“Development of a Flame Propagation Test Method for Structural Aircraft Composite Materials”

Technological advances in materials science have led to the increased use of composite materials for primary structures in aircraft fuselages. Carbon fiber composites are favorable for aerospace applications due to their increased strength, anisotropic properties, formability, and lighter weight than traditional aircraft aluminum. Nearly every major transport-category aircraft manufacturer is currently using or has plans to use carbon fiber composites for fuselage skins. Current Federal Aviation Regulations do not require flammability testing for aircraft fuselage skins or structural members, as all civil aircraft up until now have been constructed from aluminum, which will not sustain or propagate flames when exposed to an in-flight fire scenario. In order to certify an aircraft with composite skins or structures it must be demonstrated by the manufacturer that the composite materials will provide an equivalent level of safety to an aluminum-constructed aircraft when exposed to an in-flight fire. In one particular instance, this has been accomplished by obtaining Special Conditions from the FAA (Special Conditions No. 25-360-SC), where the applicant submitted a test plan to the FAA for review, performed testing and analysis, and provided the results to the FAA, which then determined if the composite material in fact does not present any significant hazard compared to aluminum.

In order to standardize the certification process for composite aircraft, this study has been undertaken to develop a laboratory-scale test method for flame propagation of composite fuselage materials. The test method was designed such that it correlates to an intermediate-scale test simulating a moderately severe hidden fire impinging on the inboard side of the aircraft skin. An intermediate-scale test rig was constructed to simulate a hidden area in an aircraft cabin with the ability to interchange the test panels in order to study various composite materials. A wide variety of materials were tested, including several types of carbon/epoxy panels, including aerospace and non-aerospace woven laminates and uni-directional laminates. Other materials tested included glass-fiber reinforced polyester and vinylester, cotton-cloth reinforced phenolic, and a baseline aluminum panel. The standard hidden fire source was a polyurethane foam block spiked with a small amount of heptane to promote uniform, consistent burning. The simulated hidden area was insulated with ceramic fiberboard in order to retain heat produced from the burning foam block and direct it towards the test panel. Panel temperatures were recorded during each test with thermocouples located on the inboard-side of the test panels in an attempt to quantify the progress of the flame along the panel surface. Video was also recorded to study the duration and intensity of panel burning, and a post-test measurement of the burn area was taken. Materials were ranked according to burn area and burn time after foam block extinguishment. This ranking was used to develop pass/fail criteria for a laboratory-scale test employing the radiant heat panel flame propagation apparatus.