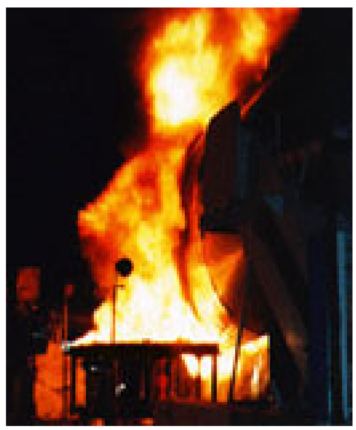
2010 FAA Fire Safety Highlights



An Analysis of Trends in Survivability and Fatalities in World-Wide Transport Aircraft Accidents

An in-depth analysis of transport aircraft accidents was conducted in an attempt to quantify the improvement in safety over the past 40 years in terms of reduction in accidents and improvement in survivability in those accidents deemed to be survivable. A survivable accident was defined as an accident that is not non-survivable (all the occupants sustain fatal injuries) but in which at least one fatality occurred or the airplane was destroyed. Of particular interest was the trend regarding fatalities attributable to fire in survivable accidents, because of the aircraft improvements derived from research activities that were implemented through the regulatory process over the past 25 years.

This study was based on 1036 world-wide accidents (of which 672 were survivable) that occurred between 1968 and 2007 involving large transport category turbojet and turboprop western-built aircraft operating in a passenger or passenger/cargo role. In 224 of the survivable accidents, the occupants were subjected to both impact and fire, and in 157 of these accidents, the cause of death could not be determined for all occupants. In such cases, the fatalities were randomly assigned to impact, impact and fire, or fire in a proportionate manner over the known possible range.

The annual number of accidents and survivable accidents for the world-wide fleet of western-built aircraft exhibited a significant decrease since the mid-1990s despite the large increase in the annual number of flights. This decline was also exhibited by the U.S. and Canadian fleets, beginning earlier in the late 1980's. The reduction is apparent when the accident rate was measured on per flight, per passenger, or per revenue passenger mile basis. For example, the number of total world-wide accidents per million departures decreased from 1.6 in 1990 to about 0.7 in 2005. For the U.S. and Canadian fleets the accident rate reduction was most pronounced since 1990, decreasing from about 0.9 to 0.15 in terms of accidents per million departures.

The survivability of accidents has also shown a marked improvement over the study period with a greater proportion of accidents being survivable and a marked increase in the proportion of occupants surviving an accident. Over the study period there has been a steady improvement in the probability that an accident will be survivable, increasing by about 40%; presently, about 75% of world-wide accidents are survivable. The improvement in survivability has also been dramatic, as measured by the probability of death in a survivable accident. That probability has improved by a factor of two, i.e., from about 0.3 to about 0.15. These overall improvements are also evident in the combined U.S. and Canadian fleets.

Surviving the effects of fire has improved considerably, as shown in the accompanying graph. This improvement is most evident in terms of the probability of death from fire in a survivable accident and, to a lesser degree, the proportion of fatalities attributable to fire in survivable accidents. The probability of death from fire has improved by a factor of three, decreasing from about 0.12 to about 0.04. Also, the proportion of fire fatalities has decreased from about 40% to about 23%.

The findings from this study are documented in FAA Report DOT/FAA/AR-10/16, "Trends in Accidents and Fatalities in Large Transport Aircraft", authored by RGW Cherry and Associates. The study was commissioned by the Cabin Safety Research Technical Group, comprised of representatives from the regulatory authorities, and was jointly funded by FAA and Transport Canada. Both the report and the CSRTG accident data base are available on the FAA Fire Safety Team web site at www.fire.tc.faa.gov.

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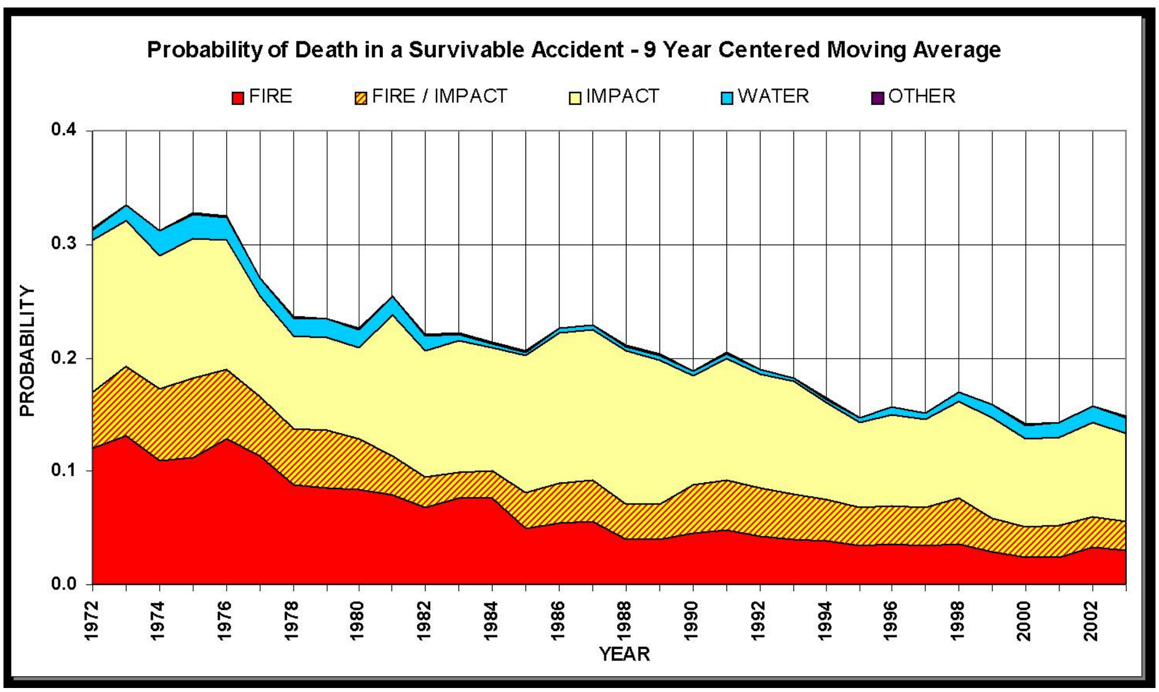

Probability of Death in a Survivable Accident
9 Year Centered Moving Average Chart

On-Line Availability of World-Wide Transport Aircraft Accident Database

The Fire Safety Team in cooperation with Transport Canada Aviation and the Civil Aviation Authority of the UK funded RGW Cherry and Associates to convert the Cabin Safety Research Technical Group's stand alone accident database to an internet database, accessible to the public. The accident database was originally constructed on behalf of the Airworthiness Authorities participating in the Cabin Safety Research Technical Group (CSRTG).

All data has been derived from reliable sources, primarily from Accident Investigating Authorities. The database contains accidents involving fixed wing civil registered transport passenger aircraft (with 19 or more passenger seats) and cargo aircraft; all certificated to Part 25 requirements or equivalent. The database includes textual and numerical data, as well as photographs and diagrams. The database contains accidents from 1967 onwards and is periodically reviewed and revised. At present, the database contains over 3900 accidents and will be continually updated.

The database can be accessed on the web at http://www.rgwcherry-adb.co.uk/

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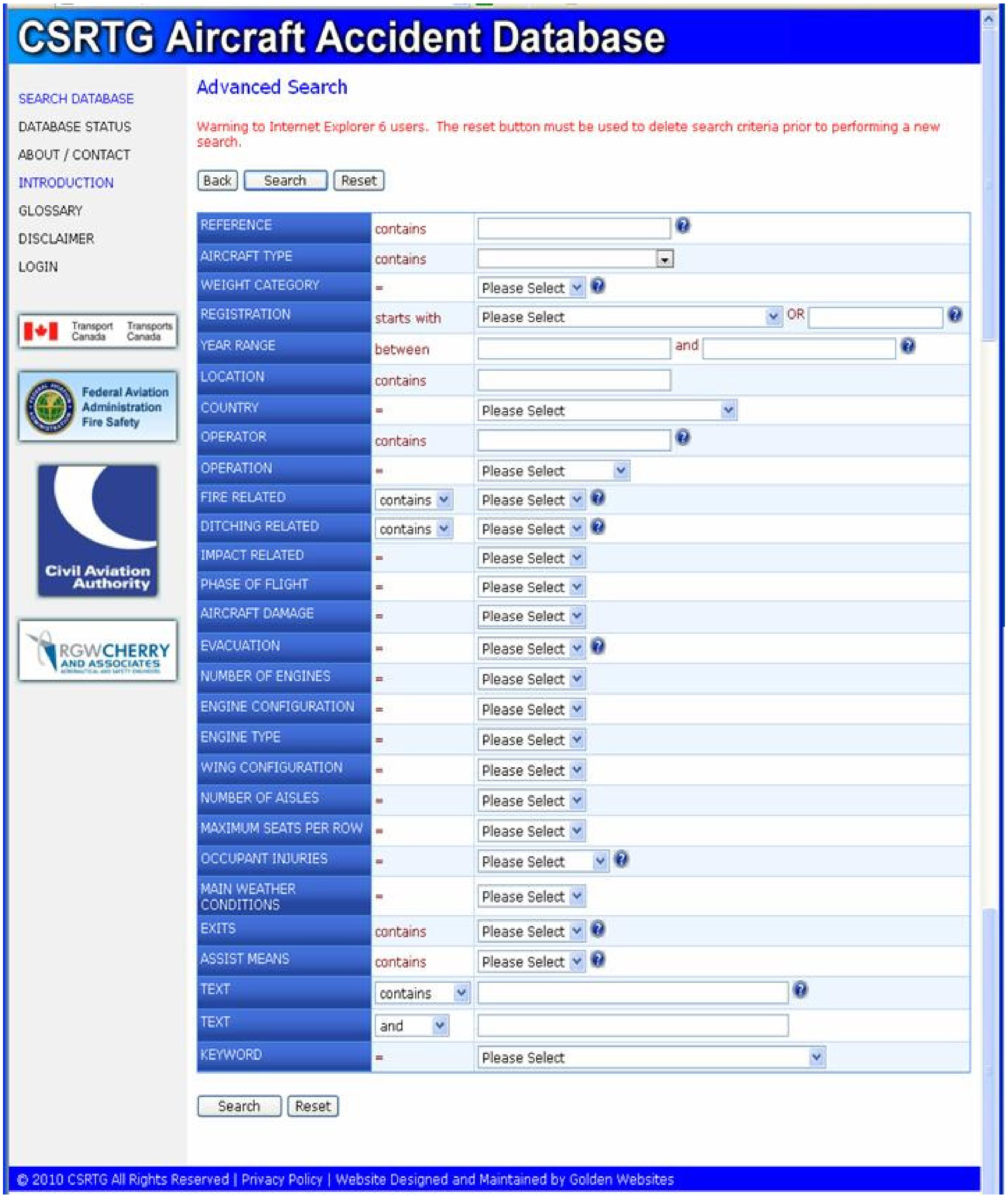

Cabin Safety Research Technical Group Aircraft Accident Database Screenshot

Preliminary Investigation of the Fire Hazards Inherent in Micro Fuel Cell Cartridges

Portable electrical power is a necessity in the modern world. The uses for portable electrical power range from electronic devices such as cell phones and laptop computers to electric automobiles. Most often this takes the form of single use or rechargeable batteries. The trade off in any portable electrical power source is always capacity versus weight and volume. Batteries have limitations in the amount of electric energy that can be stored, though the battery industry continues to push these limits, allowing more and more capacity in a given weight and volume. Rechargeable batteries must be connected to an external source of electricity for recharging. Because charge times vary, rapid recharge is the goal of research.

Micro fuel cells provide an alternative to batteries as a portable source of electricity. A fuel cell is an electrochemical device that converts fuel and oxygen into electricity. The fuel is supplied in removable or refillable cartridges and can be of several different chemistries. The fuel cell extracts hydrogen gas from the base fuel. The hydrogen gas then reacted with oxygen from ambient air to produce electricity. The reacted hydrogen and oxygen results in water or water vapor as a byproduct.

In this research, a series of tests were conducted to evaluate the flammability hazard of selected base fuels, which were packaged in the original equipment as manufactured for consumer use where possible. The base fuels included gaseous hydrogen, liquid alcohols and acids, and granular borohydride compounds and mixtures. If the cartridges were not available, the fuel was tested in bulk form. The tests measured the response of the cartridge and fuel to an external, low-level fire source.

Most of the fuels tested were flammable. It was found that the cartridge material can have a significant effect on flammability. Metal cartridges protected the fuel from an external fire better than plastic cartridges. The cartridge containing formic acid did not ignite under test conditions. Butane produced the most vigorous fire. Hydrogen gas stored in a metal matrix is under low pressure and breaching of the enclosure allows the gas to escape and ignite. Borohydrides are difficult to ignite, but emitted a flammable fume when heated and were capable of deep-seated exothermic reaction. Halon 1211 was effective against all but the deep-seated borohydride exothermic reaction.

These findings are detailed in FAA report, DOT/FAA/AR-09/53, “Preliminary Investigation of the Fire Hazards Inherent in Micro Fuel Cell Cartridges”, authored by Harry Webster.

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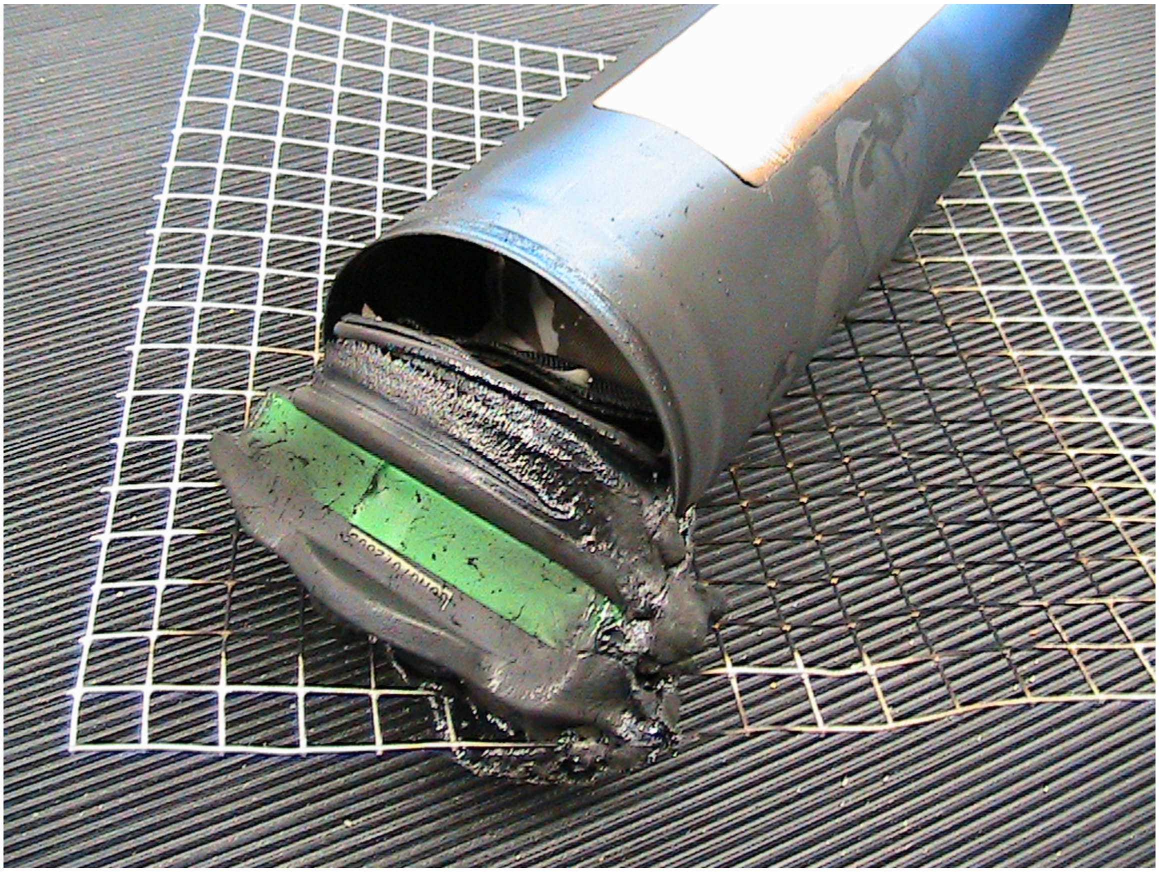

Post Fire Test Photograph of Sodium Borohydride Fuel Cell Cartridge

Evaluating the Fire Hazards of Magnesium Alloy Seat Structure Under Full-Scale Postcrash Fire Conditions

In recent years, magnesium alloys have been suggested as substitute for aluminum alloys in aircraft seat structure, as well as other applications, due to the potential for weight savings. The FAA has had several inquiries regarding the policy for using magnesium alloys in airplane cabins. Although magnesium alloys are routinely used in the construction of non-cabin aircraft components, they are currently banned from use in aircraft seats, according to FAA Technical Standard Order (TSO) -C127, “Rotorcraft and Transport Airplane Seating Systems”. This TSO prescribes the minimum performance standards that rotorcraft and transport airplane seating must meet, including the qualification requirements and minimum documentation set forth in various sections of Society of Automotive Engineers, Inc. (SAE), Aerospace Standard AS8049, “Performance Standard for Seats in Civil Rotorcraft and Transport Airplanes,” dated July 1990. Within SAE Aerospace Standard AS8049, revision A, paragraph 3.3.3 states that magnesium alloys shall not be used.

The FAA’s central concern regarding the use of magnesium and its many alloys in the cabin is flammability. The current regulations do not address the potential for a flammable metal to be used in large quantities in the cabin. Therefore, if such a material was introduced into the cabin, the FAA must be convinced that the level of safety would not be reduced. Recent developments in materials technology have shown that different magnesium alloys have different susceptibility to ignition. However, magnesium remains a material that, once ignited, is very challenging to cope with using fire extinguishers currently available on aircraft.

In order to better evaluate their general flammability, a preliminary assessment of several magnesium alloys was conducted using a laboratory-scale test rig. The test rig consisted of an oil-fired burner to simulate the fuel fire, and a mounting mechanism to mount representative test samples. One of the samples was a prototype alloy containing rare earth elements to minimize flammability. The laboratory-scale tests indicated a large difference in flammability between the various samples tested. Magnesium alloys WE-43 and Elektron-21 both showed outstanding resistance to ignition when compared to the more traditional alloys such as AZ-31. Additional laboratory-scale tests evaluated the performance of handheld fire extinguishers against these same alloys when ignited.

Subsequent full-scale testing of these alloy systems provided useful information into the feasibility of using such materials in the primary components (cross-tubes, spreaders, and legs) of aircraft coach seating. Initial baseline tests using standard, OEM aluminum-framed coach seats served as the backdrop to evaluate the performance of seats containing magnesium alloy components in the primary areas. During the testing, it was determined that the prototype WE-43 magnesium-alloy material produced no additional measurable hazard within the cabin, as temperature, and toxic and flammable gases were no greater than those obtained during the baseline tests. Thus, in terms of postcrash fire survivability certain magnesium alloys are as safe as currently used aluminum alloys in aircraft seat structure.

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Full-Scale Fire Test on Magnesium-Framed Aircraft Seats

Interior of Test Fuselage Showing three Rows of Magnesium-Framed Aircraft Seats

A Flammability Comparison of Composite and Aluminum Fuel Tanks Under Simulated Ground and Flight Conditions

The Federal Aviation Administration (FAA) has conducted a significant amount of research studying the flammability of traditional aluminum fuel tanks. This research, along with the development and demonstration of a fuel tank inerting system has led to recent regulations requiring the reduction of flammability within high risk fuel tanks. Traditionally, fuel tanks located in the wing of an aircraft are considered to be of low flammability due to the rapid cooling that occurs in flight through the aluminum skin of the aircraft. There have however been recent advances in composite materials, and these advanced materials are increasingly being used in the construction of aircraft

Tests were performed at the William J. Hughes Technical Center by the Fire Safety Branch of the Aircraft Research and Development Division using the environmental chamber as well as the air induction facility (wind tunnel) to examine the variation in flammability exposure of a fuel tank consisting of a composite material skin versus that of a traditional aluminum skin.

The results from the testing in the environmental chamber showed that the top skin temperature for the composite tank reached much higher temperatures when subjected to the same radiant heat source. This increased skin temperature caused internal ullage and fuel temperatures to be much greater for the composite skin tank and resulted in significantly higher total hydrocarbon (THC) measurements. The aluminum fuel tank never reached the accepted lower flammability limit of approximately 2.0 percent during the entire five-hour heating cycle. In contrast, the tank with composite skin reached the flammable limit with approximately 45 minutes of heating and reached a peak THC of more than twice that of the aluminum tank.

Testing in the air induction test facility showed similar changes in initial temperature and THC profiles. In each of the tests, the ullage temperature in the composite tank was between 40-60 °F higher than those from the aluminum tank tests. The average fuel temperatures however varied by only 10 °F and show much less of a temperature increase than the ullage. THC measurements in each of the aluminum tank tests varied only very slightly throughout the full length of the test, whereas extremely large increases were observed in the composite tank tests.

As airspeed through the wind tunnel was commenced, decreases in both ullage and fuel temperature were observed. The largest decrease seen was in the ullage temperature of the composite skin tank as this had the largest temperature differential relative to the ambient. THC measurements in the aluminum tank tests showed minimal change, while measurements in the composite tank tests showed a significant decrease due to the large decrease in ullage temperature. Even with this rapid decrease in THC however, the fuel tank remained in the flammable region for a significant amount of time, up to 25 minutes after the 90% throttle position of the wind tunnel was reached. From the data shown, it is clear that there is a significant increase in flammability exposure of a composite skinned tank from that of a traditional aluminum skinned tank.

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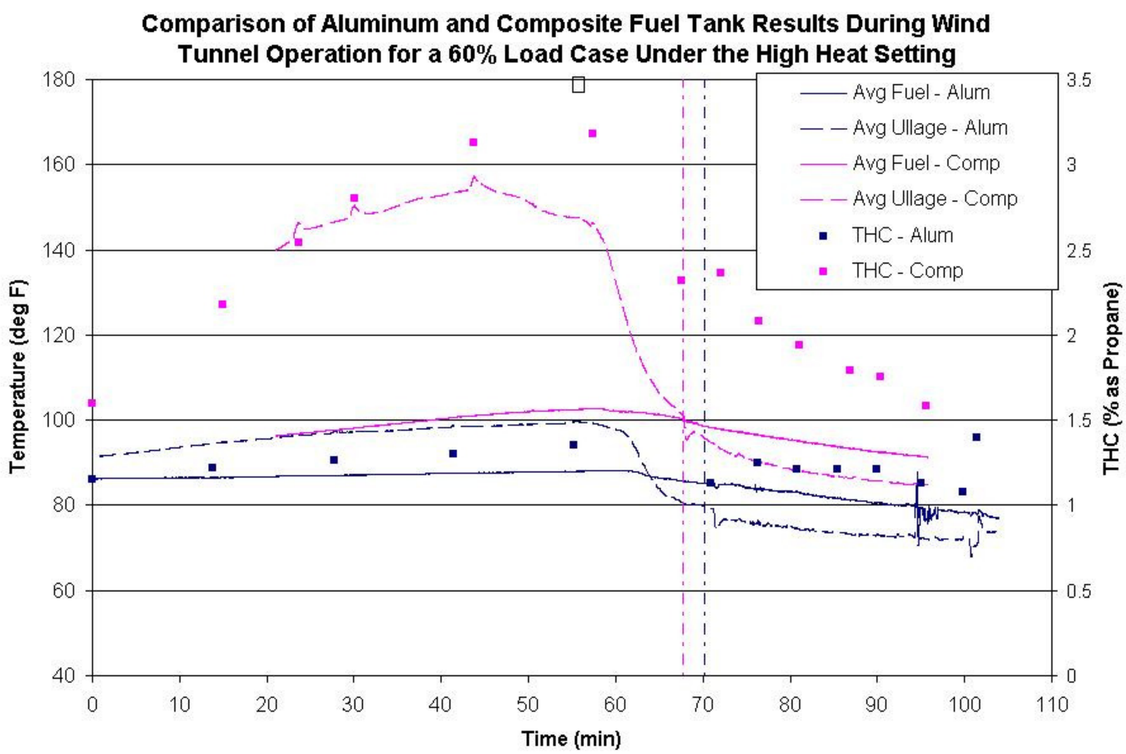

Fuel Tank Wind Tunnel Data

Development of a Flammability Test Method for the In-Flight Fire Resistance of Composite Fuselage Structural Materials

Technological advances in materials science have led to the increased use of composite materials for primary structures in commercial airframes. Carbon fiber composites are favorable for aerospace applications due to their increased strength, lower density, and better corrosion resistance 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 transport aircraft up have been traditionally constructed from aluminum, which will not sustain or propagate flames when exposed to a fire in an inaccessible area of the cabin. In recent years, the Federal Aviation Administration has been working to increase the fire worthiness of materials located in inaccessible areas, including insulation, ducting, and electrical wiring, striving to enhance in-flight cabin safety. Modern aircraft constructed from composite materials will have a significant amount of composite material in the inaccessible areas, possibly posing a threat to in-flight cabin safety. Currently, in order to certify an aircraft with a composite fuselage, the manufacturer must demonstrate that the composite materials will provide an equivalent level of safety to an aluminum-constructed aircraft when exposed to an in-flight fire. To date, this has been accomplished by obtaining Special Conditions from the FAA, 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 whether the composite material in fact did not present any increased safety hazard compared to aluminum.

In order to standardize and simplify the certification process for composite aircraft, this study was undertaken to develop a laboratory-scale test method for determination of 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 an inaccessible 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, uni-directional laminates, and carbon/epoxy structural plies bonded to a honeycomb core. Other materials tested included glass-fiber reinforced polyester, glass-cloth epoxy resin, and a baseline aluminum panel. The standard hidden fire source employed to develop improved flammability test methods for insulation, ducting and wiring was used in the test rig, consisting of 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, as shown in the attached figure. Video was taken to study the duration and intensity of panel burning, and a post-test measurement of the burn area was recorded. Materials were ranked according to burn length and burn time after foam block extinguishment.

The radiant heat panel fire test apparatus was used as the laboratory scale test since it had previously been determined to be an appropriate improved flammability test for other hidden materials. Radiant panel test parameters were varied until the intermediate-scale ranking was achieved. This was accomplished by constructing a sample holder to align the test sample parallel to the radiant heat panel, pre-heating the sample in this position for one minute, and applying the pilot flame for 15 seconds.

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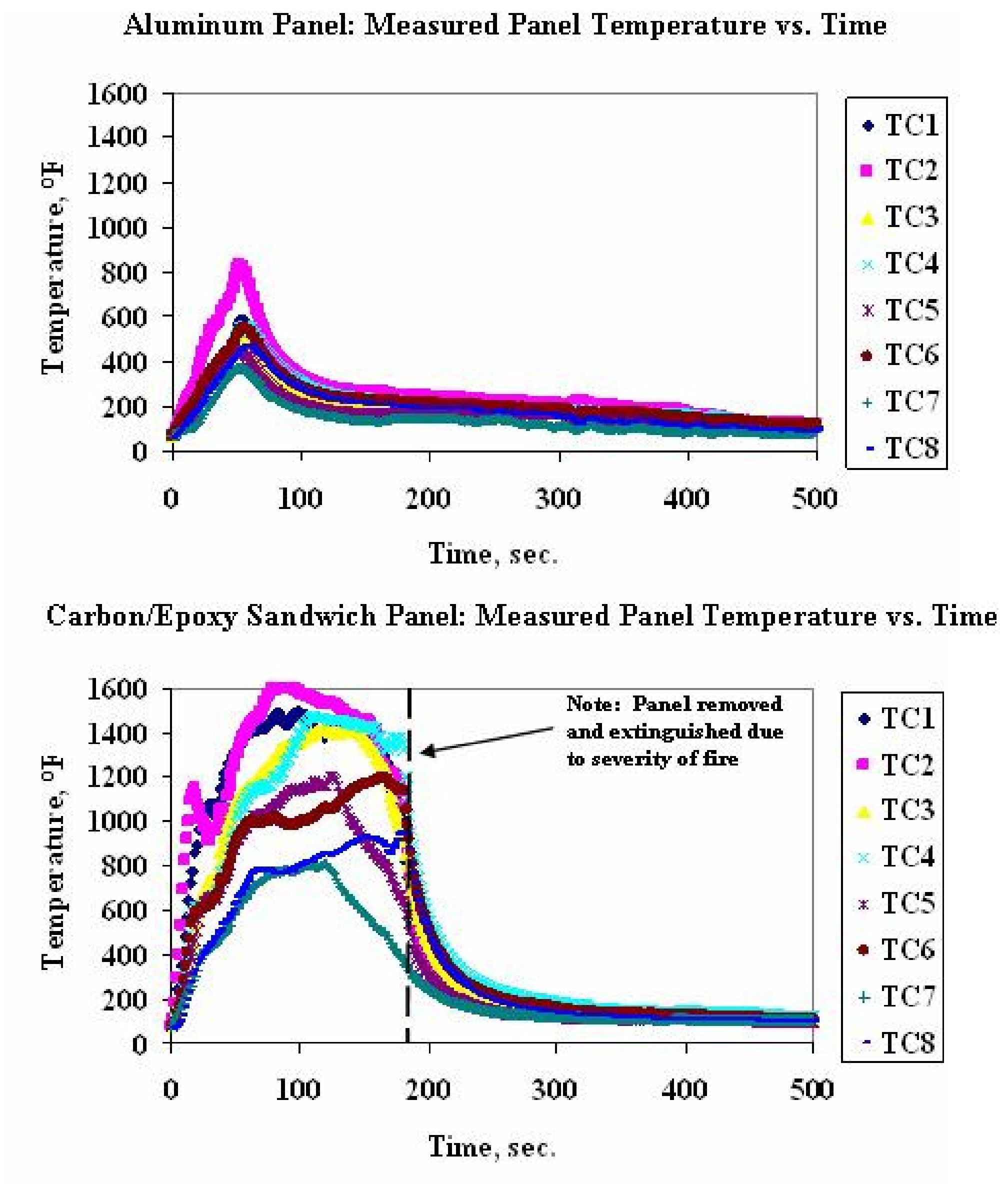

Comparison between Aluminum Panel and Carbon/Epoxy Panel

Burning of Aircraft Cabin Materials in the Vertical Flame Test

The vertical flame test for cabin and cargo compartment materials is used to determine the ignition resistance of materials held in a vertical orientation and subjected to a Bunsen burner flame for 12- or 60-seconds as specified in Federal Aviation Regulation (FAR) 25.853 and FAR 25.855. Aircraft cabin materials affected by the 60-second vertical Bunsen burner (VBB) exposure requirement include interior ceiling panels, wall panels, partitions, galley structure, large cabinet walls, structural flooring and stowage compartments and racks. Materials affected by the 12-second VBB exposure requirement include floor covering, textiles including drapery and upholstery, seat cushions, padding, coated fabrics leather, trays and galley furnishings, electrical conduit, thermal and acoustical insulation and insulation covering, air ducting, joint and edge covering, liners of Class B and E cargo or baggage compartments, floor panels of Class B, C, D, or E cargo or baggage compartments, insulation blankets, cargo covers and transparencies, molded and thermoformed parts, air ducting joints, trim strips. The vertical Bunsen burner tests in FAR 25.853 and FAR 25.855 place strict limits on the duration (< 5 seconds) and extent (< 20 cm) of burning of the affected aircraft cabin materials. Despite these strict limits on upward flame spread and the wide range of cabin materials affected by this regulation, little is known about the relationship of material properties to the test results that would allow extrapolation to other fire scenarios using engineering models or the design fire safe cabin materials. To this end, a joint study was conducted at the University of Maryland Department of Fire Protection Engineering and the Federal Aviation Administration's William J. Hughes Technical Center to relate the upward burning of plastics to their material fire properties.

It was shown that, following a brief period of ignition in the Bunsen burner (12 or 60 seconds), the heat flux from the sample flame is the driving force for sustained upward burning. The flame heat flux is proportional to the heat release rate per unit area (HRR) of the burning sample above a critical value of 80 kW/m^2 for ignition, 250 kW/m^2 for sustained burning, and 300 kW/m^2 for upward spread of flame. It was also shown that fire properties of materials that could be measured in fire calorimeters including the heat release parameter (HRP), the critical heat flux for piloted ignition (CHF), and the thermal response parameter (TRP) could be used to correlate the fire behavior of plastics in the VBB test. This is an important finding because these same material properties (HRP, CHF, TRP) determine the rate of fire growth in compartments such as aircraft cabins under severe heat flux conditions.

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Vertical Flame Test