Composite and Aluminum Wing Tank Flammability Comparison Testing

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Outline

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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

Wing Tank Model in Environmental Chamber
Simulated Wing Heating - Skin Material Comparison

Temperature (deg F)

THC (% as Propane)

Time (mins)

Aluminum Skin
- Top Surface
- Ullage
- Fuel
- Ambient
- Flammability

Composite Skin
- Top Surface
- Ullage
- Fuel
- Ambient
- Flammability
Altitude Chamber Testing – Flammability Comparison

Wing Tank Model in Environmental Chamber
Simulated Wing Heating - Skin Material Comparison

Temperature (deg R)
Pressure (psia) / THC (% as Propane)

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Aluminum Skin
- Ambient Temp
- Ambient Pressure
- Flammability

Composite Skin
- Ambient Temp
- Ambient Pressure
- Flammability

Composite Wing Tank Flammability
April 2-3, 2008
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