Materials Fire Test Facility

Building 203

The Materials Fire Test Facility, Building 203, located in the Safety Research and Development area of the Federal Aviation Administration (FAA) William J. Hughes Technical Center, is dedicated to small-scale fire testing of aircraft materials. All of the test equipment required to conduct all of the regulatory tests for aircraft interior materials specified in Code of Federal Regulations 25.853 is part of the Materials Fire Test Facility. This includes the Ohio State University (OSU) rate of heat release apparatus, the National Bureau of Standards (NBS) smoke chamber, oil burners for the seat cushion and cargo liner tests, and Bunsen burners for the vertical, horizontal, 45-, and 60-degree flammability tests. The facility provides technical support to the Northwest Mountain Region-Transport Airplane Directorate, Aircraft Certification offices, Designated Engineering Representatives, testing laboratories, and aircraft materials manufacturers.

The facility is also the site for the development of new small-scale flammability tests such as the wet and dry arc propagation tests for aircraft wiring, as shown on the left. While other test methods are used in some laboratories, a number of the NASA labs have adopted the dry arc propagation test developed in the Materials Fire Test Facility with a few minor modifications. A more realistic smoke test for aircraft wiring using the NBS smoke chamber was also developed in this facility. This test duplicates the behavior of overheated wires and smoking insulation in an in-flight hidden-fire scenario.

As a result of a fire in a stowage bin aboard an aircraft and a recommendation from the National Transportation Safety Board, a new flammability test for aircraft blankets was developed in the Materials Fire Test Facility. The new test procedure was released as a Flight Standards Information Bulletin in 1996.

Round-robin testing by interested parties in the United States and Europe is monitored and the test data is collected and evaluated by FAA personnel at the Materials Fire Test Facility. This has led to improved flammability tests for aircraft materials. One example is the “cotton swab” test method for thermal/acoustical insulation films. This test method will be incorporated into the Aircraft Materials Fire Test Handbook which is scheduled for release in early 1998. The FAA is also working with industry and regulatory personnel on an international scale to encourage use of the cotton swab test method for selection of thermal/acoustical insulation film coverings.

The Materials Fire Test Facility personnel also participate in aircraft accident investigations by testing and evaluating materials removed from the aircraft. Other projects, such as burn-through, electrical wiring, and seat component programs are also supported in this facility.

To find out more about the Materials Fire Test Facility, contact:

Ms. Patricia Cahill, AAR-422, (609) 485-6571.

Airflow Induction Test Facility
Building 204

The Airflow Induction Test Facility, Building 204, is located in the Safety Research and Development area of the Federal Aviation Administration (FAA) William J. Hughes Technical Center. The facility contains a 5 ½-foot-diameter subsonic wind tunnel and a low-turbulence, low-speed wind tunnel as described below.

5 ½-Foot-Diameter Subsonic Wind Tunnel

The 5 ½-foot wind tunnel is an induction type nonreturn design. The induction drive is provided by two Pratt and Whitney J-57 turbine engines exhausting into the diffuser cone. The high-speed

exhaust from the two engines provides the primary flow that induces a secondary flow through the test section(s). The nonreturn design allows a continuous supply of fresh air to the facility essential for combustion type work. This design is very rugged and unaffected by debris passing through the drive section. Tunnels of this design simulate an increase in altitude as the airspeed is increased.

Test Section (high speed): The test section (shown on the right) is 5 ½ feet in diameter and 16 feet in length. Maximum airspeed in this section is limited to approximately 0.9 Mach. The entire lower lobe of the section swings away to allow for the installation of the test article. A 5- x 16-foot elevator deck makes raising the test article into position simple and safe.

Test Section (low speed): This test section (shown on the left) is 9 feet in diameter and 20 feet in length and is located upstream of the high-speed section and operates at a lower speed. Maximum airspeed in this section is limited to approximately 150 miles per hour.

The 5 ½-foot wind tunnel has been used for a variety of research applications including testing of airport runway signs to determine the design requirements needed to withstand turbine engine jet blasts and simulated in-flight testing of hand-held fire extinguishers used in general aviation aircraft.

Low-Turbulence, Low-Speed Wind Tunnel

This wind tunnel was originally designed to provide an environment to calibrate wind speed instruments. The highly accurate airspeed measurement capability, in conjunction with the six component force balance system, make this facility ideal for model testing. The facility also contains a model shop and a data acquisition system.

The low-turbulence, low-speed wind tunnel consists of an Aerolab low-speed open circuit type wind tunnel and force balance. The dimensions of the test section are 20 x 28 x 48 inches. The electrically driven wind tunnel can achieve speeds ranging from 0 to 160 mph in the test section. The six component balance system can accurately measure lift, yaw, pitch, drag, side force, and rolling moment.

The low-speed wind tunnel has been used to accurately calibrate air flow and velocity devices and is now configured to conduct model testing.

Environmental Test Chamber

The environmental test chamber is designed to simulate preset temperature, humidity, and air pressure (altitude) conditions. Chamber controllers can be programmed to simulate an entire flight from takeoff to climb-out, cruise, approach, and landing. The test chamber measures 72 x 71 x 93 inches. The environmental chamber has been used to study the behavior of in-flight fires at altitude, to evaluate the performance of wing ice detectors, and to calibrate various environmental sensors.

To find out more about the Airflow Induction Test Facility, contact Mr. Harry Webster, AAR-422, (609) 485-4183.

FAA Engine Nacelle Fire Simulator
Building 205

The Engine Nacelle Fire Simulator, Building 205, located in the Safety Research and Development area of the Federal Aviation Administration (FAA) William J. Hughes Technical Center, is designed to mimic the environment found in today's modern high-bypass ratio turbofan engines. The simulator is used by the Fire Safety engineers at the Technical Center to evaluate substitutes for halon as fire suppressants.

Currently, halon replacement is an important issue for aviation. As a result of work sponsored by the Fire Safety Section, in the Airport and Aircraft Safety Research and Development Division, a document titled "The Minimum Performance Standard for the Engine and APU Compartments" (MPSE) was drafted. This document describes the geometry of an engine nacelle simulator, operational parameters, and testing requirements required to evaluate a material or technology being considered as a halon replacement within the engine or auxiliary power unit (APU) compartment. In support of this mission, a basic engine nacelle simulator was fabricated in Building 205. The simulator will simulate the proper engine environment, meeting the intent of the MPSE.

The total fire suppression simulation requires an engine nacelle geometry, an air flow, a fire scenario, and a fire suppressant delivery. To address each element of the simulation, various systems are used. All systems are housed in a test bay having a volume approaching 12,000 cubic feet and a floor area of 4,000 square feet. The control room is adjacent to the test bay and houses support personnel and control and data gathering equipment necessary to operate the simulator.

The simulator is an 80-foot-long duct containing the air supply equipment, approach and exhaust ducts, and a test section. Three additional components are required; the first provides different aviation-specific liquids, such as fuels, at the desired temperature and quantity to the simulator interior. The second component provides a gaseous fire suppressant to the simulator interior, and the third component provides the simulator control and data gathering functions for the entire process.

The air supply equipment is capable of 0.9-3.0 lbm/s air flows heated as high as 500°F. The approach ducting contains the air flow and is 3 feet in diameter and approximately 40 feet long. The approach houses airflow sensors and stream flow correcting mechanisms. The test section, measuring 18 feet long and 4 feet in diameter, follows and is the heart of the simulator. The test section contains geometry representing an engine compartment, hardware to produce two different fire scenarios, sensors to record the environmental data, and portals to visually record fire behavior. Two fire scenarios, either pool- or spray-based, are possible. The fires are fed by the external fuel supply system which is capable of delivering fuel at 150°F and up to 1 gallon per minute. The gaseous fire suppressants are delivered by piping from the agent extinguisher into the diffuser cone entrance of the test section. These fire suppressants can be stored in various quantities at differing pressures and temperatures. Four gaseous fire suppressants (Halon 1301, HFC125, HFC227ea, and CF_3I) are on-site for near-term work.

Rounding out the capabilities of this facility is the ability to record the testing. For each test, a record is established describing the fire suppression event. The record will contain a concentration profile within the test section recorded by a Halonyzer gas analyzer for gaseous fire suppressant events; a computer file containing sensor activity measuring temperatures, pressures, air flows, and ambient relative humidity; and finally, a visual recording of the fire zone and its activity during the event.

The FAA Engine Nacelle Simulator was completed in 1997 and the test program to evaluate materials or technologies being considered as a halon replacement within the engine/APU compartments will be completed by December 1998. By using a simulator and not a true aircraft engine for the bulk of the halon replacement work, maintenance costs will be reduced. Additionally, the generic geometry of the simulator can be used to develop a better understanding of the fire suppression environment. The specific geometry of an existing engine nacelle may present a unique case which might cloud general understanding and inhibit widespread application of the generated data.

To find out more about the FAA Engine Nacelle Fire Simulator, contact Mr. Douglas Ingerson, AAR-422, (609) 485-4945.

Full-Scale Fire Test Facility

Building 275

Completed in 1980, the Full-Scale Fire Test Facility, Building 275, located in the Safety Research and Development area at the FAA William J. Hughes Technical Center, is the largest U.S. Government operated facility of its kind. A 40-foot-high fire-hardened ceiling allows testing with large pool fires under controlled conditions. There are currently two aircraft fuselages inside the facility which can be set up to simulate a variety of test conditions. The narrow-body Boeing 707 test article can be configured for cabin water mist, seat comparison, and burnthrough tests, while the 132-foot-long hybrid DC-10 test article has the added capability of supporting cargo compartment fire simulations in three fully instrumented sections. Continuous gas sampling, temperature measurements, smoke levels, heat flux, and acid gases can be monitored in each of the test sections. The data obtained from the fire tests can be transferred into hazard models designed to generate estimated survival times at particular cabin locations. All testing is conducted from a remote area that contains state-of-the-art video monitoring equipment for continuous observation. Both in-flight and postcrash fire scenarios have been studied, which has led to the development of vastly improved fire safety standards for aircraft cabin interiors and cargo compartments.

In addition to the two test articles, there are small test chambers located within the facility that are capable of supporting existing and new laboratory-scale tests, as well as quick mock-up work often required during accident investigations. A full-length attached warehouse serves as an enclosure for the many aircraft components and equipment required to support the full-scale tests.

Currently, there are two major research programs underway at this facility: halon replacement and fuselage burnthrough.

<u>Halon Replacement</u>. Halon, a gaseous extinguishing agent used in aircraft cargo compartments, engine nacelles, lavatory trash receptacles, and hand-held extinguishers, is the most effective fire extinguishing agent on a weight basis. Although effective, halon depletes stratospheric ozone. Halon manufacturing was banned under the 1994 Montreal Protocol, a treaty signed by countries around the world. The FAA is in the process of developing minimum performance standards by which replacement agents' effectiveness can be measured. Candidate fire protection systems for the cargo compartment areas include gaseous agents, pyrotechnically generated aerosols, and water mist. The photograph on the left depicts the initial stages of a cargo compartment fire scenario against which the various agents will be evaluated.

Fuselage Burnthrough. After an accident, fuel fire flames can enter the cabin through an inadvertently open escape exit or, in a more severe impact, through a break in the fuselage. Fire can also enter the cabin by penetrating the fuselage structure, which is the focus of this research project. In an accident in Manchester, England, in 1985, 55 fatalities occurred due to the rapid burnthrough from an external fire. As a result of this accident, fire tests were conducted to determine the burnthrough paths and the time frame involved in order to better understand the accident scenario. The emphasis of the current test program is on evaluating improvements to delay the burnthrough time and thereby increase the escape time and to validate test work being performed on a medium-scale burnthrough rig. To date, several technologies have emerged that have the capability of delaying burnthrough for several additional minutes. The photograph below shows the external pool fire used during these experiments.

To find out more about the Full-Scale Fire Test Facility, contact Mr. David Blake, AAR-422, (609) 485-4525.

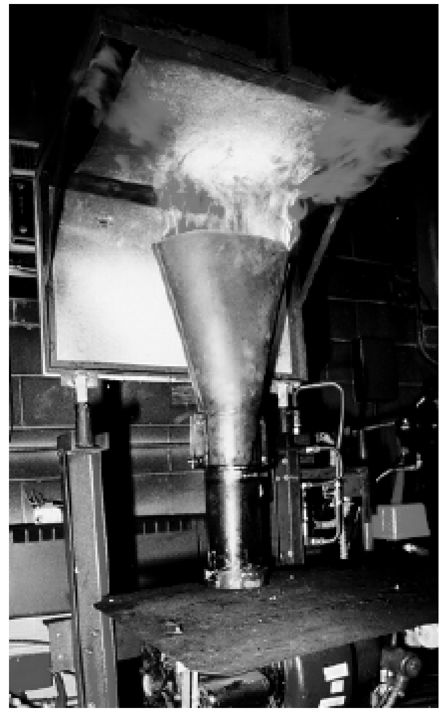
Chemistry and Materials Sciences Laboratory
Building 277

The Chemistry and Materials Sciences (C&MS) Laboratory located in Building 277 in the Safety Research and Development area at the FAA William J. Hughes Technical Center provides FAA chemists, fire scientists, and materials engineers the facilities and equipment to quantify the amount of toxic gas produced during full-scale aircraft cabin fire tests. The FAA is committed to developing the enabling materials technology for a totally fireproof cabin. The goal of the program is to eliminate cabin fire as a cause of death in aircraft accidents. To achieve this goal we will need interior plastics with an order-of-magnitude reduction in fire hazard compared to current materials. In the C&MS Laboratory, research and development of new, more fire-resistant materials is conducted using state-of-the-art laboratory equipment for thermal analysis, calorimetry, spectroscopy, rheology, surface chemistry, microscopy, and multiaxial mechanical testing. Flammability and combustion parameters of cabin materials are determined in bench-scale fire calorimeters. Prototype components up to 1/2 meter square can be fabricated. C&MS Laboratory equipment includes:

- Netzsch High-Speed Thermogravimetric Analyzer (TGA) for evolved gas analysis
- Perkin Elmer System 7 TGA and Differential Scanning Calorimeter
- Nicolet Magna 550 Fourier Transform Infrared (FTIR) Spectrometer
- Parr Oxygen Bomb Calorimeter for heat of combustion determinations
- FAA Microscale Combustion Flow Calorimeter (patent pending)
- Dionex DX 500 Ion Chromatograph with Thermo-Separations AS 3500 Autosampler
- Rheometrics RDA-II Dynamic Analyzer for rheological testing of fluids and solids
- Instron Model 1125 Universal Mechanical Testing Machine
- Rame-Hart Contact Angle Goniometer for surface chemistry measurements
- PHI Heated Laminating Press–50 Ton/1000°F capability
- Gruenberg Curing Oven–800°F (426°C) capability
- Atas Scientific Cone Calorimeter–measures flaming combustion parameters of materials

A unique instrument, the microscale combustion calorimeter which was developed by FAA researchers, is located in the C&MS Laboratory. The calorimeter is used to measure flammability parameters of milligram polymer (plastic) samples under conditions which approximate aircraft cabin fires. The tests performed using the calorimeter provide a quantitative measure of the fire hazard of new materials in an aircraft cabin fire when only research quantities are available, thus saving the expense of manufacturing and testing large quantities of new materials. The photograph on the right shows the microscale combustion calorimeter, showing, from left to right, the sample pyrolysis stage, the heated oxygen mixing manifold, and the combustion furnace and oxygen analyzer.

A new, potentially fire-resistant material being tested in the C&MS Laboratory is the Geopolymer resin. This material is being evaluated as a resin for use in fireproof aircraft cabin interior panels and cargo liners (see test at right). Geopolymer is a two-part, water based, liquid potassium aluminosilicate resin which cures at 80^{o}C (176^{o}F) to a fireproof solid having twice the density of water. Geopolymer has the empirical formula: $Si_{32}O_{99}H_{24}K_{7}Al$. The fire response and mechanical properties of Geopolymer composites were measured and compared to lightweight organic matrix composites and aluminum used in aircraft.



Carbon fabric reinforced Geopolymer crossply laminates were found to have comparable initial strength to phenolic resin composites currently used in aircraft interiors. Unlike the phenolic laminates however, the Geopolymer composites did not ignite, burn, or release any heat or smoke even after extended exposure to high heat flux. Geopolymer composites retained 67 percent of their original flexural strength after fire exposure while organic (e.g., phenolic) composites and aluminum had no residual strength after the test. Geopolymer composites have higher strength and stiffness per unit weight, higher temperature capability, and better fatigue resistance than steel or aluminum.

Work in the C&MS Laboratory is continuing on understanding how the Geopolymer resin protects the carbon fibers from oxidative degradation at 800ºC (1500ºF) in air, on optimizing the processing of materials made with the Geopolymer resin to obtain maximum strength, and on improving the toughness of laminated composites made with the Geopolymer resin.

To find out more about the Chemistry and Materials Sciences Laboratory, contact Dr. Richard Lyon, AAR-422, (609) 485-6076.

Aircraft Components Fire Test Facility

Building 287

The Aircraft Components Fire Test Facility, located in the Safety Research and Development area at the FAA William J. Hughes Technical Center, houses two test bays designed and used for component or intermediate-scale fire tests. The larger of the test bays is 2000 sq. ft. and the smaller is 1600 sq. ft. Both bays are 20 feet high and have access through a large roll up door. Both bays are constructed of fireproof materials and contain large blowout panels for explosion protection. A centrally located instrumentation and control room contains test monitoring and data collection equipment and is connected to the bays via under floor conduits. In addition to the test bays, the building includes a small work and buildup area, a conference room, a computer lab, and office space for six fire safety personnel.

Recent testing in the building has included the development of new fire test standards for flight data recorders. The testing included propane burner tests, shown on the left, as well as long-term elevated temperature tests, using a high-temperature programmable oven. The results were used in the development of a new Technical Standard Order (TSO) for flight recorders.

The testing of solid oxygen generators was conducted under various scenarios. This included the testing of a single canister (see photo on right) under various conditions up to full-scale tests of over 100 generators in a Boeing 727 cargo compartment. The results were used as part of the Valujet investigation and as part of the justification for rulemaking to eliminate class "D" cargo compartments.

Testing was conducted to develop a methodology to use HFC 125 as a substitute for Halon 1301 in certification testing of fire suppressant/extinguishing systems. By substituting HFC 125 for Halon 1301, less Halon 1301, an ozone depleting gas, is expended during the certification tests of new systems.

The testing of thermal/acoustic insulation materials included the standardization of a small-scale flammability test method. This method has been included in the Aircraft Materials Fire Test Handbook and has been adopted by major airframe manufacturers. Additionally, larger scale mockup tests were conducted (photo on right) in sections of an aircraft fuselage. The results of those tests have lead to the modification of the specification for thermal/acoustic insulation by at least one major airframe manufacturer.

The cargo compartment fire suppression testing included comparisons of class “D” and class “C” compartments for various fire threats and suppression systems. The test article used was a Boeing 727 cargo compartment. Fire scenarios included exploding aerosol cans (photo on left) and suppression systems ranging from the presently used Halon 1301 to nonconventional water mist systems. Work was in support of ongoing rulemaking.

To find out more about the Aircraft Components Fire Test Facility, contact Mr. Richard Hill, AAR-422, (609) 485-5997.