Intermediate Scale Flammability Testing of Composite Fuselage Structure

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In July of 2013 a lithium battery fire occurred in an emergency locator transmitter (ELT) in an inaccessible area of a Boeing 787 that was parked at an off-terminal stand at Heathrow airport, London. The fire was not immediately noticed, and is thought to have burned for several hours before smoke was observed by the tower controllers. The resulting fire was found to have ignited the epoxy in the composite fuselage and structure, and spread along the skin and structure behind the thermal acoustic insulation. Although the composite was certified to have been at least as safe as aluminum when faced with an in-flight fire scenario, the ignition source in the 787 incident was significantly more severe than the standard foam block source, and the confined configuration in the 787 incident resulted in more heat being retained near the composite surface than in the certification testing performed years earlier. The in-flight conditions, however, are thought to be less severe, as there is significant heat transfer through the skin to the high speed, low temperature ambient air flowing over the skin. Nonetheless, the FAA was interested in investigating the conditions necessary to replicate the flame spread as seen in the 787 incident, and determine if simulated in-flight cooling was present, would the flame propagation be as extensive.

Tests were designed to simulate an inaccessible overhead cabin area, with a composite skin section 18 inches by 48 inches, opposed to a thermal acoustic insulation blanket with a small gap between them in the range of one quarter to one inch. A simulated ELT was designed to contain 5 D-cell lithium primary batteries, which were set into thermal runaway with a cartridge heater attached to one cell. Inboard near-surface temperatures were measured with thermocouples, and the outboard external surface temperature was measured with an infrared camera. Combustion products were analyzed for gas concentrations of oxygen, carbon monoxide, and carbon dioxide to determine the type and efficiency of the combustion process occurring in the confined space. An outboard surface cooling regime was set up with three water spray nozzles misting over the back surface during a test, thus conducting heat away from the panel at an accelerated rate. A similar flame propagation event to the 787 incident was replicated, and it was found that the backside cooling significantly reduced and prevented extensive flame propagation. Future testing will include larger test sections with all composite structure (stringers, shear ties, frames) and a more accurate method of simulating the in-flight cooling power will be developed.