Composite and Aluminum Wing Tank Flammability Comparison Testing

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Overview - Background

- Recent FAA rulemaking and regulation has focused on improving the safety of the fleet through more thorough systems analysis and ignition source reduction
  - FAA proposes to make a rule requiring limits on flammability of some or all CWTs with an emphasis on inerting system technologies
- Next generation aircraft scheduled to enter service in the coming years have composite skin that could change baseline fleet wing tank flammability
  - Logic assumes composite wings will be more flammable as they reject heat less effectively compared to aluminum
  - Could also absorb more heat and/or transfer heat more readily to the ullage

Overview: Wing Tank Flammability Parameters

Flammability Drivers on Ground

- Top skin and ullage are heated from sun
- Hot ullage heats top layer of fuel, causing evaporation of liquid fuel
- Bulk fuel temperature however, remains relatively low

Flammability Drivers In Flight

- Decreasing pressure causes further evaporation of fuel
- Cold air flowing over the tank causes rapid cooling and condensation of fuel vapor in ullage

➢ These concepts were observed during previous testing and reported on recently (see rpt #DOT/FAA/AR-08/8)

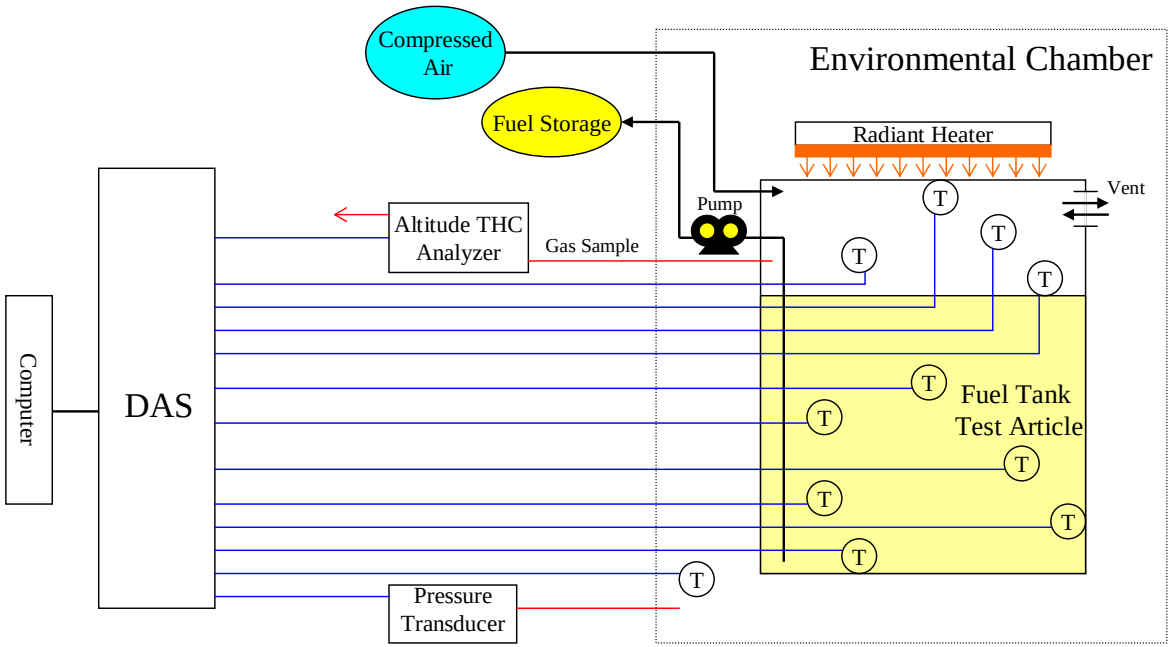
- Now want to now compare flammability progression in a wing fuel tank test article with both aluminum skin and composite skin

Test Apparatus - Wing Tank Test Article

- Had wing tank test article made from previous test article
  - Has interchangeable aluminum and composite skin panels on top and bottom and an aerodynamic front shape
  - Has vent and extensive array of thermocouples used for this testing as well as gas sample port for THC analysis

Test Apparatus - Environmental Chamber Testing

- Used recently made wing fuel tank test article in altitude chamber to compare Al and Composite Flammability
  - Did two identical tests, one with each skin, with 90 deg F ambient temperature, moderate top heat, and average F.P. fuel
  - Measured skin, ullage and fuel temperature progressions over 5-hour period



Previous Wind Tunnel Testing Results

- Previous testing of a 727 wing section mounted in the low speed section of the wind tunnel (along with other flight test data showed:
  - that even low speed aerodynamics at ambient pressures will cause a rapid decrease in flammability
  - that this cooling effect greatly overpowers any effect due to depressurization
  - similar decreases in flammability whether heat was applied to top or bottom of the tank
  - that fuel temperature in bottom heated tests decreased much more rapidly than in top heated tests
  - little change in results seen when wing was pitched at 15° relative to the wind direction
  - that cross-venting of tank resulted in a rapid decrease of tank flammability

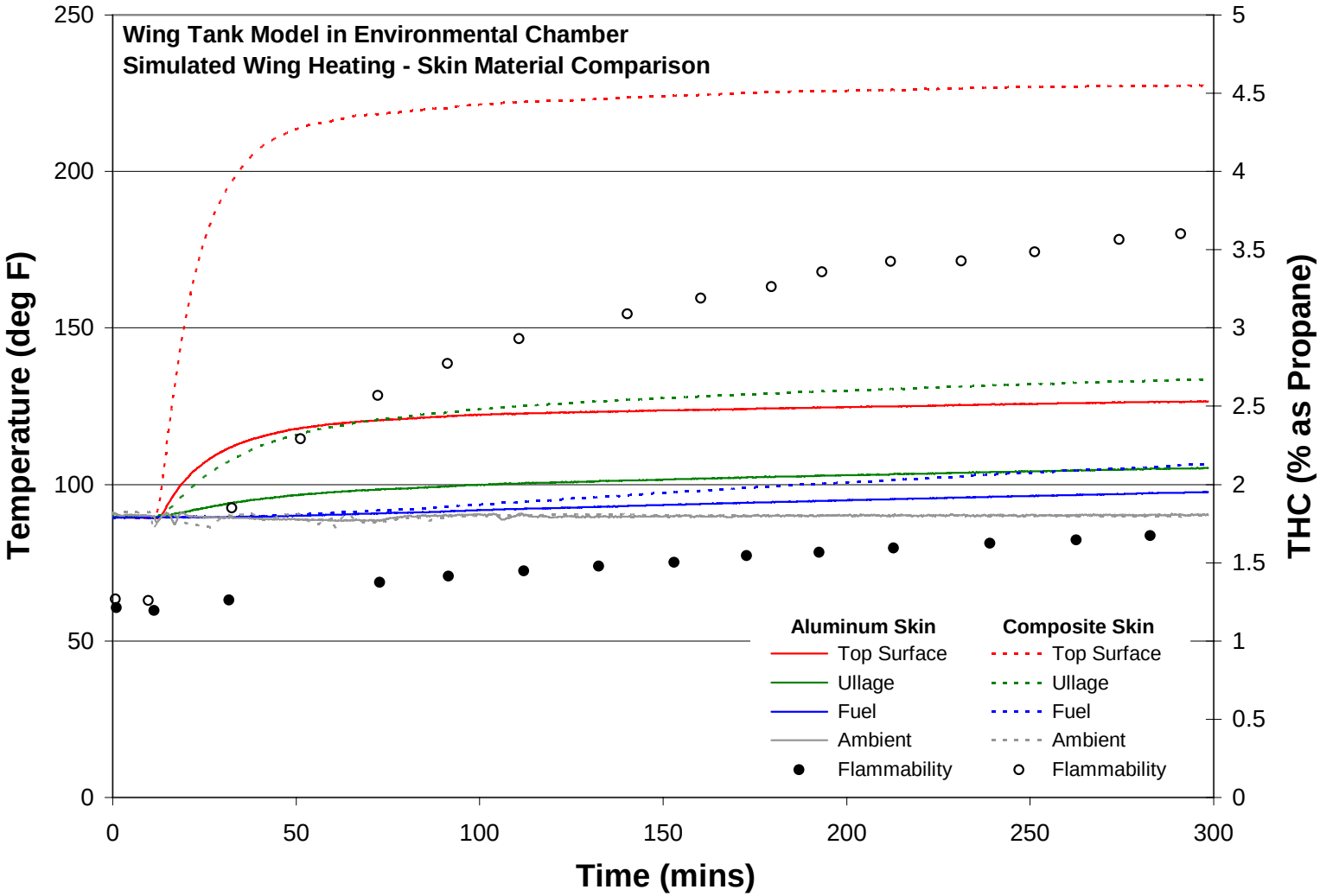
Wing Tank Test Article Planned Testing

- Tests in a similar manner to the 727 tests will be conducted with the tank that has been used in the altitude chamber
  - Tank is currently being mounted in ***high-speed*** section of wind tunnel *(this will allow us to conduct tests at much more realistic wind speeds)*
  - Testing will be conducted under varying fuel loads, fuel temperatures, and wind speeds to evaluate variation in cooling effects and its impact on tank flammability
  - In addition, tank heating will be varied by applying heat both to the top and bottom of the tank
  - Tests will be conducted with both aluminum and composite top skins to provide a comparison of composite vs aluminum tank flammability

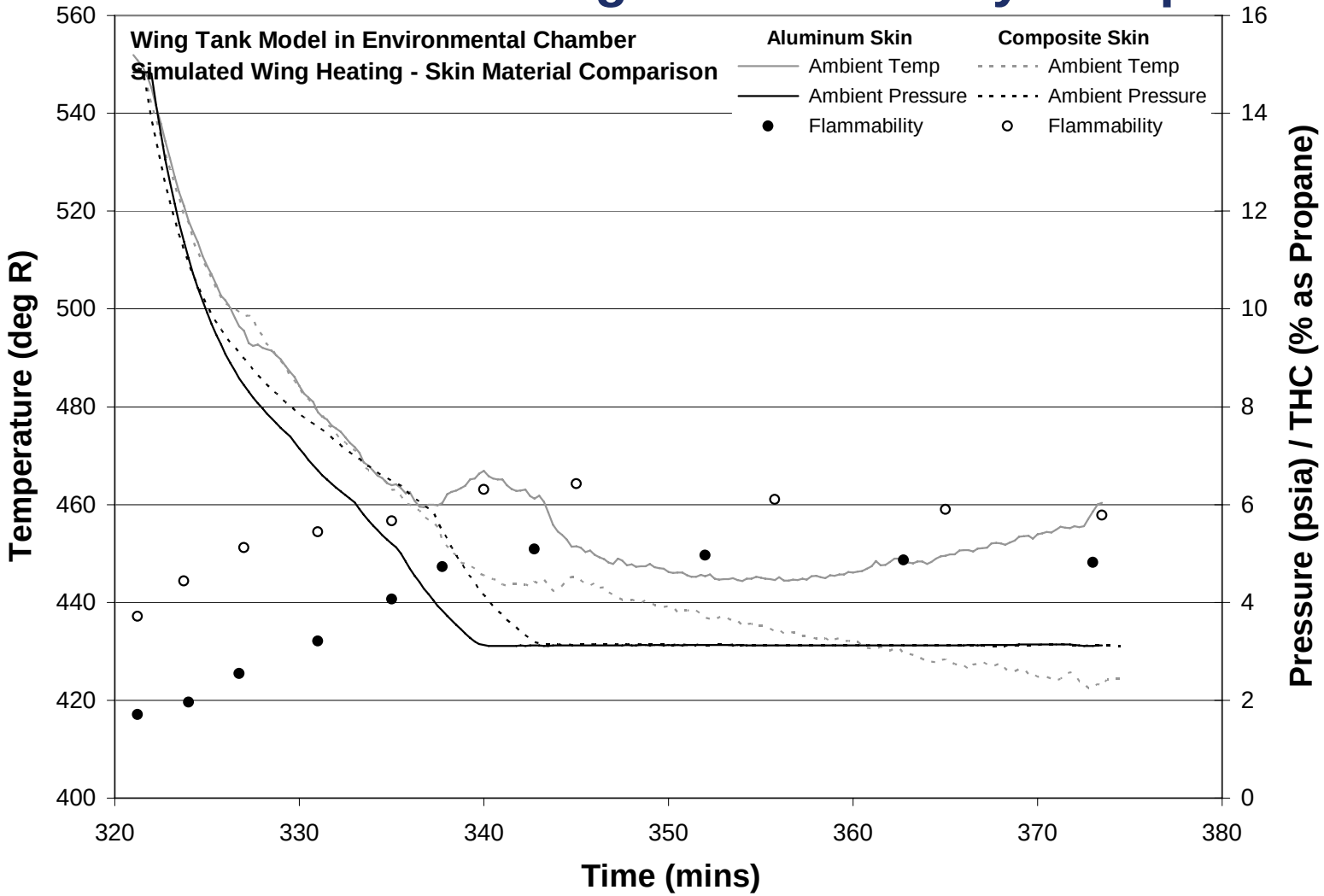
Preliminary Results - Scale Tank in Altitude Chamber

- Testing shows large increases in flammability with composite wing fuel tank skin not seen with aluminum skin when heated from top during ground conditions
  - Used same heat source, fuel flashpoint, and ambient temperature on tank with both skin surfaces
- When bringing the fuel tank to altitude and dropping the temperature, spike in flammability occurred for both
  - This is not representative of a wing fuel tank ullage because flight conditions not simulated
  - Conditions not simulated with good fidelity (different conditions)
- Preliminary data suggests center-wing flammability would not be affected significantly

Altitude Chamber Testing – Flammability Comparison



Altitude Chamber Testing – Flammability Comparison



Planned Work

- Fuel tank is currently being mounted in the wind tunnel
- Once installed and all instrumentation has been checked, testing will begin, starting with composite skin
- Testing should commence within the next 2-3 weeks and is expected to take 6-8 weeks to complete