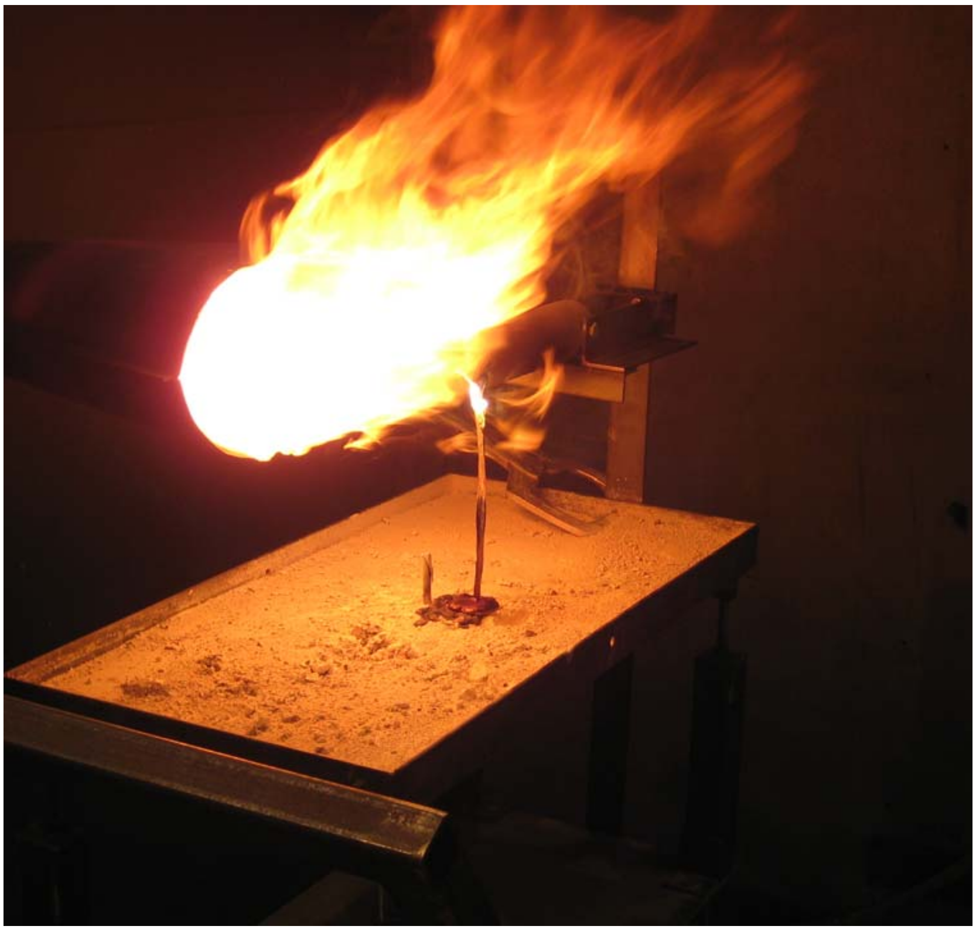
2011 FAA Fire Safety Highlights



FREIGHTER AIRPLANE CABIN FIRE RISK ANALYSIS MODEL

The number of accidents caused by in-flight fire in freighter aircraft appears to be increasing. In 2006 a UPS DC-8 freighter experienced an in-flight fire in the main cargo compartment during approach to Philadelphia International Airport. Although the airplane was safely landed and both pilots escaped, the aircraft was gutted by fire. In 2010 a UPS 747 crashed while attempting to land at Dubai International Airport, United Arab Emirates. Prior to the fatal crash the pilots reported a heavy build-up of smoke in the cockpit. Both aircraft reportedly carried large quantities of lithium batteries. Therefore, a study was initiated to assess the magnitude of the potential threat to freighter airplanes from onboard cargo fires.

As part of this study, a risk model was developed to assess the likely number of U.S.-registered freighter fire accidents through the year 2020 and the average annual cost due to their occurrence. The study focused on the potential fire threat from the bulk shipment of lithium batteries because they were likely contributors to the freighter fire accidents that occurred in Philadelphia and Dubai. For this reason, the risk model considered the potential threat from lithium batteries separately from other cargo.

The risk model is based on the assumption that the risk of a cargo fire accident occurring is a function of the revenue ton-miles (RTM) of the cargo, or the product of the quantity of cargo shipped and the distance the cargo is carried. RTM is a usage value that is routinely recorded by the air transport industry. Similarly, in order to predict the probability of a cargo fire in which lithium batteries were a contributing factor, calculations were made of the shipment of lithium batteries by air in terms of RTM. The rate of freighter fire accidents is the ratio of the number of such accidents and the cumulative revenue ton-miles. However, because of the small number of data sets, it is more realistic to develop distributions that indicate a confidence level in a range of accident rates rather than determining an average value. Although the risk model predictions are considered to be reasonable, the limited number of accidents contained in the data set results in a large range in the prediction of future accidents. For example, on average the model predicts about 6 cargo fire accidents from 2011 through 2020 but the 95% confidence level has a wide range of about 2 to 13 accidents over that time period. Also, lithium batteries may be a contributing factor in as many as 4-5 of these accidents if it is assumed this was the case in the 2006 accident in Philadelphia (the model user has the option of selecting this accident as battery or non-battery related). The risk model predictions are also highly influenced by the future prediction of RTM), which are, by necessity, based on extrapolations from past data.

The model also calculates the cost of future cargo fire accidents on U.S.-registered freighter airplanes, considering crew injuries, airplane damage, cargo damage and collateral damage. It was determined that the largest accident cost was the cost of the airplane (84%), followed by crew fatalities (12%), cargo (3%), collateral damage (2%), and serious crew injuries (1%).

FAA Report DOT/FAA/AR-11/18, entitled "Freighter Airplane Cargo Fire Risk Model", summarizes the risk model, explains the data and algorithms used, and explains how the model may be used. The report and model are available on the Fire Safety Team web site at www.fire.tc.faa.gov.

POC: R. Hill

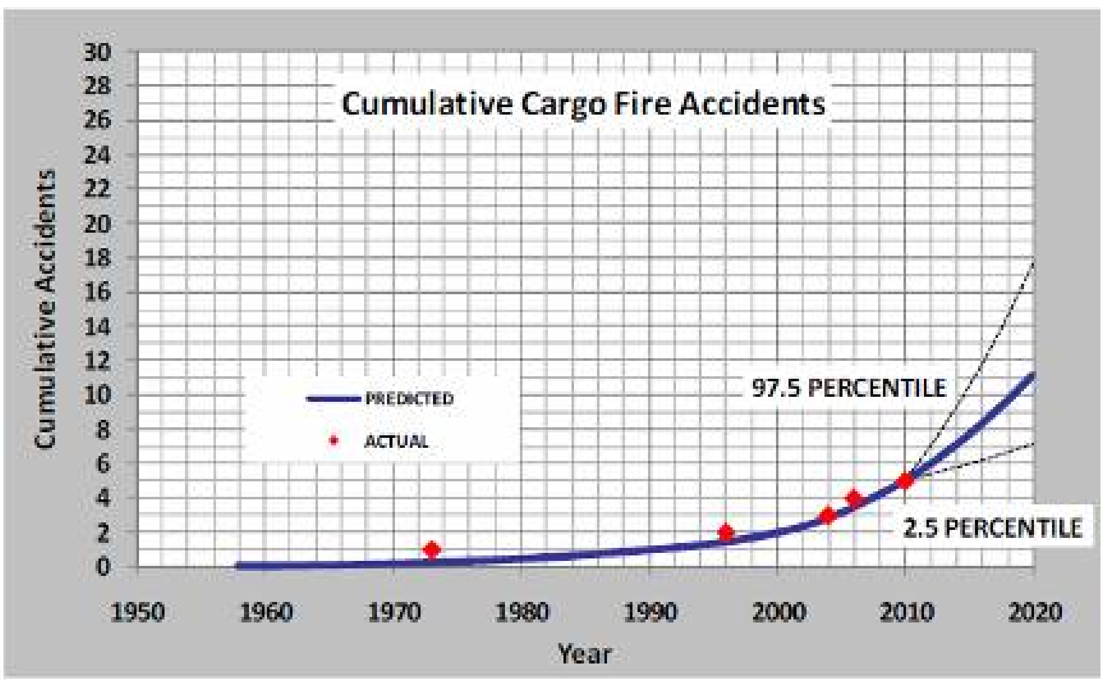


Figure 6 Predicted Number of Freighter Airplane Cargo Fire Accidents through to 2020

THE SIXTH TRIENNIAL INTERNATIONAL AIRCRAFT FIRE AND CABIN SAFETY RESEARCH CONFERENCE

The Sixth Triennial International Aircraft Fire and Cabin Safety Research Conference convened in Atlantic City on October 25-28, 2010. The conference was the sixth in a series of triennial conferences to inform the aviation community about recent, ongoing and planned research activities in aircraft fire and cabin safety. It is the only technical conference devoted exclusively to fire and cabin safety R&D in civil transport aircraft. The conference was sponsored by the following regulatory authorities: FAA, CAA (UK), Transport Canada, ANAC (Brazil), CASA (Australia), CAAS (Singapore) and EASA (Europe).

Deputy Administrator Michael Huerta and Transport Canada Aviation Director General Martin Ely delivered keynote addresses. A record 600 attendees participated in the 2010 conference. Conference sessions included presentations in the following areas: aircraft fire safety, advanced fire resistant materials, cabin safety, and crash dynamics. In addition, a Fuel Tank Flammability Workshop was conducted by Fire Safety Team and Transport Airplane Directorate personnel, related to the recent fuel tank flammability reduction rule and the use of the Fuel Tank

Flammability Assessment Method (Monte Carlo Model) for demonstrating compliance with the rule. A Lessons Learned Database Workshop was also held.

The fire safety sessions were dominated by papers on material flammability test method development, lithium battery fire hazards, cargo compartment fire safety, fuel tank flammability, halon replacement and magnesium applications in aircraft. New flammability tests were described for ducting, wiring and composite fuselage (interior surface), aimed at reducing the risk of in-flight fires originating in hidden areas. Presentations on lithium batteries delved into aircraft fire accidents and incidents with lithium batteries and tests demonstrating their unusual fire hazards. Recent cargo compartment fire safety work has focused on the detection and difficult challenge of suppressing a fire in a large freighter main deck cargo compartment. Fuel tank flammability work included experiments and modeling related to gaining a better understanding of the vulnerability of aircraft to fuel tank explosions, including comparative experiments with composite and traditional aluminum wing fuel tanks. Halon replacement presentations included the main drivers – contaminated halon and potential environmental mandates, and promising progress for determining replacements for hand-held extinguishers and engines. The magnesium session included presentations on new fire resistance alloys, potential aircraft applications and their demonstrated postcrash fire safety when used as lightweight seat structure.

The three sessions on advanced fire resistant materials focused on impressive research to develop ultra-fire resistant materials and understanding the behavior of polymers during thermal degradation and burning. Research was described on novel materials, including nanocomposites, benzoxazine resins, preceramic polymers, graphite oxide flame retardants and deoxybenzoin-containing polymers. The need for environmentally-safe flame retardants was repeatedly emphasized due to cabin health concerns with certain brominated types of fire retardants..

The cabin safety sessions addressed emergency evacuation, cabin air quality, passenger briefings and cabin crew training. Presentations on emergency evacuation included studies of grouped behavior, selection of exits, effect of pre-flight briefings, problems related to baggage retrieval, injured passengers, and computer modeling the effects of fire and ventilation and advanced blended body designs. A number of presentations addressed cabin air quality health concerns associated with engine oil fume exposure, including pyrolyzed oil, and instrumentation developed to monitor cabin air quality. The effectiveness of passenger briefings and benefits of improvements was a recurrent theme as was the need to assess current crew firefighting training in terms of current and future needs.

Child restrain systems is an area of considerable crash dynamics research because of the challenges of protecting small infants and the difficulty of extrapolating automotive applications to an aircraft. Significant research is conducted to reduce and simplify dynamic seat test requirements, which can be costly, for example, by using computer models to address variations in seat cushion designs. Numerical models are being developed to examine and compare the crashworthiness of new composite fuselages compared with contemporary aluminum structures. Air bags are being deployed in general aviation aircraft and as a potential means for vertical energy absorption.

The proceedings of the sixth triennial, including abstracts and powerpoint presentations, attendees list and executive summary, as well as for the previous 5 triennials, are available on www.fire.tc.faa.gov.

POC: Gus Sarkos

Development of Guidance for the Safe Shipment of Lithium Batteries

The Pipeline and Hazardous Material Safety Administration (PHMSA) and the Federal Aviation Administration (FAA) are proposing new regulations for the shipment of lithium-ion and lithium primary batteries and cells. Much of the regulation involves record keeping, package markings, cell size and lithium content. Part of the regulation may restrict packaging, shipping mode, and cell type for those shippers who elect to ship their devices on transport category aircraft.

In support of this regulatory initiative, additional fire tests were conducted in FY-2011 to add to the flammability knowledge of lithium-ion and primary cells generated in earlier test efforts. Based on the previous work of the FAA Technical Center Fire Safety Team, tests were conducted with larger number of cells in a bulk shipment package with a single cell experiencing a simulated thermal runaway condition. The effectiveness of Halon 1301 was evaluated both from the perspective of suppression of open flames as well as the ability halt the propagation of thermal runaway within a shipment.

Preliminary tests were also conducted to characterize the flammability hazard of lithium polymer batteries of the type used in some laptop computers.

The capability of existing shipping containers to contain a lithium-ion and lithium primary fire was evaluated. A proposed draft specification for a fire-safe shipping container or over pack for lithium-ion cells was also developed

The results from these tests confirmed that Halon 1301 is effective at suppressing open flames from lithium-ion cells in thermal runaway. The Halon, as expected, was totally ineffective at stopping the progression of thermal runaway. Even in the presence of Halon 1301, all cells in the shipment were consumed. Data was collected showing the propagation rate between adjacent cells as well as cell temperature while in thermal runaway.

Currently available robust shipping containers, such as metal pails and drums were not effective in controlling lithium primary fires, but were effective in containing lithium-ion fires. A fiberboard container designed to ship oxygen generator canisters was tested against a 100 cell lithium-ion fire and successfully contained the fire. The proposed draft specification for a fire-safe over pack for lithium-ion cells is based partly on the oxygen generator over pack specification.

The findings of this test effort were used as the basis for a Safety Alert For Operators issued by the FAA Flight Standards Service: SAFO 10017, "Risks in Transporting Lithium Batteries in Cargo by Aircraft." This SAFO presents important safety information to airline and air cargo operators regarding safe handling and shipment of lithium batteries. The information contained in the SAFO is largely based on FAA report DOT/FAA/AR-10/31, "Fire Protection for the Shipment of Lithium Batteries in Aircraft Cargo Compartments," authored by Harry Webster. The report and SAFO are available on the Fire Safety Team web site www.fire.tc.faa.gov.

POC: Harry Webster

Chemical Oxygen Generator Overpack tested with 100 lithium metal cells.

Intermixing Cells in an Aircraft Nickel-Cadmium Battery

The Federal Aviation Administration (FAA) issues Parts Manufacturer Approvals (PMA) for aircraft replacement parts that are not manufactured by the original equipment manufacturer (OEM). To obtain a PMA, the replacement part manufacturer must meet the FAA requirements for safety regulations and standards, and it must meet the OEM's specifications and standards for the part it is replacing.

Replacement battery cells within aircraft batteries are issued PMAs from the FAA; however, there have been claims from OEMs that intermixing PMA with OEM cells in an aircraft battery can have drastic effects on battery performance and may cause a safety of flight issue.

There is also some confusion within the FAA regulations as to what practices are acceptable relative to PMA cells. Technical Standard Order C173, which specifies the minimum performance standards required for nickel-cadmium (NiCd) and lead-acid batteries, says these batteries must adhere to RTCA/DO-293. This document however, states that "mixing cells or batteries with different part numbers, made by different manufacturers for from different sources, is a non acceptable practice." This statement contradicts the FAA PMA process and clearly advises against the intermixing of cells, yet is referenced by the applicable Technical Standard Order.

To address these concerns, tests were performed by the Fire Safety Team to determine if intermixing cells within an aircraft NiCd battery has an effect on battery performance, and if any such effect results in a safety of flight issue.

Two aircraft SAFT 4078-7 batteries were evaluated through a series of tests specified in RTCA/DO-293, including several rated capacity tests at various temperatures, a charge stability test, duty cycle test, and an induced destructive overcharge test. One of the batteries was kept in its original form with all OEM cells, while half of the cells in the other battery were replaced with PMA replacement cells. Prior to testing, both batteries were fully serviced as though they were being commissioned for service onboard aircraft.

Throughout the tests, only slight differences between the OEM and intermixed batteries were observed. The PMA cells consistently charged at a higher voltage; however, none of the cells exceeded the maximum voltage of 1.7 V. During some tests, individual cells showed some differences in behavior and recorded battery temperatures. The most notable difference occurred during the induced destructive overcharge tests, in which a larger number of cells from the intermixed battery recorded increased voltage readings, indicating signs of possible thermal runaway. These measurements were all within the requirements of the test standard however and there was no resulting flame or explosion of either of the batteries. The main conclusion from the study, based on the various tests was that the intermixing of OEM and PMA battery cells within a nickel-cadmium aircraft battery provided no indication of any safety of flight issues.

POC: Steve Summer

Aircraft Nickel-Cadmium Battery

Combustion Characteristics of Adhesives Used in Aircraft Cabins

Adhesives are widely used in the construction of aircraft cabin materials because they provide a lightweight and fatigue resistant method of assembly. At the present time, there is no separate requirement for the flammability of adhesives, potting compounds, and fillers used in construction of cabin materials. This makes substitution or replacement of these adhesive compounds for reasons of performance, supply, or changing environmental regulations, costly to the industry because the entire cabin material/part must be fabricated and tested with the new adhesive according to approved FAA procedures (certificate). The Flammability Standardization Task Group (FSTG) is an aircraft industry working-group that is interested in establishing the similarity of different adhesives, with regard to flammability, by comparative testing of the adhesive separately from the cabin material/part/construction in which it is used and for which it was originally certified. To this end, the FSTG has proposed [1] testing adhesives in a standard size by the12-second and 60-second and vertical Bunsen burner (VBB) requirement for cabin materials in Federal Aviation Regulation (FAR) 25.853, a test that adhesives currently do not have to pass as separate components. Cabin materials pass or fail the VBB test based on criteria for burn length, after flame time, and the time required for flaming drips to extinguish. The present study was conducted to determine whether the microscale combustion calorimeter (MCC), which is a quantitative laboratory test for flammability, supported the use of the VBB to establish similarity of adhesives, potting compounds and fillers used in the construction of aircraft cabin materials.

Several aircraft material suppliers in the FSTG provided adhesive samples to the FAA Fire Safety Team at the William J. Hughes Technical Center along with the pass/fail VBB test results determined in their laboratories using (in most cases) FAR 25 standard 6-mm x 100-mm x 300-mm (1/4 x 4 x 12 inch) specimens as shown in figure 1. Adhesive samples weighing 5±2 mg were tested in the MCC, also shown in figure 1, according to a standard procedure [2] to obtain thermal combustion properties that were correlated with the VBB ratings. A qualitative analysis showed that there is a critical/threshold value for each of the several thermal combustion properties measured during the MCC test, below which all of the samples passed the VBB test. The use of a threshold value of the thermal combustion property to classify adhesives is warranted only if all possible adhesives are tested and analyzed to determine the value of the property, i.e., the threshold value is specific to the data set. In practice, new adhesives are introduced and old ones are replaced as circumstances (e.g., supplier issues, environmental regulations, etc.) require, so a statistical analysis of the data was performed to determine the *probability* of passing the VBB test given a particular value of a MCC thermal combustion property. To this end, pass/fail VBB data were converted to binary outcomes (Y = 1 for pass and Y = 0 for fail) and the binary data were fit to a continuous probability distribution $p(X)$ developed for fire tests [3] using values X of each of the MCC thermal combustion properties as explanatory/predictor variables. These binary (pass/fail) and continuous probabilities are shown in figure 2 for the 60-second vertical Bunsen burner test classification versus the heat of combustion of the adhesive *HR* as the predictor variable X. Figure 2 shows that the solid line representing the continuous probability distribution captures the binary data in the region where both passing and failing results are obtained, and can therefore be used to calculate the likelihood of passing the 60s VBB test for candidate replacement adhesives.

1. Flammability Standardization Task Group Kickoff Meeting, International Aircraft Materials Fire Test Working Group, Clearwater, FL, January 12, 2010.

2. Standard Test Method for Determining Flammability Characteristics of Plastics and Other Solid Materials Using Microscale Combustion Calorimetry, ASTM D 7309-07, American Society for Testing and Materials (International), West Conshohocken, PA, 2007.

3. R.E. Lyon, N. Safronava, R.N. Walters and S.I. Stoliarov, A Statistical Model for the Results of Flammability Tests, Fire and Materials 2009, San Francisco, CA, Jan. 26-28, 2009.

POC: Rich Lyon

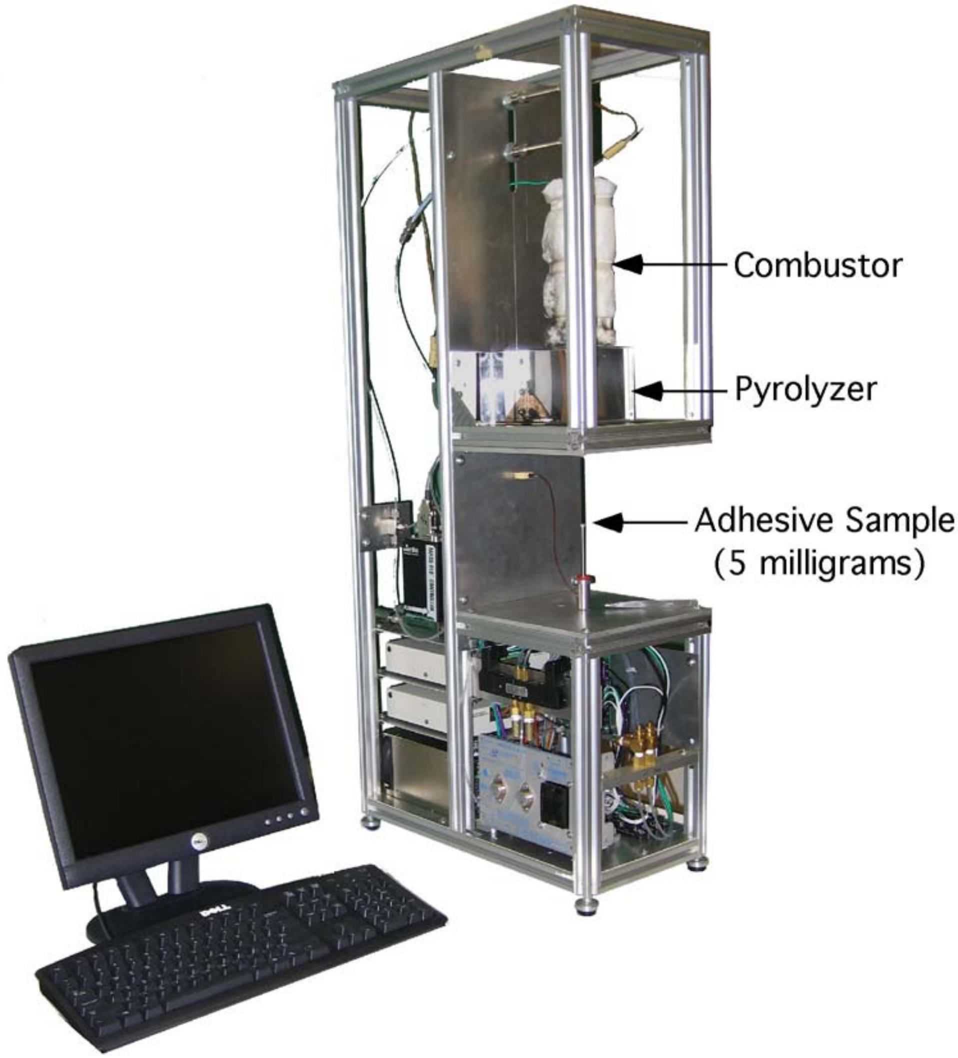


Figure 1a. Microscale Combustion Calorimeter

Figure 1b. Vertical Bunsen Burner Test Method

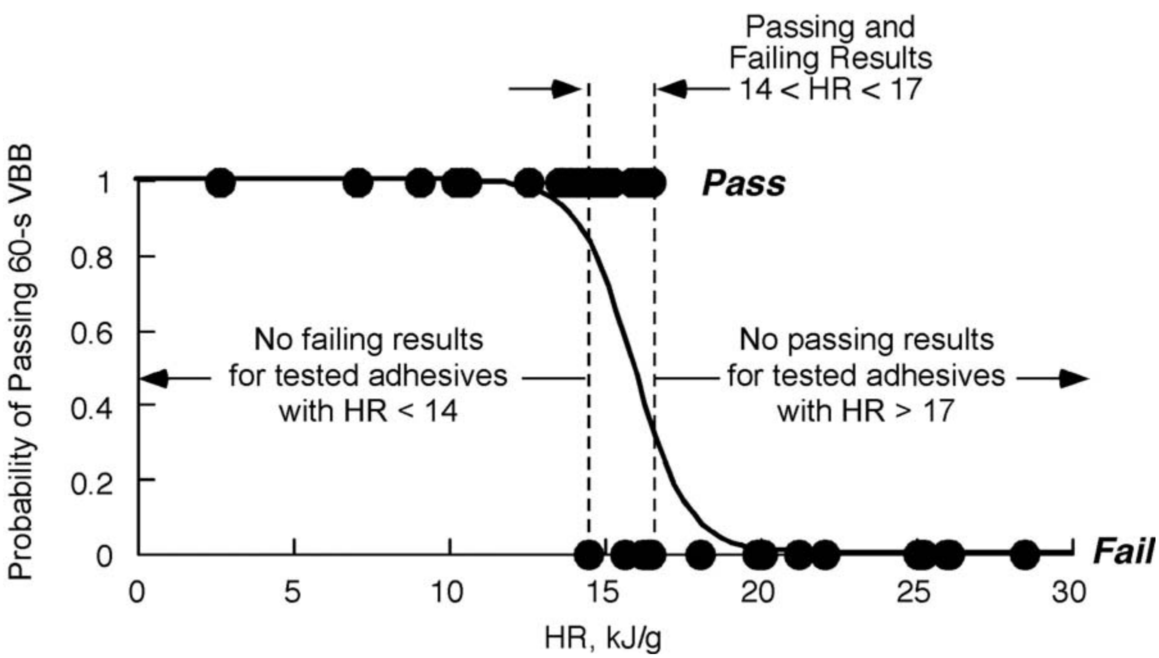


Figure 2. Effect of Heat Release on Passing Vertical Test

PREDICTING THE BURNING RATE OF CHARRING MATERIALS

Aircraft cabin materials are required to meet the stringent flammability requirements of Federal Aviation Regulation (FAR) 25.853. Thermoformed parts, ducting and decorative panels account for nearly 50% of the weight of cabin materials [1] and all of the plastics used in these applications leave a carbonaceous residue (char) after burning that enables them to meet the fire performance requirements [2]. Charring is a process that takes place in the solid plastic that reduces the amount of combustible fuel gases in a fire and provides a molecular mechanism of fire resistance that minimizes the need for potentially toxic flame retardant chemicals. Despite the demonstrated importance of char formation of aircraft materials in passing fire tests [2], very little is known about the mechanisms by which charring effects ignition and flame spread, but this knowledge is fundamental to the development of cabin material sub-models for our long range goal of predicting fire growth in aircraft cabins.

During the past decade, there has been a significant effort to develop mathematical models of polymer pyrolysis, which is the process by which a burning plastic thermally decomposes to char and fuel gases in a fire. Typically, the pyrolysis model parameters are the thermal and chemical properties of the material, and these are used as adjustable parameters to fit experimental burning rate data from bench scale fire calorimeters. The parameterized pyrolysis model is subsequently used in conjunction with a model of gas phase combustion to predict the development of a large-scale fire. The main drawback of this approach is that the problem of deriving material properties from the results of fire calorimetry is under defined, i.e., there is more than one set of property values that provides a good fit to a particular test. Consequently, this approach provides only a limited understanding of the physics and chemistry of pyrolysis because the properties are specific to the test that is used to obtain them and may be inappropriate for other scenarios, such as an aircraft cabin fire.

The principal objective of the present effort was to directly measure the thermal and chemical properties of common plastics that exhibit charring and swelling and try to predict bench-scale burning rate data *a priori* using our detailed one-dimensional pyrolysis/burning model ThermaKin [3-5]. ThermaKin is a flexible computational framework that solves energy and mass conservation equations describing a one-dimensional material object subjected to external heat. In ThermaKin the material is represented by a mixture of components that can interact chemically and physically. The components are assigned individual properties and categorized as solids, liquids or gases. Of particular interest in this study was to determine the best way to represent heat transfer from the radiant heater, flame and burning surface through the expanded, low density, carbonaceous char layer to the underlying polymer. To this end, a pure conduction mechanism and a radiation diffusion mechanism of heat transfer through the low density, graphitic char layer were investigated.

The polymers in this study were bisphenol-A polycarbonate (PC) and polyvinylchloride (PVC) and these were tested in a fire calorimeter at various radiant heat fluxes using a bench scale fire calorimeter according to a standard method [6]. Figure 1 shows a 6-mm thick sample of PC after burning in a fire calorimeter at 75 kW/m^2 external flux on the left and the ThermaKin simulation of the PC fire test on the right. It is seen that heat transfer from the burning surface to the underlying polymer by pure conduction through the char and radiation diffusion produce equivalent burning rate histories for PC (shown) and PVC.

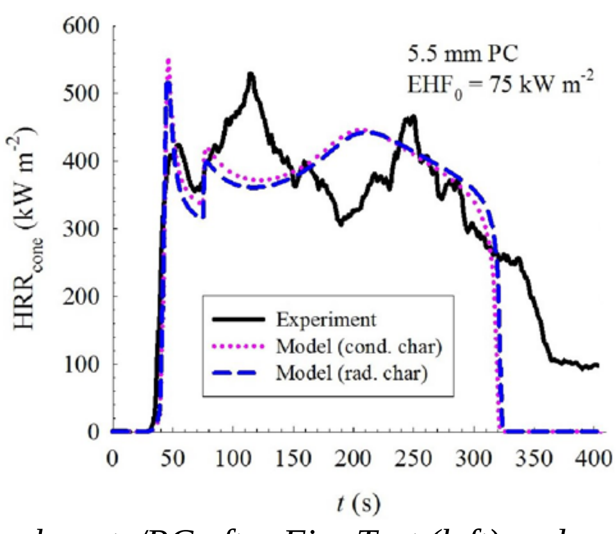


Figure 1. Photograph of Polycarbonate/PC after Fire Test (left) and ThermaKin simulation of PC Fire Test Data (right).

The results of this study demonstrate that the ThermaKin one-dimensional numerical pyrolysis model can be used to predict the outcome of fire calorimeter experiments performed on a charring and intumescing polymer.

The predictions require the knowledge of the thermal and optical properties of the polymer and a quantitative description of the kinetics and thermodynamics of its decomposition. All this information can be obtained from direct milligram and gram scale measurements or obtained from existing structure-property correlations. A simple heat transfer model of the char based on the thermal properties of graphite and a single adjustable heat transfer parameter determined from a cone calorimetry experiment provides a reasonable approximation of the heat transfer through the charred surface.

1. R.E. Lyon, *Materials With Reduced Flammability in Aerospace and Aviation,* Advances in Fire Retardant Materials, A.R. Horrocks and D. Price, Eds., Chapter 20, CRC Press, Boca Raton, FL, 2008.

2. R.E. Lyon and T. Emrick, Non-halogen Fire Resistant Plastics for Aircraft Interiors, *Polymers for Advanced Technologies*, 19, 609-619 (2008).

3. S.I. Stoliarov and R.E. Lyon, Thermo-Kinetic Model of Burning, Federal Aviation Administration Technical Note, DOT/FAA/AR-TN08/17 (2008).

4. S.I. Stoliarov, S. Crowley, R.E. Lyon and G.T. Linteris, Prediction of the Burning Rates of Non-Charring Polymers, *Combustion and Flame*, 156, 1068-1083 (2009).

5. S.I. Stoliarov, S. Crowley, R.N. Walters and R.E. Lyon, Prediction of the Burning Rate of Charring Polymers, *Combustion & Flame*, 157, 2024-2034 (2010).

6. Test Method for Heat and Visible Smoke Release Rates for Materials and Products Using and Oxygen Consumption Calorimeter, ASTM E 1354-04a, American Society for Testing and Materials International, West Conshohocken, PA.

POC: Rich Lyon

PUBLICATION OF TOXICITY MODEL FOR NEW HALOCARBON FIRE EXTINGUISHERS IN TOXICOLOGY JOURNAL

A simple kinetic model for calculating the blood concentration history of humans exposed to time-varying concentrations of gaseous, halocarbon fire-extinguishing agents was published in the Journal *Inhalation Toxicology* in December 2010 [1]. The publication in a peer-reviewed inhalation toxicology journal provides credibility to the kinetic calculations developed and employed by the same authors in the basis document [2] for the FAA Advisory Circular AC 20-42D "Hand Fire Extinguishers for Use in Aircraft" [3].

The kinetic model was developed to extend experimental physiologically based pharmacokinetic (PBPK) models for arterial blood concentration of halocarbons, obtained from constant concentration exposures of dogs, to time-varying exposure conditions for humans. The kinetic model for the transport of halocarbon is shown in figure 1. In this kinetic model, the rate constants k_1 and k_2 represents the rate of transport between the cabin air (in the lungs) and the bloodstream, k_3 and k_4 represents the rate of transport between the bloodstream and the organs and tissues, and k_5 represents the rate of transport from the organs and tissues to waste. In the present work, the simplified kinetic model was calibrated using published PBPK-derived arterial concentration histories for constant concentration exposure to several common halocarbon fire-extinguishing agents.

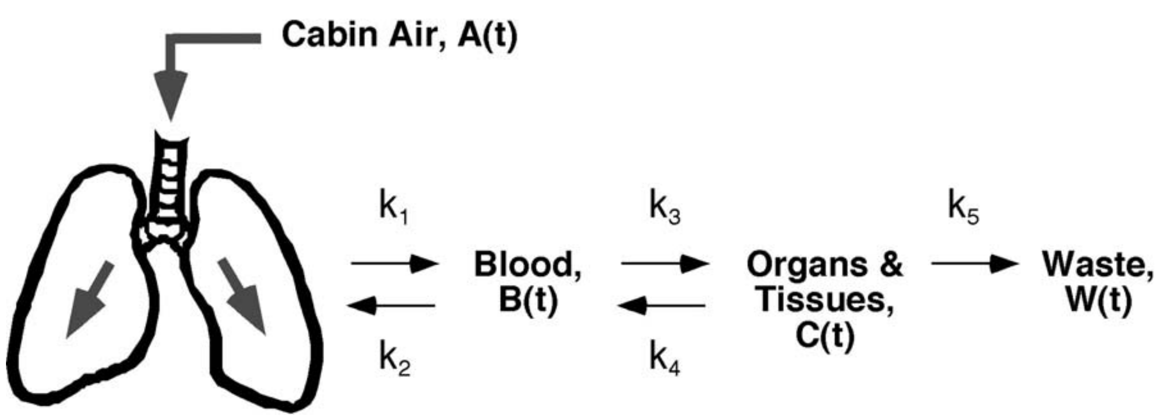


Figure 1. Kinetic Model of Halocarbon Transport in Humans.

The calibrated kinetic model was able to predict the blood concentration histories of passengers in perfectly mixed, constantly ventilated aircraft cabins in which these agents are instantaneously discharged as well as the PBPK model for HCFC-123. Figure 2 illustrates that the kinetic model also captured the magnitude and dynamics of the human arterial blood concentration history as well as the PBPK model for a time-varying Halon 1211 concentration in a small compartment [4]. It was therefore concluded that the kinetic model, properly calibrated with PBPK-derived human arterial blood concentration data for a constant exposure concentration, represents an economical methodology for calculating safe exposure limits in compartments with time-varying concentrations of halocarbon fire extinguishing agents.

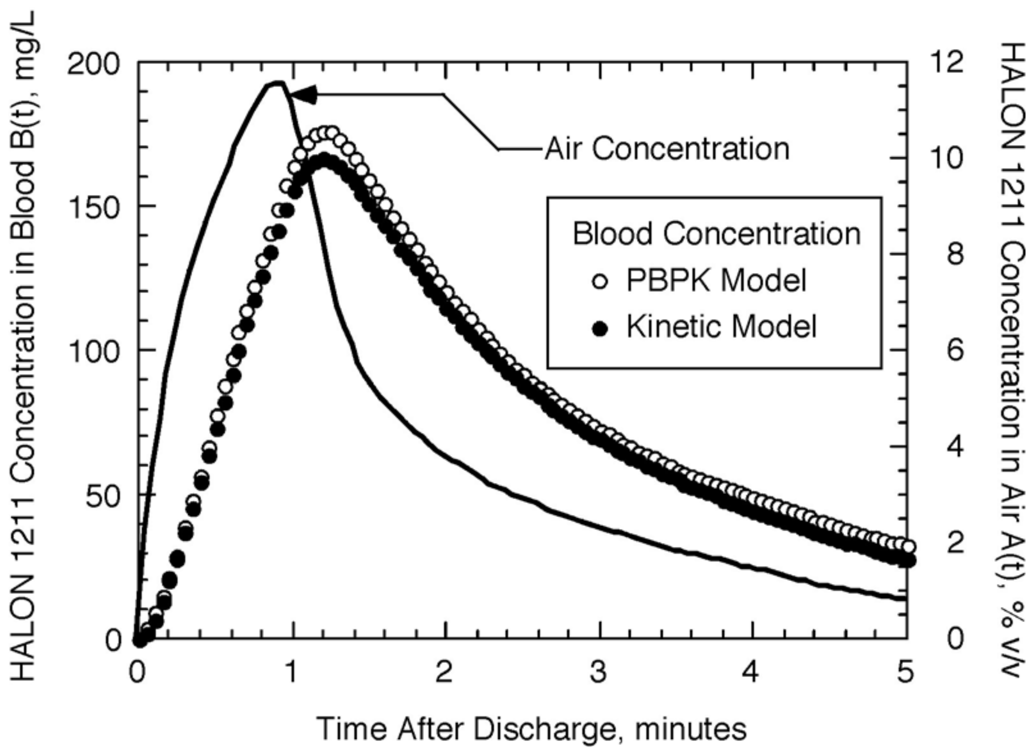


Figure 2. Comparison of the Arterial Blood Concentration History in a Small Compartment for Time-varying Concentration of Halon 1211 Calculated by the Kinetic Model (Black Circles) and the Physiologically Based Pharmacokinetic (PBPK) Model (White Circles) [4]. The Average Relative Deviation of the Kinetic and PBPK Models is 5.7%.

1. Lyon, R.E. and Speitel, L.C., A kinetic model for human blood concentrations of gaseous halocarbon fire-extinguishing agents, *Inhalation Toxicology*, 22(12-14), 1151-1161, Dec. 2010.

2. Speitel, L.C., Lyon R.E. , "Guidelines for Safe Use of Gaseous Halocarbon Extinguishing Agents in Aircraft", FAA Report DOT/FAA/AR-08/3, August 2009.

3. FAA Advisory Circular AC 20-42D "Hand Fire Extinguishers for use in Aircraft", Jan. 2011.

4. Vinegar, A., Jepson, G.W., Overton, J.H., PBPK Modeling of Short-Term (0-5min) Human Inhalation Exposures to Halogenated Halocarbons, *Inhalation Toxicology*, 10, 411-429, 1998.

POC: Louise Speitel

Options to the Use of Halons for Aircraft Fire Suppression Systems—2011 Update

The draft copy of the report “Options to the Use of Halons for Aircraft Fire Suppression Systems—2011 Update” was completed in 2011. This updated report reflects the many changes that have occurred in the aircraft fire suppression arena since the last update was published in 2002. Changes have occurred in regulatory restrictions, commercialized halocarbon replacements, halocarbon replacements under development, alternative technologies, and the evaluation of fire fighting effectiveness for aircraft onboard applications.

The fire suppression technologies are discussed and the applicability of each is assessed for the four primary aircraft applications for halon fire extinguishing/suppressing agents: (1) engine nacelles, (2) hand-held extinguishers, (3) cargo compartments, and (4) lavatory protection. Fire suppression Halon equivalency guidance is also provided for these applications.

This report also contains a summary of available fire suppression agents and their properties. It is also a source of information on physical properties, design concentrations and exposure limits for Halon replacements. Environmental and toxicological properties of Halon replacement agents are discussed and tabulated. The name of agent manufacturers, product names, and company contact information is provided for commercially available agents and systems.

The chapters and sections were written by assigned experts within the International Aircraft Systems Fire Protection Working Group (IASFPWG), which is chaired and administered by the FAA Fire safety Team. Chapter/section leads and assists include fire safety engineers and chemists, environmental regulators, airframe and agent manufacturers, and a non-profit trade corporation HARC which promotes the development and approval of environmentally acceptable Halon alternatives. Additional review and contributions were provided by the members at large of The Halon Option Task Group, a subgroup of the IASFPWG.

POC: Louise Speitel

DOT/FAA/AR-11/31

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
New Jersey 08405

Options to the Use of Halons for Aircraft Fire Suppression Systems—2012 Update

February 2012

Final Report

This document is available to the U.S. public through the National Technical Information Services (NTIS), Springfield, Virginia 22161.

This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at actlibrary.tc.faa.gov.

U.S. Department of Transportation
Federal Aviation Administration

Figure 1. The Report "Options to the Use of Halons for Aircraft Fire Suppression Systems—2011 Update"