Federal Aviation Administration

Composite and Aluminum Wing Tank Flammability Comparison Testing

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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)

  - The objective is to now compare flammability progression in a wing fuel tank test article with both aluminum skin and composite skin with varying topcoats and thicknesses

Summary of Previous Results

The results of initial testing have been documented in FAA report DOT/FAA/AR-11/6 and is available on the Fire Safety Branch Website

- Initial testing consisted of bare composite and aluminum panels.
- Bare composite (black) resulted in significantly increased ullage temperatures, and therefore also higher flammability readings than the bare aluminum, however
  - Once airflow over the tank was initiated, temperature and flammability profiles behaved very similarly
  - When aluminum tank was heated sufficiently, and the starting temperature and flammability values were equivalent, the two tanks behaved very similarly.

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Summary of Previous Results – Topcoat Colors

- White topcoat, and black topcoat applied to aluminum panels both resulted in tank temperatures and THC measurements consistent with composite fuel tank.

- Topcoat color (white) applied to composite panel had little effect of tank temperatures and flammability levels.
  - It was believed that this was evidence, that the differences seen in previous results was not due to differences in property materials, but was rather due to the reflective behavior of the bare aluminum material.

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Summary of Previous Results – Composite Panel Thickness

- Panel heat tests with composite panels of varying thickness showed that the thinner the material is, the more readily heat transmits through it.
- Once installed on tank however, there was a large variation in results. Thus, a correlation between composite thickness and tank flammability was not able to be made.

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Current Tests

- A high reflectivity epoxy was applied to the 3/8″ thick composite panels and testing at the 40 and 80% fuel loads was repeated.
  - The objective was to validate the hypothesis that the reflective behavior of the bare aluminum material was responsible for the differences observed in the initial results.

- Tests were repeated on the various thicknesses of the composite material at an intermediate heat setting to see if any discernible correlation between composite thickness and tank flammability could be made.

Test Apparatus - Wing Tank Test Article

- Constructed wing tank test article from previous test article
  - Interchangeable aluminum and composite skin panels on top and bottom with an aerodynamic nose and tail piece
- Tank is vented and has a gas sample port for THC analysis, pressure transducer, and an extensive array of thermocouples
- Radiant panel heaters used to heat top surface to simulate ground conditions

Test Apparatus – Airflow Induction Test Facility

- Subsonic induction type, nonreturn design wind tunnel
- Induction drive powered by two Pratt & Whitney J-57 engines

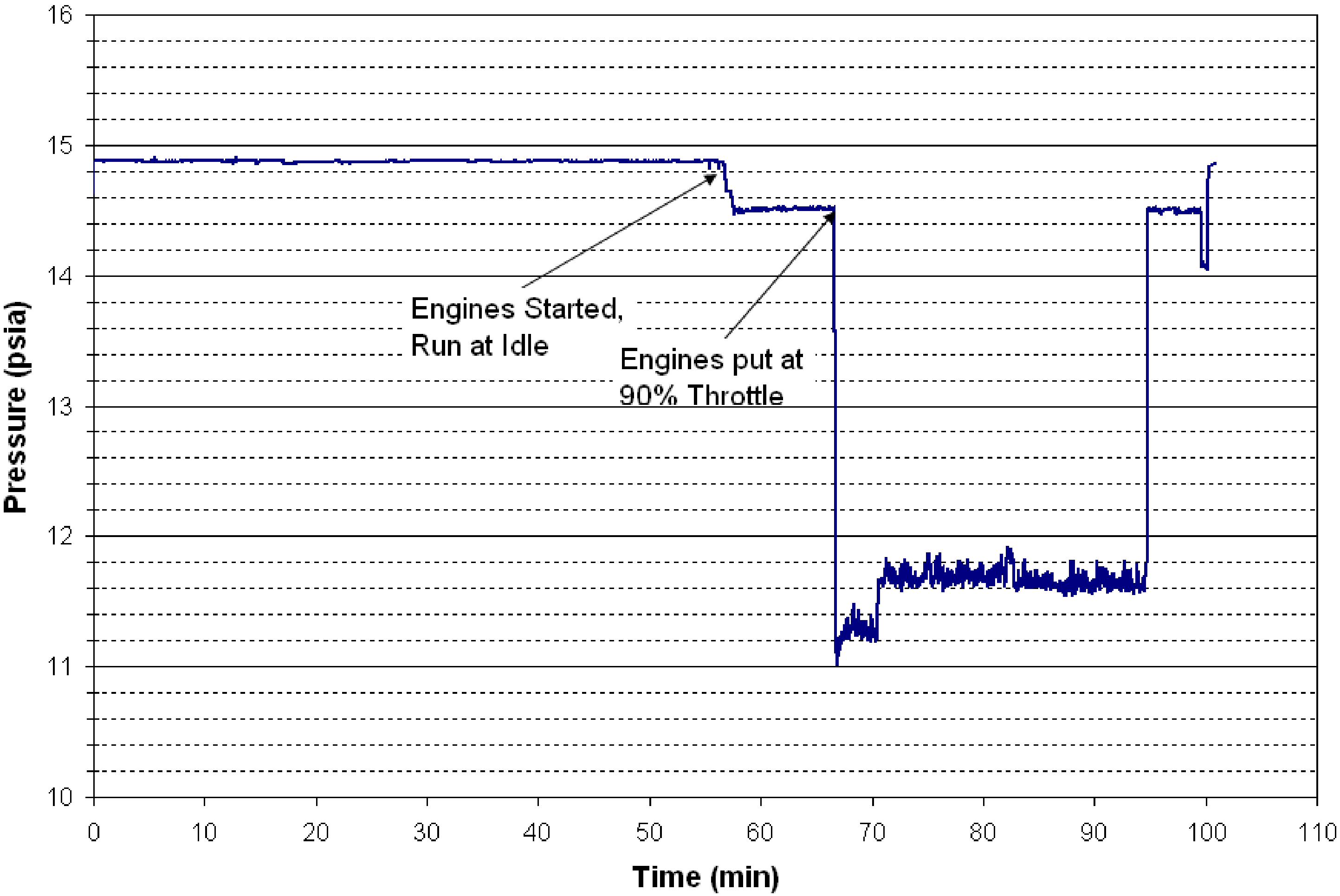
Test Apparatus – Airflow Induction Test Facility

- Test article was mounted in the high speed test section
  - 5-½ foot in diameter and 16 feet in length.

- Maximum airspeed of approximately 0.9 mach, though with the test article we measured airspeeds of approximately 0.5

Test Apparatus – Airflow Induction Test Facility

- Due to the design, a simulated altitude (i.e. reduction in pressure) is observed as the airspeed is increased.



Test Conditions – Airflow Induction Test Facility

- Fuel levels of 40, 60, 80% were examined
- Three radiant heaters used to heat top surface of tank for 1 hour prior to fueling
  - Each heater had a low/high setting
  - For intermediate heat setting, two heaters on high setting were used
- Fuel was preconditioned to 90F and transferred into the tank
- Heating of tank was continued for 1 hour at which point heaters were removed and wind tunnel was started.
- Engines initially run at idle for 5-10 minute warm up period and then taken to 90% throttle
- 90% throttle position maintained for a period of 30 minutes
- Discrete THC sample points were taken throughout testing

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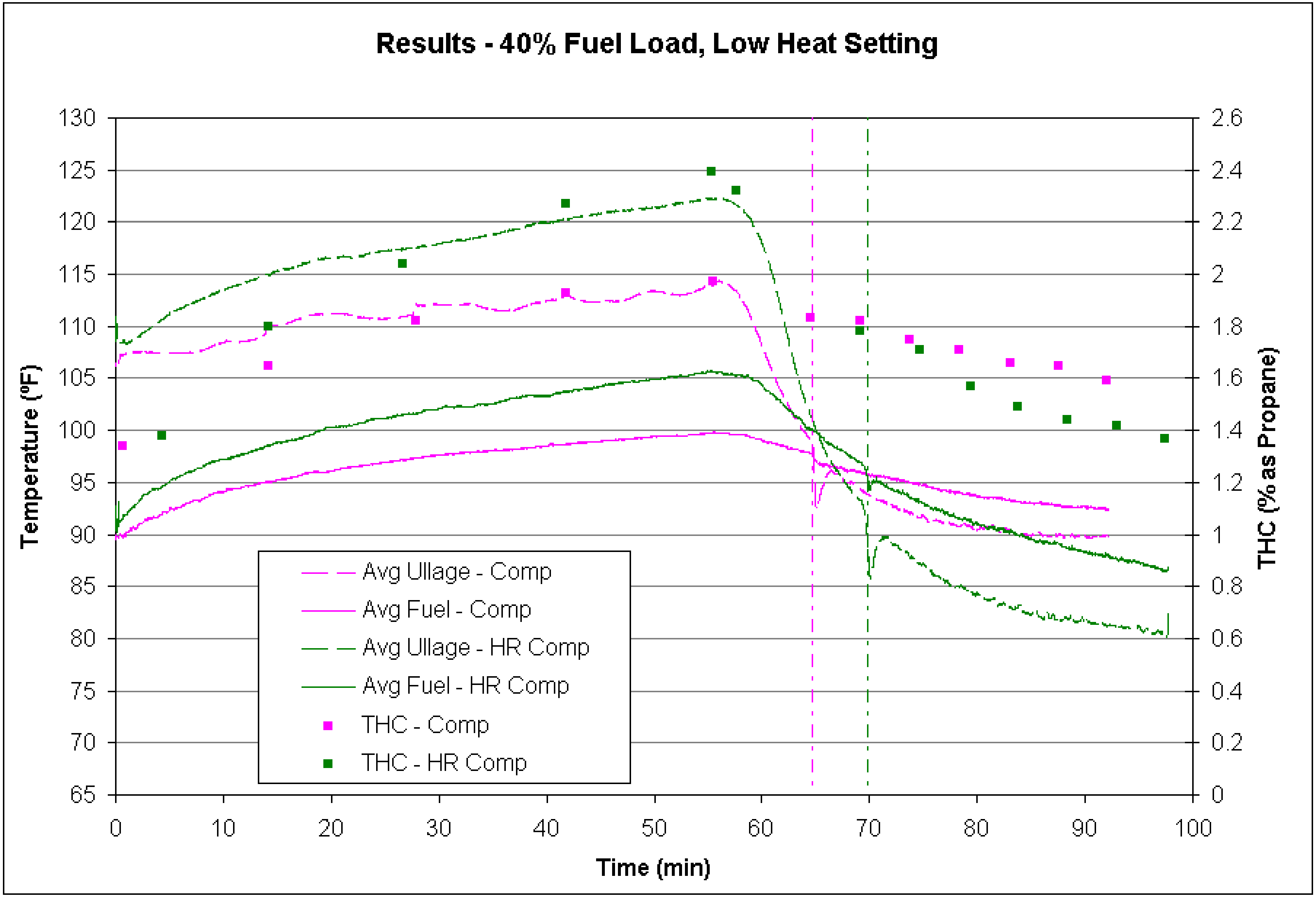
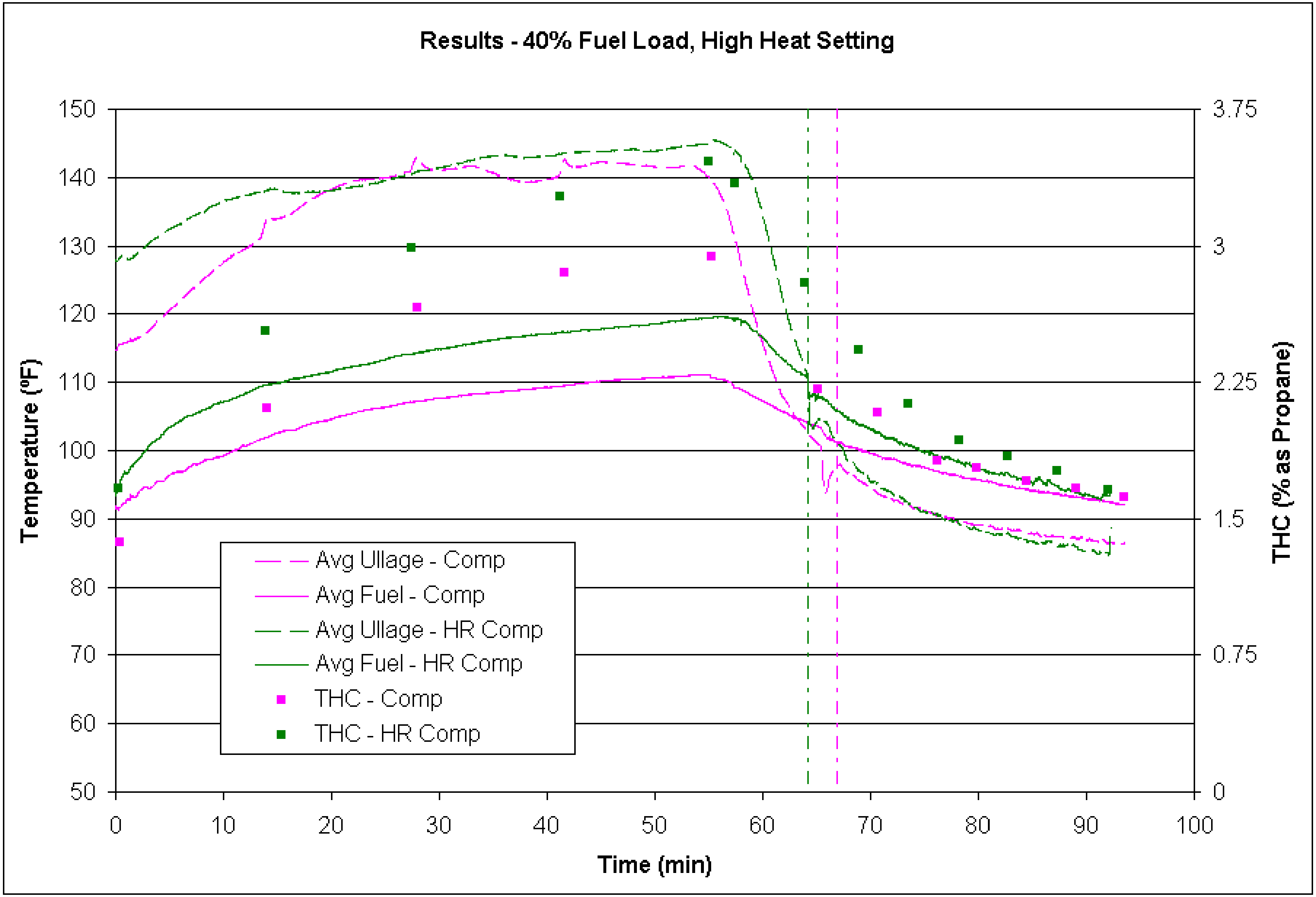
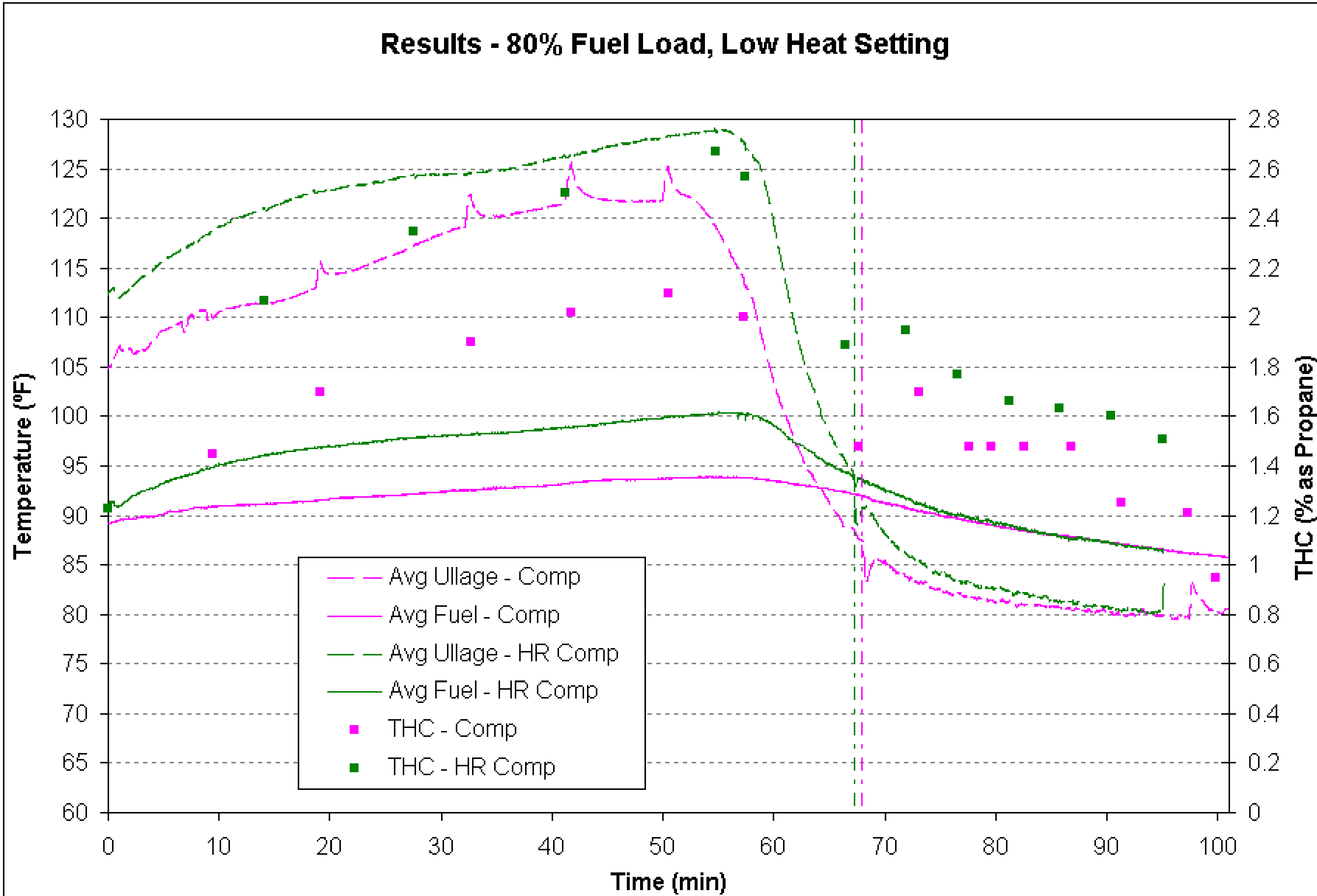
High Reflectivity Epoxy Results



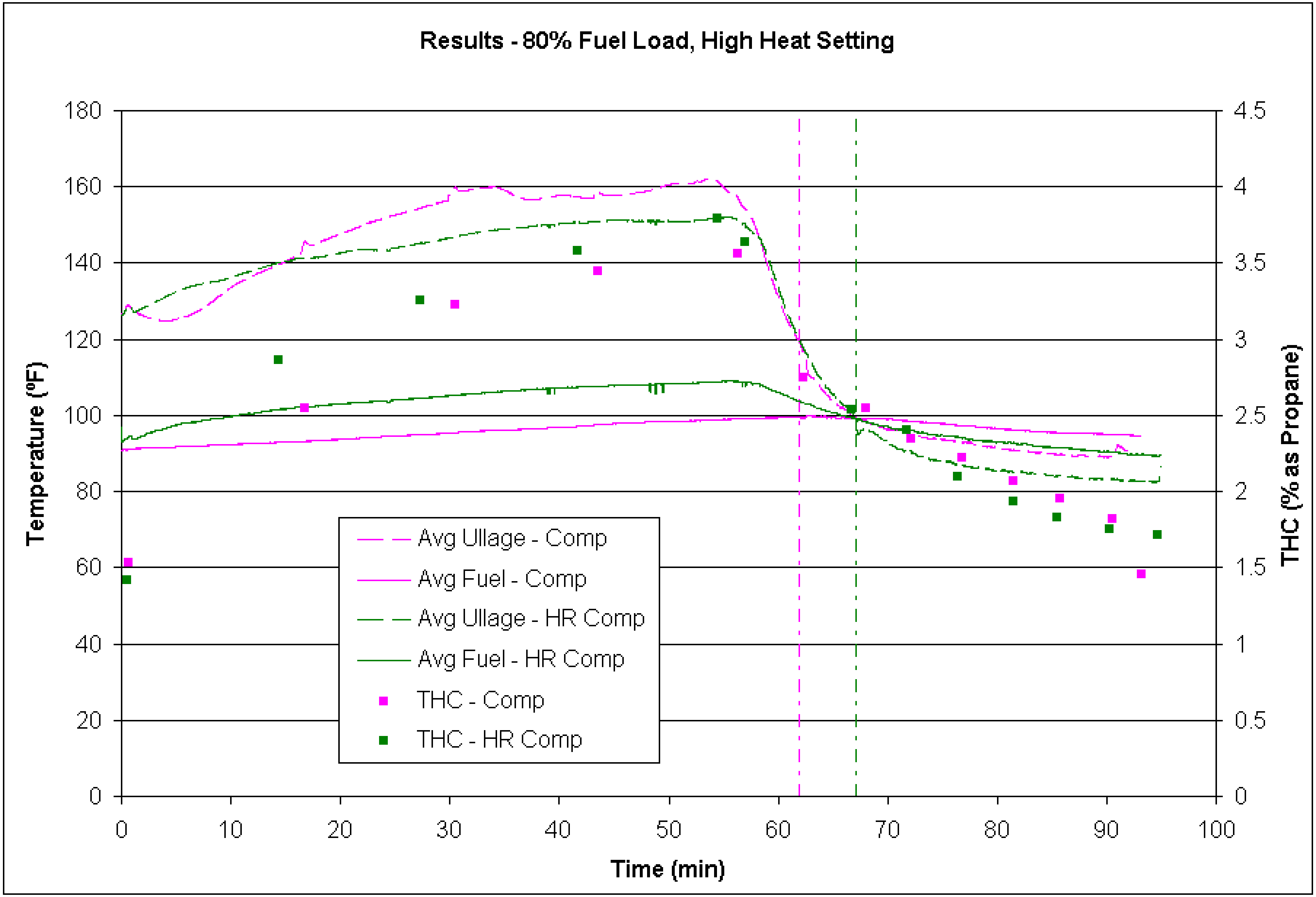
High Reflectivity Epoxy Results



High Reflectivity Epoxy Results



High Reflectivity Epoxy Results



Conclusions - High Reflectivity Epoxy Test Results

- The high reflectivity epoxy applied to the composite panels did not have a significant impact on the internal tank temperatures and flammability measurements.

- This is contrary to what has been seen with the aluminum panels, where the reflective behavior of the bare aluminum caused significant reductions in both tank temperatures and flammability when compared to panels with a topcoat applied.

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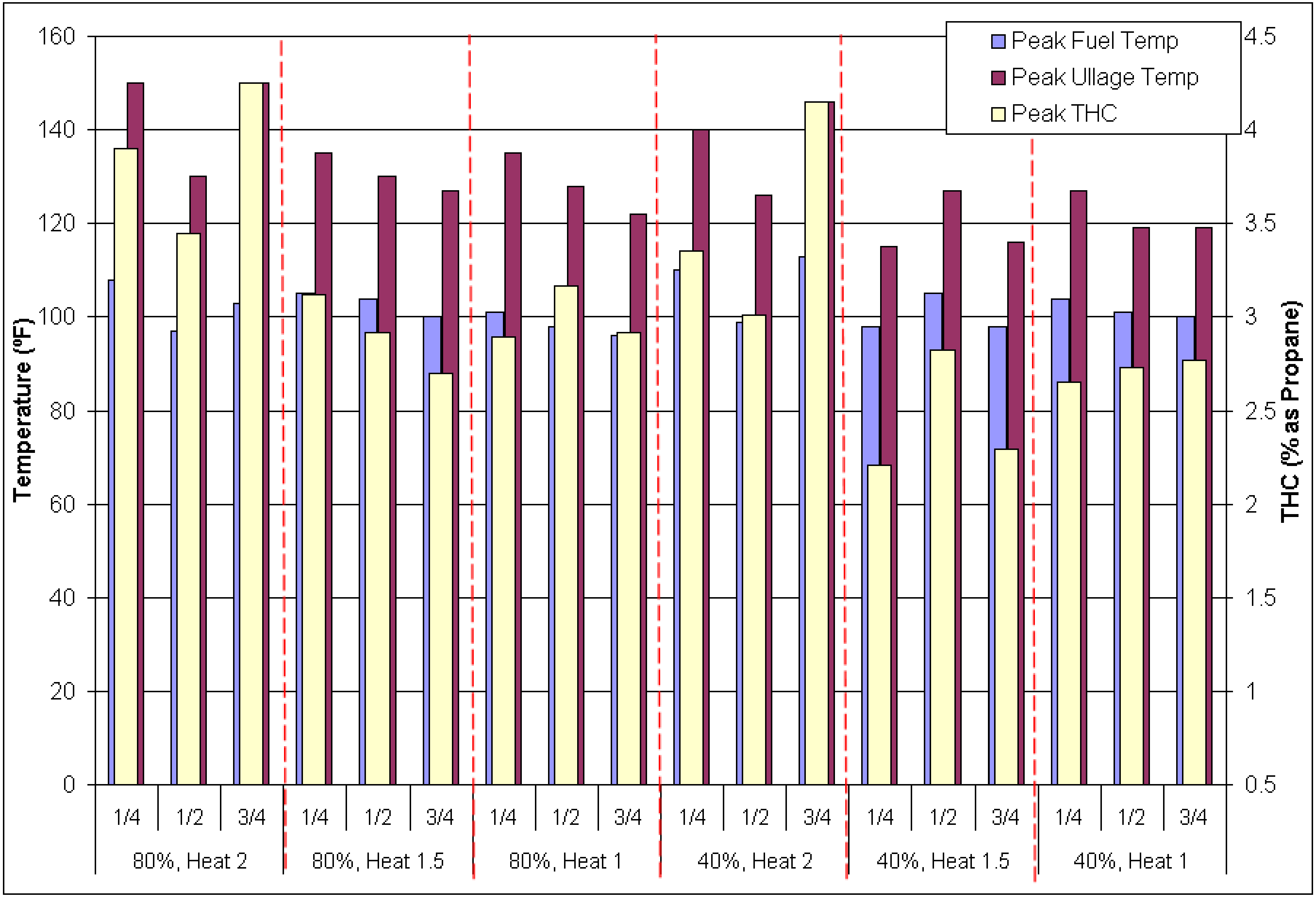
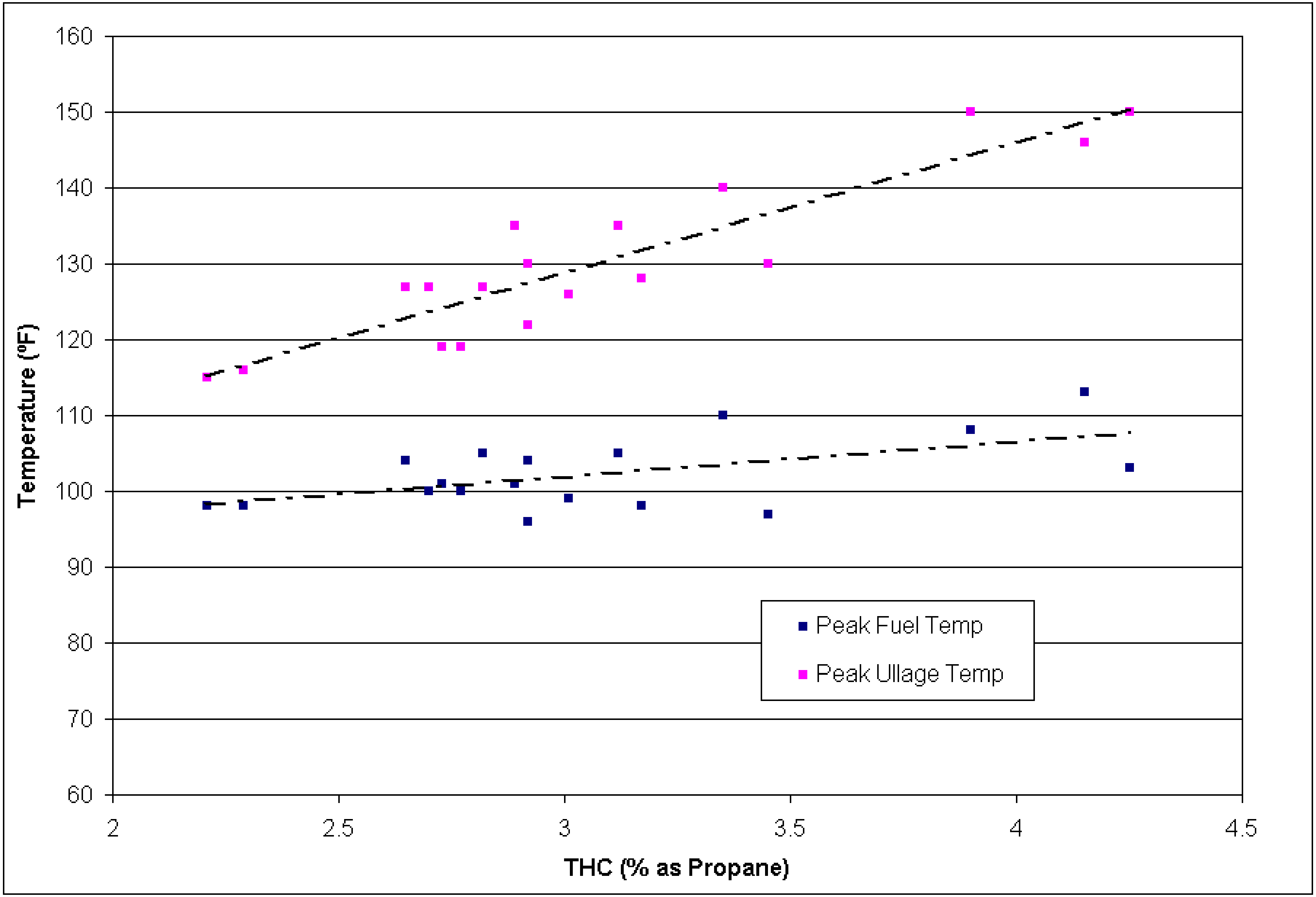
Summary of Panel Thickness Test Results



Panel Thickness Test Results



Conclusions – Panel Thickness Test Results

- Panel heat tests (reported previously) with composite panels of varying thickness showed that the thinner the material is, the more readily heat transmits through it.

- Further testing of these panels installed on the tank with various heat intensities showed a large variation in results.

- A correlation between composite thickness and tank flammability was not able to be made.

- These tests however further validate the strong correlation of high THC measurements with high ullage temperatures for wing tank flammability.

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