Variable Pressure Isothermal Flammability Comparison Tests

Federal Aviation Administration

William Cavage
Federal Aviation Administration
Fire Safety Branch

International Aircraft Systems Fire Protection Working Group
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Outline

- Overview
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  - Problem Statement
- Apparatus and Test Methods
- Preliminary Results
- Planned Work

Overview - Background

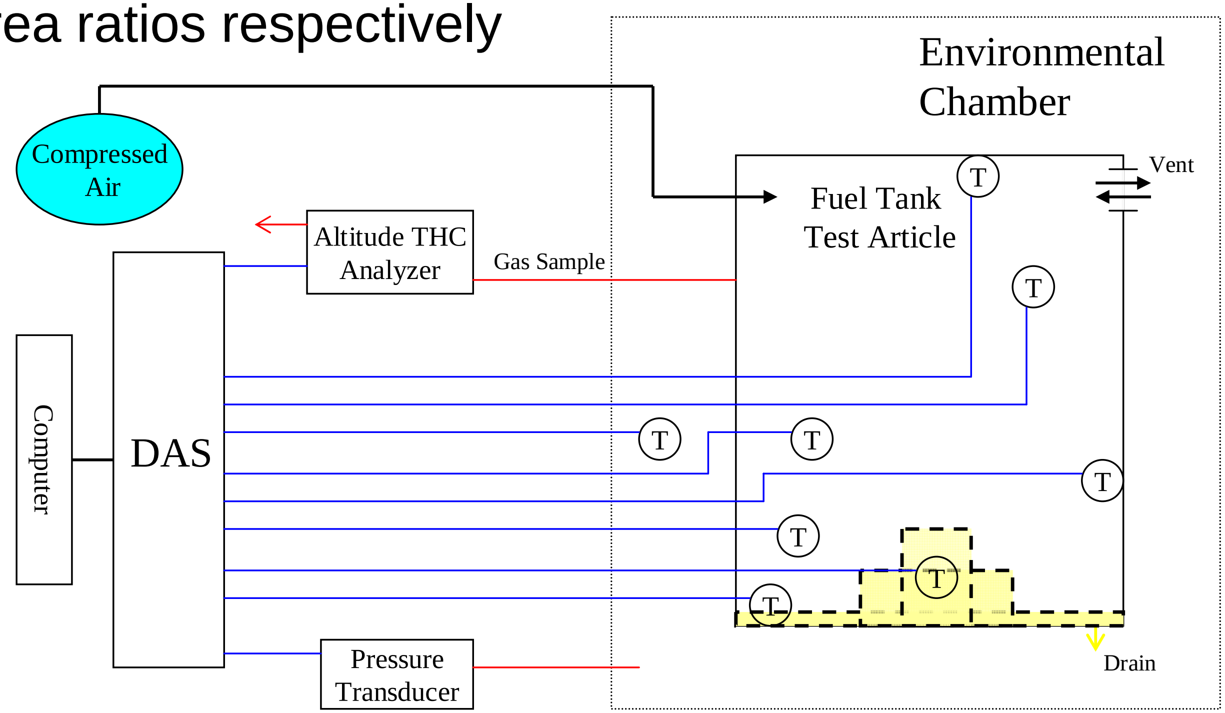
- Recent FAA rulemaking and regulation now requires manufacturers and operators to quantify and limit fuel tank flammability
  - Long awaited rule has been published
  - Presently in the first phase of planning and specifying
- Understanding of various factors affecting flammability is more important then ever
  - We have a basic model of isothermal flammability given F.P. and distillation) created by Ivor Thomas and modified by Steve Summer which has had some validation at reduced pressures
  - Beginning to understand the mechanisms that effect wing tank flammability in flight and have some predictive capability
  - Many secondary factors effecting flammability have never been studied in depth

Overview - Problem

- Evaporation models and theory illustrate that the rate at which hydrocarbon vapors evolve from fuel depends on the surface area of the fuel in the tank
  - This means the geometry of the fuel tank can effect the progression of flammability when the pressure in the tank ullage is changing (accent and descent)
  - These kinds of transient and geometric effects have never been studied separately and is assumed to be overshadowed by the greater temperature/pressure effect seen during a flight cycle
- The rate at which pressure changes during a flight cycle could potentially have a large effect on the rate of change of ullage flammability

Test Apparatus – Scale Aluminum Fuel Tank

- Used existing 17 ft^3 aluminum fuel tank in environmental chamber with different size fuel pans (fuel surface areas)
  - Baseline test used entire bottom of tank (35.5 x 35.5 inch surface area). Also had 8 x 10 pan and 10 x 16 pan which gave 16/1 and 8/1 surface area ratios respectively
  - All tests used about 3 gals of fuel (680 in^3)
  - Had two temperatures in fuel pan
  - Sampled THC intermittently

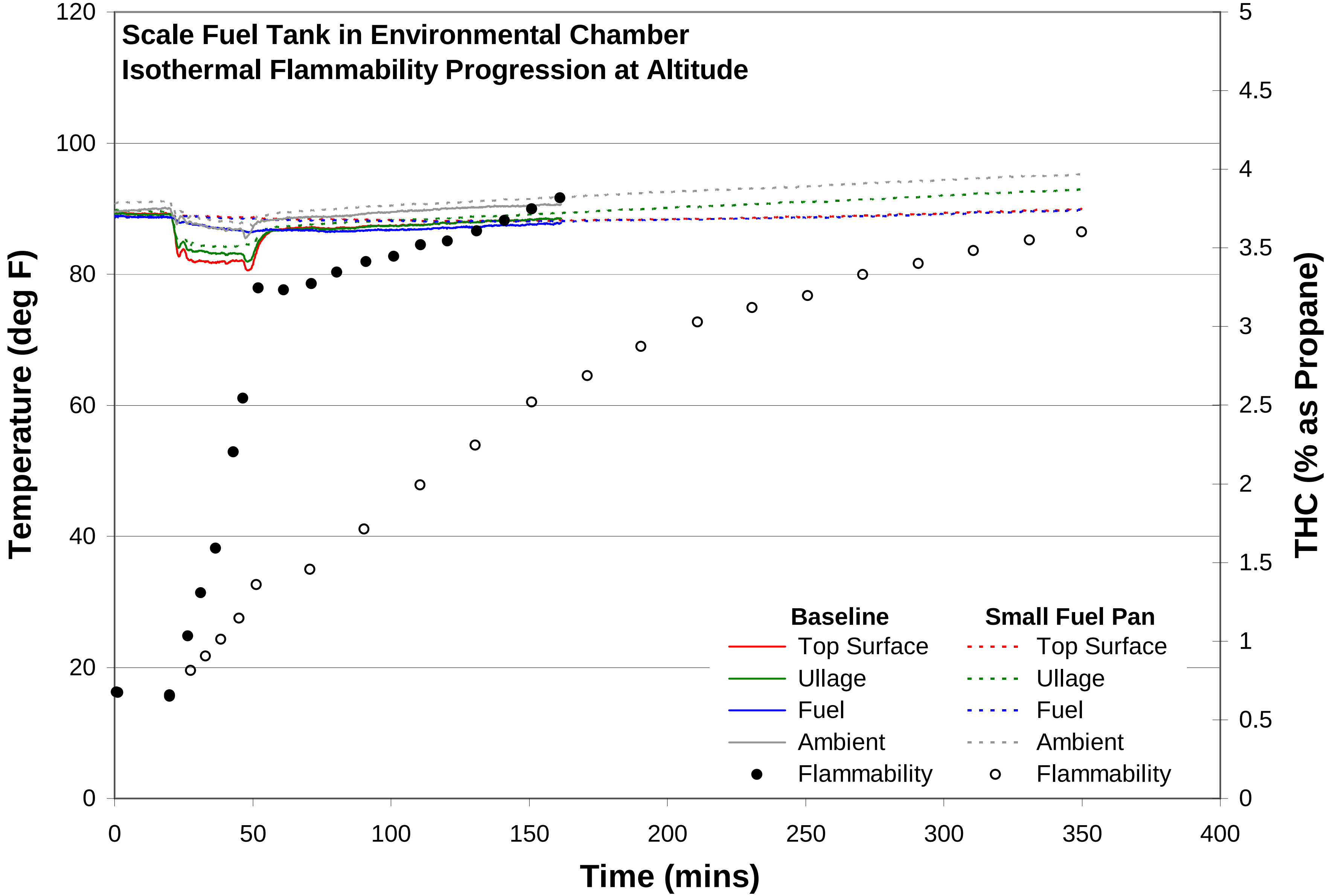


Test Methods – Scale Aluminum Fuel Tank

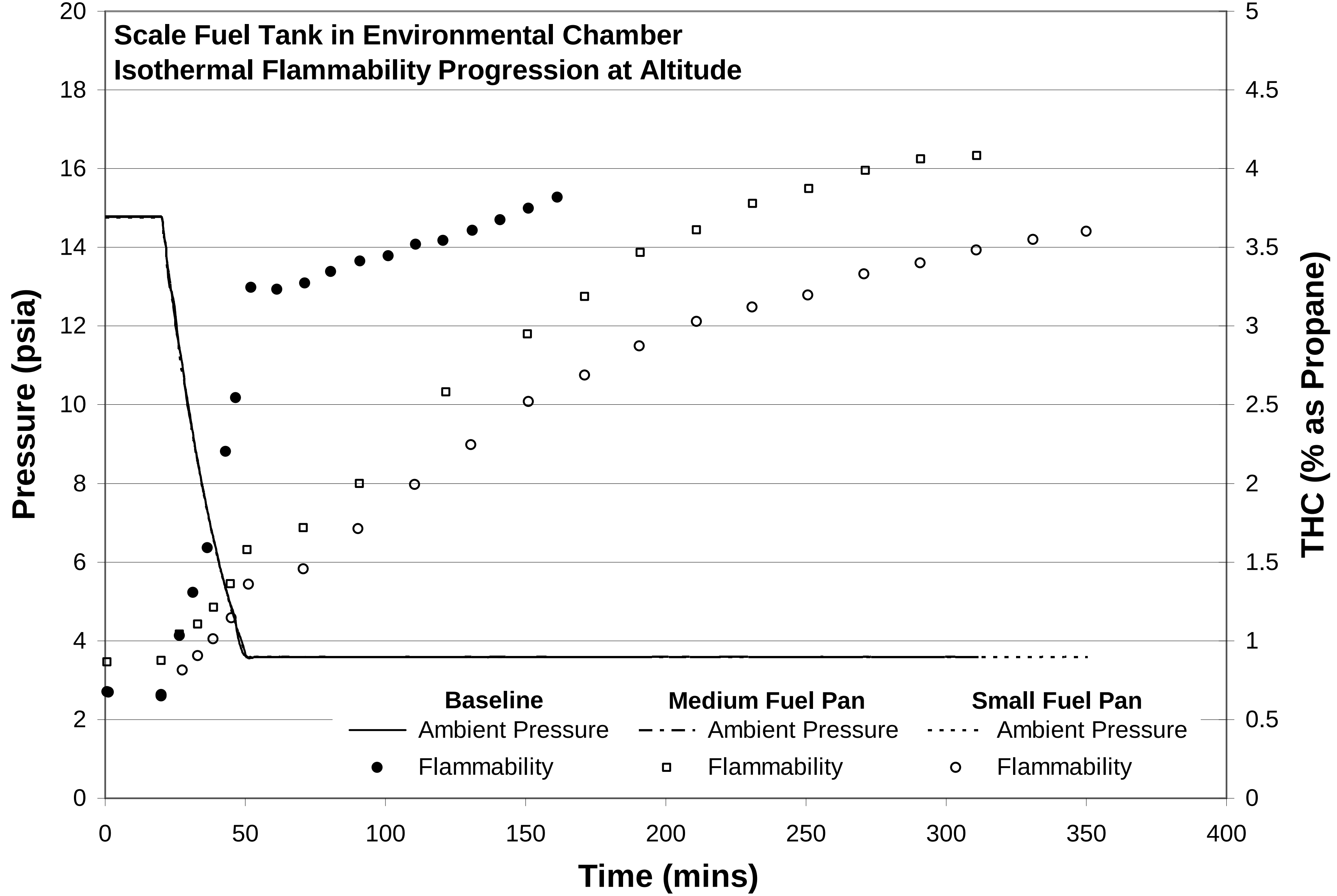
- Did three different identical tests, each having a different size fuel pan (surface area), with 90 deg F ambient temperature and no heating, with a given pressure profile
  - Baseline used entire tank bottom (about ½ inch of fuel)
  - All tests had same fuel and tank volume
  - Also compared two tests with different pressure profiles (ascent rates) using a constant 3.5 psia “cruise” pressure for all tests

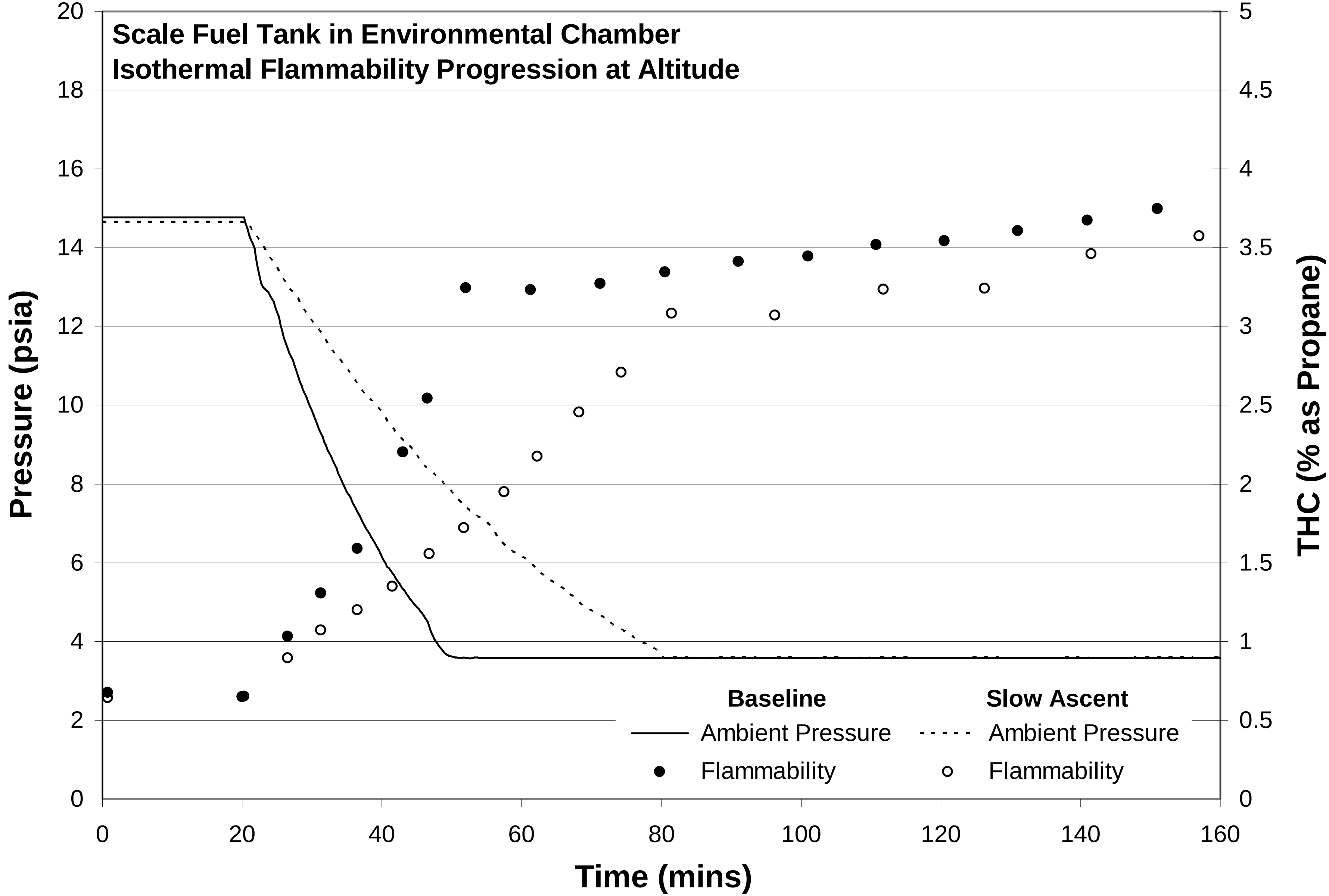
Preliminary Results - Scale Aluminum Fuel Tank

- Testing shows large differences in the time progression of flammability for different surface area of fuel given the same volume of fuel and ullage, and pressure profile
  - Could not keep all temperatures isothermal during climb do adiabatic cooling effects but fuel temperature deviated very little during tests
  - Difficult to obtain stable flammability data for all size fuel pans but data trends appear to converge on similar equilibrium THC
- Slowing the ascent rate does change the progression of flammability as expected
  - Pressure is the driving force behind the flammability change in time so changing the time to achieve the “cruise” pressure changes the amount of fuel vapor evaporated in time



Scale Fuel Tank in Environmental Chamber
Isothermal Flammability Progression at Altitude
Temperature (deg F)
THC (% as Propane)
Time (mins)
0
20
40
60
80
100
120
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
50
100
150
200
250
300
350
400
Baseline
Small Fuel Pan
Top Surface
Ullage
Fuel
Ambient
Flammability
Top Surface
Ullage
Fuel
Ambient
Flammability


Scale Fuel Tank in Environmental Chamber
Isothermal Flammability Progression at Altitude
Pressure (psia)
THC (% as Propane)
Time (mins)
0
2
4
6
8
10
12
14
16
18
20
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
50
100
150
200
250
300
350
400
Baseline
Medium Fuel Pan
Small Fuel Pan
Ambient Pressure
Flammability
Ambient Pressure
Flammability
Ambient Pressure
Flammability



Scale Fuel Tank in Environmental Chamber
Isothermal Flammability Progression at Altitude
Pressure (psia)
THC (% as Propane)
Time (mins)
Baseline
Slow Ascent
Ambient Pressure
Flammability
Ambient Pressure
Flammability
0
2
4
6
8
10
12
14
16
18
20
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
20
40
60
80
100
120
140
160

Planned Work

- Re-baseline with new batch of fuel and do test with increased amounts of fuel with same baseline fuel surface area

- Examine other tank geometries?

- ??????????????