highest HF 1 minute (ppm) 4.5 minute (ppm)	**9.28 6.01**	**21.04 13.87**	**19.83 12.92**	**20.5 11.7**	**20.4 11**	**25.8 14.6**	HF<200 1 min HF<100 4.5 min
Agent Used (lbs)	1.2	0.8	0.96	.644	.638	.566	
Discharge Time (sec)	6	4.5	4.7	2.14	2.35	2.04	
BTU	0.35	0.45	0.36	0.561	0.628	0.692	
Peak H1211 10s avg (%)	0.065	0.054	0.058	0.024	0.018	0.019	
Peak CO (%)	0.01	0.035	0.055	0.0017	0.002	0.002	
Peak CO2 (%)	0.06	0.18	0.16	0.211	0.212	0.245	
Peak Cabin Temp (°F)	85	82	80	112	111	122	
Comments	Gasoline			N-Heptane			

Replacing MPS Test Fuel

- **Lowest gasoline HF value achieved was 32 ppm (1 min) and 14 ppm (4.5 min)**
  - Worst value was 55 ppm/26 ppm
- **Lowest N-Heptane HF value achieved was 18.6 ppm (1 min) and 9.5 ppm (4.5 min)**
  - Worst value was 47.5 ppm/23.8 ppm
- **3 test N-Heptane HF average of 21 ppm/ 11 ppm was more in line with 1999 numbers**
- **Decision was made to change from Gasoline to N-heptane as MPS test fuel**
- **Tested Halotron BrX (2-BTP)**

Test No.	15	16	17	12	13	14	Comment
Test Date	03/01/2011	03/02/2011	03/03/2011	02/08/2011	02/09/2011	02/10/2011	
Agent Tested	Halon 1211	Halon 1211	Halon 1211	BTP-2	BTP-2	BTP-2	
Highest HF 1 minute (ppm) 4.5 minute (ppm)	20.5 11.7	20.4 11	25.8 14.6	47.8 23.9	65.7 34.5	88.2 47.7	HF<200 1 min HF<100 4.5 min
Agent Used (lbs)	.644	.638	.566	1.852	1.756	1.55	
Discharge Time (sec)	2.14	2.35	2.04	2.2 1st shot 1 2nd shot	3.83	1.96 1st shot 1.95 2ndshot	
BTU	0.561	0.628	0.692	0.525	0.625	0.499	
Peak H1211 10s avg (%)	0.024	0.018	0.019	0.0316	0.338	0.0321	
Peak CO (%)	0.0017	0.002	0.002	0.002	0.002	0.004	
Peak CO2 (%)	0.211	0.212	0.245	0.22	0.249	0.232	
Peak Cabin Temp (°F)	112	111	122	113	110	105	
Comments				Used Like A 1211 Novice	Back & Forth Sweeping	Quick Back & Forth Sweeping	

Test No.	15	16	17	18	19	20	Comment
Test Date	03/01/2011	03/02/2011	03/03/2011	03/22/2011	03/23/2011	03/24/2011	
Agent Tested	Halon 1211	Halon 1211	Halon 1211	None	None	None	
Highest HF 1 minute (ppm) 4.5 minute (ppm)	20.5 11.7	20.4 11	25.8 14.6	1 1	0.7 0.7	0.3 0.3	HF<200 1 min HF<100 4.5 min
Agent Used (lbs)	.644	.638	.566	N/A	N/A	N/A	
Discharge Time (sec)	2.14	2.35	2.04	N/A	N/A	N/A	
BTU	0.561	0.628	0.692	.396	0.417	0.408	
Peak H1211 10s avg (%)	0.024	0.018	0.019	N/A	N/A	N/A	
Peak CO (%)	0.0017	0.002	0.002	0.002	0.002	0.002	
Peak CO2 (%)	0.211	0.212	0.245	0.428	0.362	0.392	
Peak Cabin Temp (°F)	112	111	122	138	134	134	
Comments				Uncontrolled Fire Tests			

MPS Conclusions

- **Reused the original acid gas collection system to obtain current test data**
- **Seat template size, position, and air exchange rates have little or no effect on seat fire intensity**
- **Gasoline pour speed and soak time have a dramatic effect on seat fire intensity**
- **1999 HF levels could not be obtained using today's ethanol enhanced gasoline blends**
- **1999 Halon 1211 gasoline tests correlate very well with 2011 Halon 1211 N-Heptane tests**
- **N-Heptane is the new MPS test fuel**
- **MPS revision?**
  - Could be an appendix or complete report update

Future Work

- **Fire Extinguisher Optimization Market Survey**
  - We are putting out a contract for optimization of a 5BC hand held extinguisher using a SNAP approved streaming agent
  - Looking for the lightest, smallest volume, most practical design to replace the Halon 1211 unit
  - Evaluation criteria
    - Performance
      - MPS hidden fire test
    - Ease of Use
    - Size, weight, design type