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AIRCRAFT FIRE SAFETY

NORTH ATLANTIC TREATY ORGANIZATION

DEVELOPMENT OF IMPROVED FIRE SAFETY STANDARDS ADOPTED BY THE FEDERAL AVIATION ADMINISTRATION

Constantine P. Sarkos
Manager, Fire Safety Branch
Federal Aviation Administration Technical Center
Atlantic City International Airport, NJ 08405
U.S.A.

SUMMARY

This paper summarizes a series of improved fire safety standards for transport aircraft adopted or proposed by the United States Federal Aviation Administration over the past five years and describes the technical development of these standards. Important test results and analyses employed to develop the new standards are described. Reference is made to technical publications issued by the FAA for each fire safety area. Emphasis is placed on recent and high-impact rulemaking actions such as the heat release standard for large surface area interior panels (based on the Ohio State Rate-of-Heat-Release Apparatus). Other activities summarized include heat resistance evacuation slides, smoke detectors and fire extinguishers, cargo compartment fire protection, seat cushion fire blocking layers, floor proximity lighting, and crewmember protective breathing equipment.

INTRODUCTION

The Federal Aviation Administration (FAA) has undertaken an unprecedented series of regulatory actions over the past five years for the purpose of improving transport aircraft interior fire safety. These initiatives were part of a broad, scheduled program to enhance airliner safety that includes such diverse topics as water survival, child restraints, and crashworthiness (1). They are a culmination of a number of factors, including advisory committee recommendations (2), congressional support, product oriented FAA technical programs, accident pressures, and industry cooperation.

Aircraft interior design for fire safety covers three broad areas: material fire test methods, fire management and suppression, and evacuation and survival. Because of the overriding concern with the effect of the hazards of burning interior materials on occupant survivability, the FAA has placed greatest emphasis in its research, engineering and development program for cabin fire safety on the development of improved fire test methods for interior materials. Products from this program were incorporated into new fire test standards for seat cushion fire blocking layers (3), low heat/smoke release interior panels (4,5), burnthrough resistant cargo liners (6), and radiant heat resistant evacuation slides (7). New requirements for detectors and extinguishers (8) will improve in-flight fire management and suppression. Evacuation and survival has been enhanced by new standards for floor proximity lighting (9) and flight crewmember fixed protective breathing equipment and cabin crewmember portable protective breathing equipment (10).

SEAT CUSHION FIRE BLOCKING LAYERS

Aircraft seats are typically constructed of fire retardant polyurethane foam and upholstery fabric, which previously was required to pass the vertical Bunsen burner test prescribed in Federal Aviation Regulation (FAR) 25.853 (11). However, under the conditions of a severe cabin fire, the foam core ignites readily and burns rapidly, significantly contributing to the spread of fire. The concept of a fire blocking layer material to encapsulate and to protect the polyurethane foam was recommended for evaluation and development by the Special Aviation Fire and Explosion Reduction (SAFER) Advisory Committee (2).

The initial phase of FAA evaluation consisted of a series of full-scale tests to determine the effectiveness of the seat cushion fire blocking layer concept under the conditions of an intense postcrash fuel fire. Prior work by others was limited to the evaluation of fire blocking layers under moderate fire conditions for office, theater, institutional, and surface transit vehicle settings. The FAA full-scale tests were conducted in a new building with the capability of subjecting aircraft test articles to large jet fuel pool fires under controlled environmental conditions (12). A C-133 airplane modified to resemble a wide body interior was employed as the test article (figure 1). Basically, a section of the C-133 test article was lined and furnished with actual cabin materials and subjected to an intense external fuel fire placed adjacent to a simulated fuselage rupture. The results of four tests with modified seat cushions (13), but with all other test aspects identical, are shown in figure 2. In this figure the fractional effective dose (FED) accounts for the assumed additive effect of measured levels of toxic gases and elevated temperature on survival (12). An FED value of unity corresponds to incapacitation and indicates the hypothetical survival time. The additional time available for escape when the seats were protected with Vonar™ and Norfab™ fire blocking layers was 60 and 43 seconds, respectively, and was comparable in the case of Vonar to the safety benefits provided by noncombustible foam cushions. Further testing demonstrated that blocking layers could provide even greater improvements against certain types of ramp and in-flight fires, for example, preventing fires that may otherwise become out of control when initiated at an unprotected seat and left unattended (14). Although these data demonstrate the efficacy of the fire blocking layer concept, extensive additional FAA work was needed to make the concept into a viable product. This additional work covered the subjects of weight optimization and durability (15), flotation (16), cost-effectiveness (17), and certification testing of cushions (18).

The final rule established that transport aircraft seat cushions meet new and more severe flammability requirements by November 26, 1987 (3). The new test methodology, developed by FAA, subjects seat back and seat bottom cushion specimens to a burner with temperature and heat flux typical of a cabin fire (figure 3). Unlike most flammability tests, the test specimens simulate the end use seat configuration and allow for the burning interaction of upholstery cover, fire blocking layer, and foam cushion. In addition, other important effects such as seat construction features (thickness, seams, foam layering, etc.) and the melting, dripping, and pool burning behavior of urethane foam are taken into consideration. Acceptance criteria consist of 10 percent weight loss and a burn length of 17 inches - performance essentially matching that attained by the Vonar™ and Norfab™ blocking layer materials proven effective in full-scale tests. An advisory circular was issued by FAA to provide guidance material for testing seat cushions to show compliance with the rule (19).

Approximately 350 fire blocking layer materials were evaluated by FAA following the development of the seat cushion flammability test methodology. About 130 materials met the performance criteria, including, for example, thin foams, fiberglass cloths, aluminized fabrics, and graphitized fabrics, demonstrating the availability of suitable fire blockers. Many of the materials later proved to be impractical from weight, comfort, and durability considerations upon subsequent indepth evaluation by seat manufacturers. Today, the majority of seats manufactured in the United States are constructed of either polybenzimidazole felts or aramid fire resistant quilts, weighing 6 to 10 ounces per square yard. The entire United States airline fleet, consisting of approximately 650,000 seats, is protected with seat cushion fire blocking layers.

LOW HEAT RELEASE INTERIOR PANELS

The interior panels of an aircraft cabin, such as the sidewalls, ceiling, stowage bins, and partitions, are very important to the cabin fire load because of their large surface area and, in some cases, location in the upper cabin where fire temperatures are greatest. This importance was evidenced in the full-scale fire tests with fire blocking layers (figure 2). In the test with noncombustible seat cushions, the flashover was caused primarily by the burning panels. Interior panels are usually complex composites consisting generally of a Nomex™ honeycomb core, resin-impregnated fiberglass facings, and a decorative laminate finish.

The next logical step in fire-hardening the interior of a transport aircraft, after the establishment of a seat cushion flammability standard (3), was to improve the fire performance of the interior panels by development of more stringent and new fire test requirements. The issue of improved test methodology was complicated by the requirement to consider the interrelated concerns of flammability, smoke, and toxicity. However, test methodology development was preceded by the need to document (by full-scale fire tests) the potential benefits of fire-hardened panels for several fire scenarios.

The potential for improved safety was examined in the C-133 wide body test article used earlier for evaluation of the effectiveness of seat cushion fire blocking layers. A section of the test article was fitted with sidewalls, stowage bins, a ceiling, and a partition, each constructed of an advanced composite panel selected by the National Aeronautics and Space Administration (NASA), as well as fire blocked seats and carpet, and subjected to three types of full-scale fire conditions. The same tests were repeated with a panel design used extensively in early wide body interiors and still retained for some interior applications. The safety improvement associated with the advanced panel when compared to the in-service panel was significant. With the advanced panel, flashover was actually prevented when the external fuel fire was adjacent to a door opening or when an in-flight fire was started from a gasoline drenched seat. In the more severe ruptured fuselage scenario, wherein seats are more directly exposed to the external fuel fire, use of advanced panels resulted in a 2-minute delay to the onset of flashover (20).

The full-scale fire tests in the C-133 wide body test article, conducted to examine the benefits of seat cushion fire blocking layers and fire-hardened interior panels, demonstrated that occupant survivability was largely driven by cabin flashover. Flashover may be defined as the sudden and rapid uncontrolled growth of fire from a relatively small area surrounding the ignition source to the remainder of the cabin. Typical C-133 test data exhibiting this behavior are shown in figure 4. Before the onset of flashover, which occurred at about 150 seconds, the smoke and toxic gas levels were minimal and survival was clearly possible. After the onset of flashover, smoke and toxic gas levels and temperature increased rapidly to a level that would have made survival highly unlikely.

It should be noted that flashover is a phenomenon that generally occurs when fire in an enclosure generates heat at some critical rate that is effected by heat transfer and ventilation. Flashover to a large degree is caused by the heat release rate of burning interior materials. Thus, a rate of heat release test methodology will tend to yield the contribution of a given material to the flashover event. Also, selection of interior materials on the basis of minimizing heat release rate also serves to implicitly reduce the cabin smoke and toxic gases hazards since it is the flashover event that generates hazardous quantities of combustion products (figure 4).

Several studies were conducted to correlate the performance of composite panels in a heat release test device and under realistic cabin fire conditions. Initially, a variety of laboratory flammability tests were evaluated in terms of panel performance with results in a 1/4-scale cabin model (21). The Ohio State University (OSU) rate-of-heat-release apparatus exhibited the best correlation with model fire test results. Although probably any of the available heat release rate tests would serve to yield the flashover potential of various panel materials, the OSU apparatus was selected specifically for further evaluation and development. The decision to select the OSU apparatus was based on the above correlation study as well as recommendations of the SAFER committee (2), the use of the OSU apparatus in the development of the Combined Hazard Index (22), the availability of the OSU apparatus with the airframe manufacturers and its standardization by the American Society of Testing and Materials (ASTM). A second study corroborated the earlier good correlation results in that it established an inverse relationship between heat release measurements in the OSU apparatus and the time-to-flashover of a series of composite panels evaluated in the full-scale C-133 test article under postcrash fire conditions (23).

The second correlation study involved C-133 tests of five composite panel constructions under a scenario consisting of an external fuel fire adjacent to an open door. To realistically evaluate panel performance, the flat panel test specimens were installed in a typical configuration that included sidewalls, stowage bins, a ceiling and partitions (figure 5). In this arrangement, other factors such as ease of ignition and flame spread rate for the panels, as well as the contribution of fire-blocked seats and carpet, were allowed to come into play. The results of these tests are shown in figure 6 as an FED history plot. The graph indicates a wide range in behavior for the five types of panels. The phenolic/Kevlar^{TM} and epoxy/fiberglass panels displayed the earliest flashovers, whereas the phenolic/fiberglass panel delayed flashover by about 3 minutes. Moreover, there was a monotonic, inverse relationship between heat release measured by the OSU apparatus and time to flashover. Also, the data indicate that small changes in heat release by materials may result in large changes in the time to cabin flashover.

The actual criteria for material selection were driven by the level of benefits evidenced by full-scale testing. The phenolic/fiberglass panel tested well under virtually any test condition (23), and this construction was achievable by state-of-the-art manufacturing processes. Thus, the phenolic/fiberglass panel was used as a benchmark for selection of the performance criteria for OSU testing of panel materials. A pass/fail criterion of 65 kw-min/m^2 for a 2-minute total heat release was selected to embrace the performance of the phenolic/fiberglass panel. An additional criterion of 65 kw/m^2 for peak heat release rate was included to eliminate usage of those materials that burn rapidly but produce small quantities of heat because of their low weight. The final rule also contains a new requirement for smoke emission testing in order to minimize the possibility that emergency egress will be hampered by smoke obscuration (5).

A schematic of the OSU apparatus is shown in figure 7. The equipment is basically a flowthrough device that measures the heat release rate as a function of time by a material subjected to a preset level of irradiated heat. Although the relationship between heat release rate data measured by the OSU apparatus and cabin fire conditions was demonstrated, the OSU data have been found to be sensitive to certain design features and operational conditions. Three round-robin test programs between FAA and the United States Aerospace Industries Association (AIA) were necessary to reduce the reproducibility of data between laboratories to an acceptable level (24). Results from the third round robin, with Boeing, Douglas, OSU, and FAA as participants, however, indicate that consistent results are attainable (figure 8). For example, the reproducibility of the third round robin, as measured by the percentage average relative standard deviation, was 7.7 and 7.8 percent for total heat release and peak heat release rate, respectively (24). Moreover, in a more recent round robin involving FAA and four laboratories in Europe, the reproducibility was quite acceptable after the initial comparison - 5.4 and 10.9 percent for total and peak measurements, respectively.

CARGO LINER BURNTHROUGH RESISTANCE

Lower cargo compartments in large transport aircraft are categorized as either class C or class D types (11). The latter are small compartments designed for fire containment by oxygen starvation, while the former are larger compartments that are required to have a fire detection and suppression system. FAA conducted full-scale fire tests to investigate the resistance of cargo liners to flame penetration for both compartment classifications. In a class D compartment, where it is critical that liners not be breached in order to allow oxygen starvation to take place, it was found that some types of liners failed (25). Fiberglass liners resisted burnthrough, whereas Nomex liners were penetrated by the flames (figure 9). It was concluded that a class D cargo fire was controllable if fiberglass or equivalent were the liner materials; but, if Nomex were used, the fire would continue to burn because of the availability of oxygen due to liner failure. In tests conducted inside a class C cargo compartment, even with a detection/suppression system, liner burnthrough resistance equivalent to fiberglass was required to ensure fire suppression under all scenarios (26). For example, Kevlar liner burnthrough occurred when sudden, intense flaming fires were employed and when a time lapse was allowed between the points of detection and discharge of suppression agent. Although the fire may be suppressed by the agent, it was determined that the breached cargo liner would cause a more rapid depletion of agent concentration and re-ignition at an earlier point in time than in an intact compartment. The main conclusion from the testing was that a more realistic and severe test requirement was needed for cargo liners used in both class C and class D cargo compartments.

A new fire test method that measures the burnthrough resistance of cargo liners, shown in figure 10, was developed with the features of severe liner exposure (matching the maximum heat flux and temperature measured during full-scale tests) and realistic ceiling and sidewall liner orientation (27). This test method is the basis for more stringent test requirements in newly certified aircraft (6) and a similar proposal for certain transports now in service (28). Criteria for acceptance are that there must be no flame penetration of ceiling and sidewall specimens and that the temperature measured above the ceiling specimen must not exceed 400 °F. The flame penetration criterion can be met by fiberglass liners but not by Nomex or Kevlar liners (27). However, many fiberglass liners cannot meet the peak temperature criterion because of the type or weight of resin and type of cloth weave (29). It appears that fiberglass suitably tailored to meet the peak temperature criterion will be the material of choice for new burnthrough resistance requirements although several new materials or combinations are being studied.

In a more recent, separate action, the FAA has proposed a new airworthiness directive (AD) for "combi" airplanes certified with a main deck class B cargo compartment (30). This action was prompted by the loss of a 747 airplane that apparently developed a major fire in the main deck cargo compartment. The AD proposes design changes that would require that the class B compartments be modified to a class C configuration or that burnthrough resistant cargo containers, meeting the more stringent test requirements for cargo liners (6) and employing smoke detection and extinguishing systems, be used to carry all cargo.

RADIANT HEAT RESISTANT EVACUATION SLIDES

In 1978, a DC-10 experienced an aborted takeoff resulting in a major jet fuel fire and the resultant collapse of a deployed evacuation slide caused by radiant heat damage. Although the two fatalities were not attributable to loss of the slide for emergency egress, the FAA undertook a test and development program to improve the radiant heat resistance of slide fabrics. From a series of full-scale fire tests in which pressurized slides were subjected, at various distances, to a 30-foot-square fuel fire, it was determined how slides failed and the time duration for failure (loss of pressurization) to occur (31). For example, a typical urethane nylon slide, located 15 feet from the edge of the fuel fire, where the irradiance was 1.5 Btu/ft^2-sec, failed in 25-30 seconds on the plain surface (non-seam area). Also, it was shown that an aluminized reflective coating significantly improved the airholding qualities. The uncoated urethane nylon slide that failed in 25-30 seconds held pressure for 70-75 seconds when protected with an aluminized coating and loss in pressure occurred at an opened seam.

To permit the development and qualification of improved slide fabrics, a laboratory test was developed (31). The essential features of the laboratory test, shown in figure 11, are a radiant heater, calorimeter, pressure holding cylinder, specimen holder, pressure gage, pressure transducer, and recording device. Basically, a slide fabric specimen is mounted to the pressure holding cylinder which is then pressurized. The irradiance to the specimen is set by the calorimeter. Pressure holding capability of the specimen at the set irradiance level is determined by the recorded pressure history.

On June 3, 1983, FAA issued Technical Standard Order (TSO)-C69a, Emergency Evacuation Slides, Ramps, and Slide/Raft Combinations, which made general improvements to the equipment requirements and contained new requirements for radiant heat resistance (7). TSO-C69a required that all evacuation slides purchased after December 3, 1984, meet the new standards. For radiant heat resistance, the requirement is retention of pressure for 90 seconds at an irradiance of 1.5 Btu/ft^2-sec. The pressure holding members of all TSO-approved inflatable evacuation slides are now constructed of aluminized materials in order to provide adequate radiant heat resistance.

SMOKE DETECTORS AND FIRE EXTINGUISHERS

As the result of investigations of in-flight fires, including the Air Canada DC-9 on June 2, 1983, (that resulted in 23 fatalities) and an inspection survey of the United States air carrier fleet, the FAA amended the FARs with the following requirements: a smoke detector in each lavatory, an automatic fire extinguisher in each lavatory trash receptacle, increased number of hand fire extinguishers, and the use of Halon 1211, or equivalent, as the extinguishing agent in at least two of the hand fire extinguishers (8). A separate time period was specified for implementation of each requirement, with the longest period extending to April 29, 1986.

FAA supportive experimental and analytical studies for these amended regulations have concentrated on the effectiveness and safety of Halon 1211 (bromochlorodifluoromethane) hand extinguishers. Initial tests showed the superiority of Halon 1211 in knockdown and extinguishment capability against fuel drenched seat fires in comparison to water, dry chemical, and carbon dioxide extinguishers. However, opposition to the usage of Halon 1211 centered on the toxicity associated with the agent and, in particular, its decomposition products. Subsequent tests by the FAA clearly showed that virgin agent and decomposition gas concentrations peaked at levels significantly below values considered dangerous and rapidly dissipated due to the effect of adsorption, stratification, dilution, and ventilation (32). Typical gas profiles measured near an extinguished seat fire in the C-133 test article are shown in figure 12. Hydrogen fluoride (HF) and hydrogen bromide (HBr) concentrations peaked at about 10 parts per million (ppm), hydrogen chloride (HCl) peaked at 17 ppm, and the peak virgin agent concentration was 1800 ppm (0.18 percent). Most importantly, it became evident that the hazards associated with an uncontrolled seat fire would quickly surpass those transient hazards resulting from Halon 1211 decomposition (32) and would possibly result in cabin flashover within 3 to 4 minutes if left unchecked (13).

To place a conservative upper limit on the quantity of agent that could safely be discharged inside a compartment, a perfect stirrer model was used to analyze the decay of agent concentration due to ventilation (33). Nomographs developed from this analysis predict maximum safe agent weight for a given compartment volume and ventilation rate and are incorporated in a revised advisory circular (AC) on hand fire extinguishers (34).

In related studies, the FAA has examined the safety of Halon extinguishing agent discharge in small airplanes (35,36,37). A major concern is the warning label on Halon bottles against discharge in a small enclosure volume. For example, for the common size 2 1/2 pound Halon 1211 extinguisher, the upper volume limit for "safe" agent discharge is 312 cubic feet. However, FAA tests conducted under simulated flight conditions in a Cessna 210 with a cabin volume of 140 cubic feet clearly demonstrated that both Halon 1211 and Halon 1301 could be safely discharged in this relatively small airplane cabin (35,36). The absence of significant concentrations of agent near a seated occupant was shown to be primarily the result of accumulation of the heavy agent near the floor and, to a lesser degree, high cabin ventilation rates. Apparently, the Halon bottle warning labels are based on safety factors for human exposure as well as assumptions of zero ventilation and homogeneous agent distribution. Fire tests conducted inside a Piper Commanche airplane also demonstrated the effectiveness of Halon 1211 and Halon 1301 in extinguishing hidden electrical and hydraulic fires behind an instrument panel (37). In summary, the safety and effectiveness of Halon hand-held extinguishers has been demonstrated for both large and small airplane cabin applications.

FLOOR PROXIMITY LIGHTING

Rapid passenger evacuation is the most critical and overriding consideration in postcrash cabin fire safety. Buoyant hot smoke from a cabin fire, however, clings to the ceiling and rapidly obscures conventional ceiling mounted emergency illumination and exit signs, thereby reducing the visibility of occupants and prolonging evacuation time. The resultant reduction in visibility and escape guidance often occurs when the lower portion of the cabin is relatively free of combustion products. FAA tests have demonstrated the effectiveness of emergency lighting placed below the smoke layer in the proximity of the cabin floor. In one study, the improved visibility of floor proximity lighting systems, including lights mounted on armrests, floor mounted electroluminescent lights and self-powered betalights, was evidenced during full-scale postcrash cabin fire tests (38). Another study translated the improved visibility of low level lighting to faster evacuation rate (39). People were able to evacuate in approximately 20 percent less time from a cabin simulator filled with stratified theatrical smoke when seat mounted lighting illuminated the main aisle than from the simulator with conventional ceiling lights. In a third study, the degree of merit of 11 improved emergency lighting systems was evaluated on the basis of illumination, reliability, cost, and other parameters (40).

The final rule, published on October 26, 1984, required floor proximity emergency escape path marking to enable passengers to visually identify the emergency escape path along the cabin aisle and to readily identify each exit by reference only to markings and visual features not more than 4 feet above the floor (9). All in-service airplanes, type certificated after 1958, were required to comply with the new design standards within 2 years, or by November 26, 1986. Issuance of the rule was followed by an advisory circular (AC) to provide guidance material for use for demonstrating compliance with the floor proximity lighting rule (41). The AC clarified, by example, systems that could or would not meet the requirements of the rule. To meet the requirements of 25.812(e)(1) for markings that enable each passenger to visually identify the emergency escape path along the cabin aisle floor, the AC states that the system must provide a reasonable degree of illumination over the entire length of the escape path along the aisle floor. A distant light at an exit that allows the escape path to remain essentially dark would not be acceptable. Also, the requirement to readily identify each exit by reference only to markings and visual features not more than 4 feet above the floor would not be met by a system that provides only general diffused light in the vicinity of the exit or a system which merely marks the fore and aft location of the exit along the aisle floor, and not the exit itself.

CREWMEMBER PROTECTIVE BREATHING EQUIPMENT

Protection of crewmembers against smoke and toxic gases produced by an in-flight fire includes fixed protective breathing equipment (PBE) for flight deck crewmembers and portable PBE for cabin crewmembers. Criteria for design of flight crewmember PBE are contained in TSO-C99 (42) and include requirements for testing masks and/or goggles for smoke leakage. Portable PBE for cabin crewmembers is required for all transport aircraft by July 6, 1989 (10). Basically, a portable PBE must be located at each approved hand-held extinguisher station.

FINAL COMMENTS

In recent years the FAA has issued an unprecedented series of new standards to improve fire safety in transport aircraft. Many of the new standards are products of FAA's research, engineering and development (R, E & D) program. The use of fire blocking layers for seat cushions and low heat/smoke release interior panels are expected to furnish the greatest gains in airliner fire safety from these standards. However, it is unlikely that further improvements in fire safety from even more fireworthy interior materials can be anticipated in the foreseeable future due to the fact that the new, stringent FAA fire test requirements, especially for interior panels, are driving technology to produce suitable composite designs. Exclusive of fuels and fuel systems safety considerations, additional improvements in aircraft fire safety are more likely from current R, E & D activities related to active fire protection, such as cabin water mist fire suppression or enhanced smoke venting.

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(42) Protective Breathing Equipment, Federal Aviation Administration, Technical Standard Order TSO-C99, June 27, 1983.

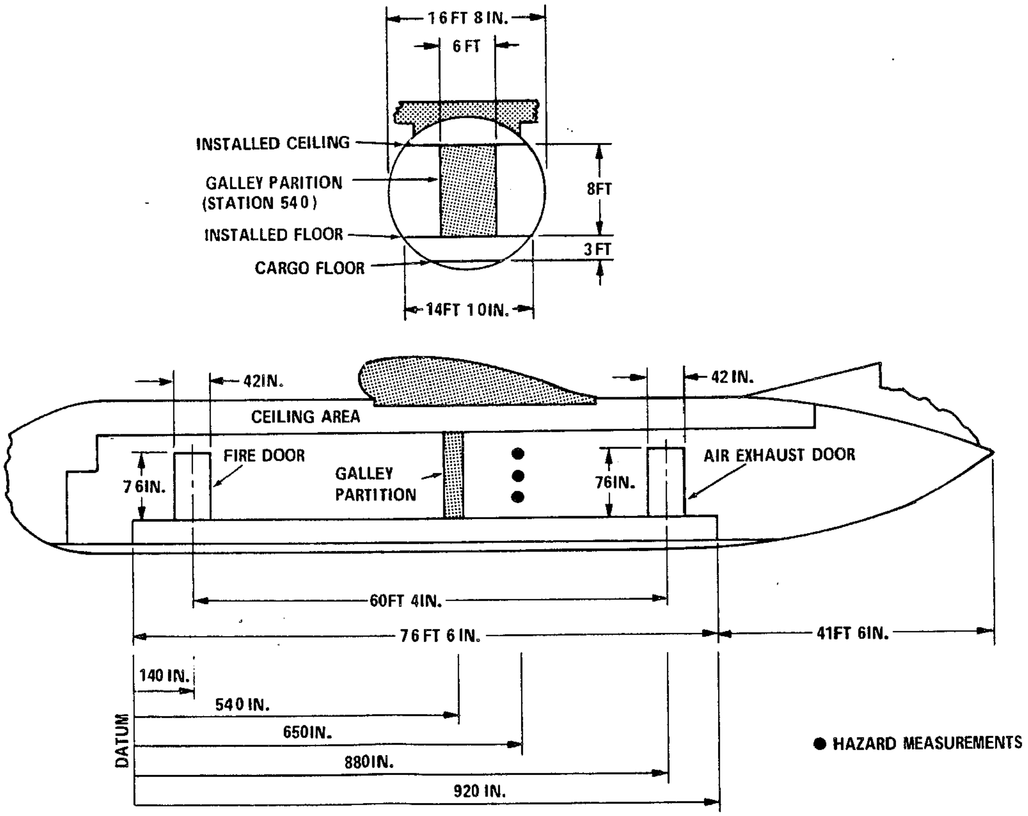

FIGURE 1. C-133 WIDE BODY CABIN FIRE TEST ARTICLE

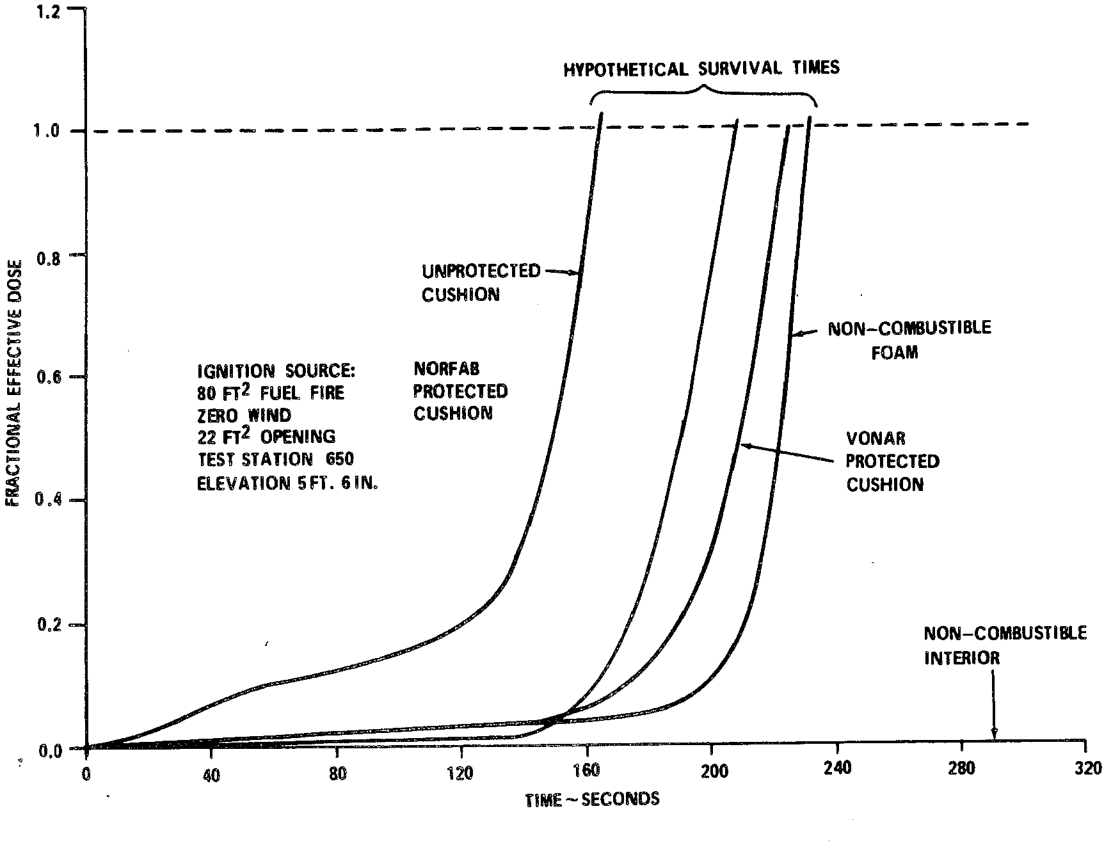

FIGURE 2. EFFECT OF SEAT CUSHION PROTECTION ON FRACTIONAL EFFECTIVE DOSE

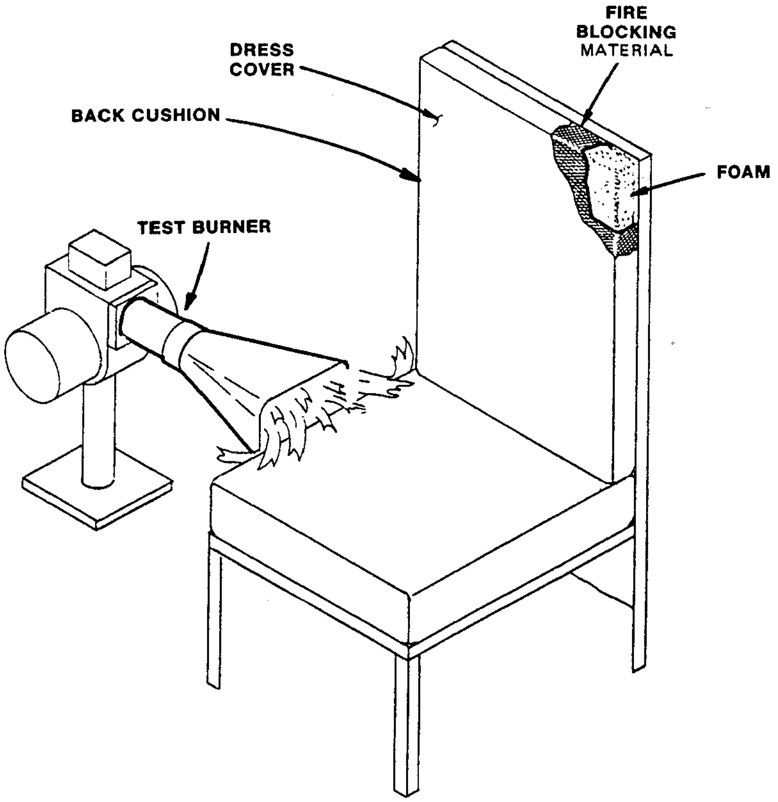

FIGURE 3. FAA SEAT CUSHION FLAMMABILITY TEST APPARATUS

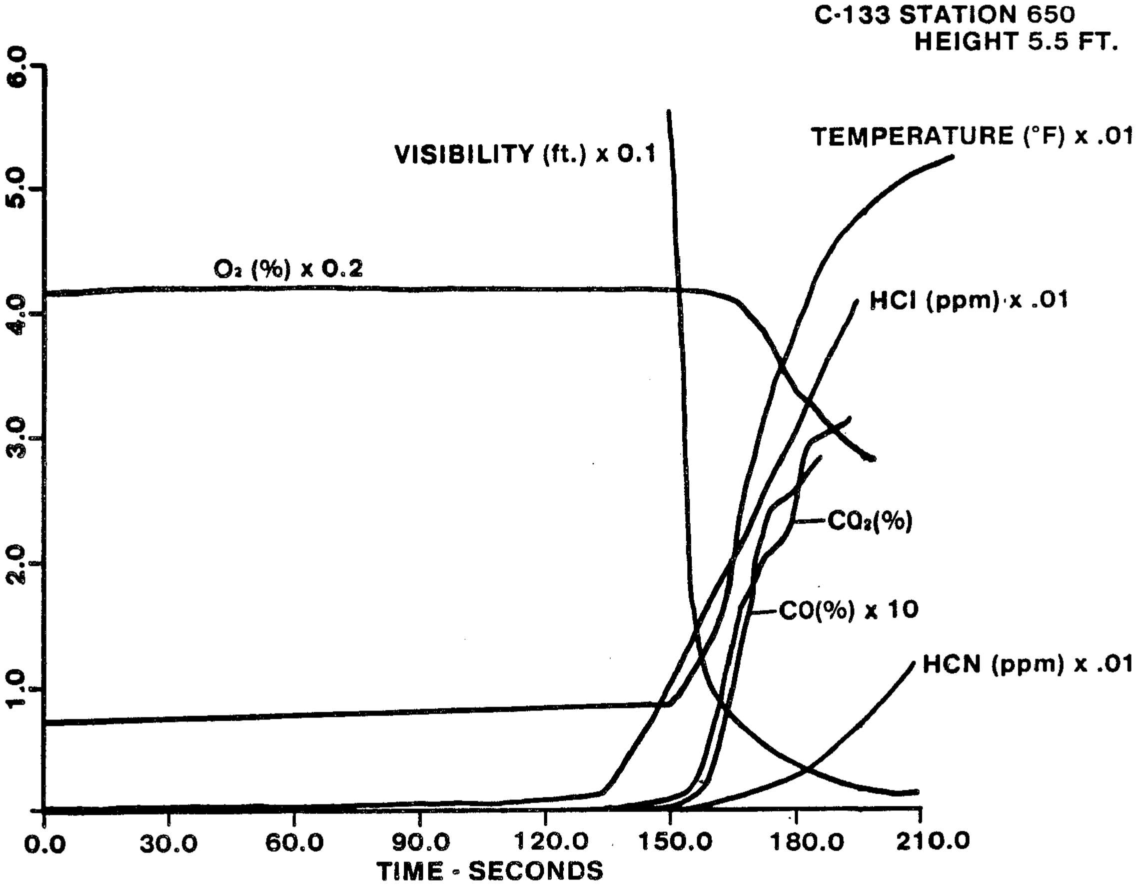

FIGURE 4. TYPICAL C-133 CABIN FIRE HAZARDS PROFILE

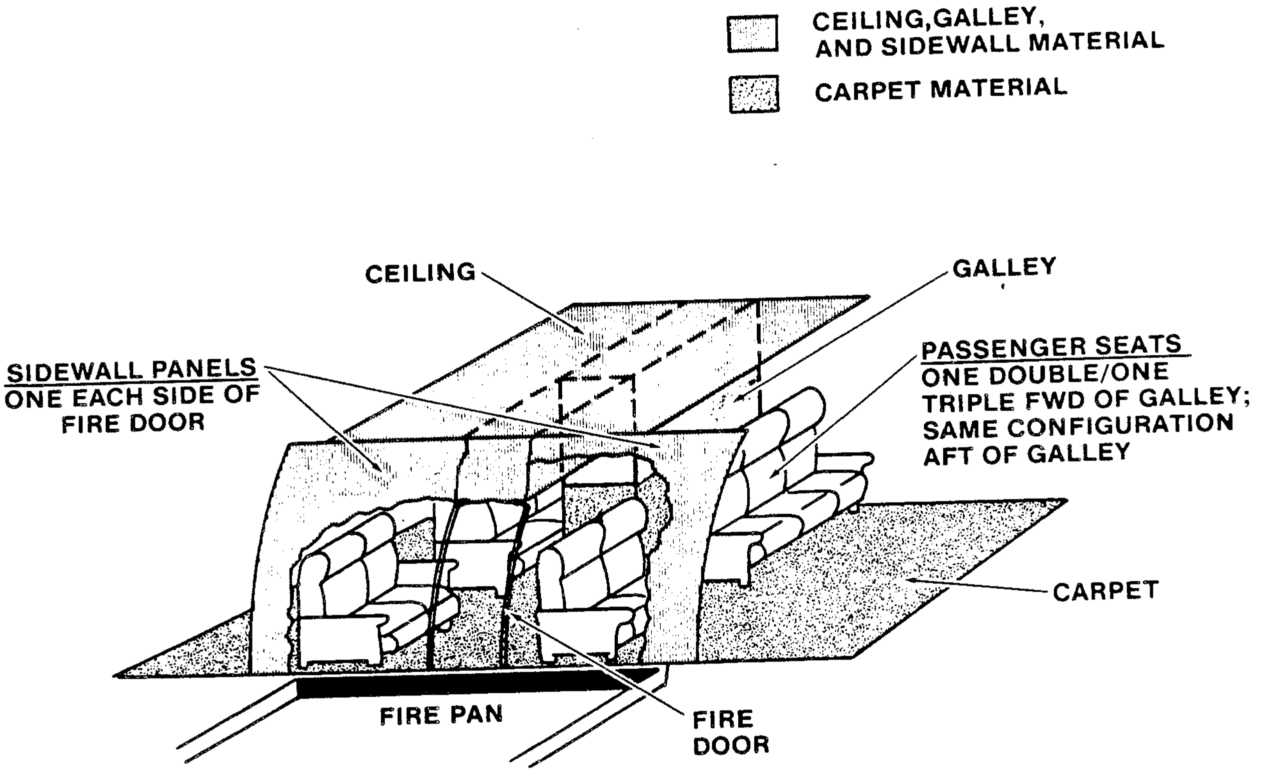

FIGURE 5. POSTCRASH FUEL FIRE OPEN DOOR SCENARIO

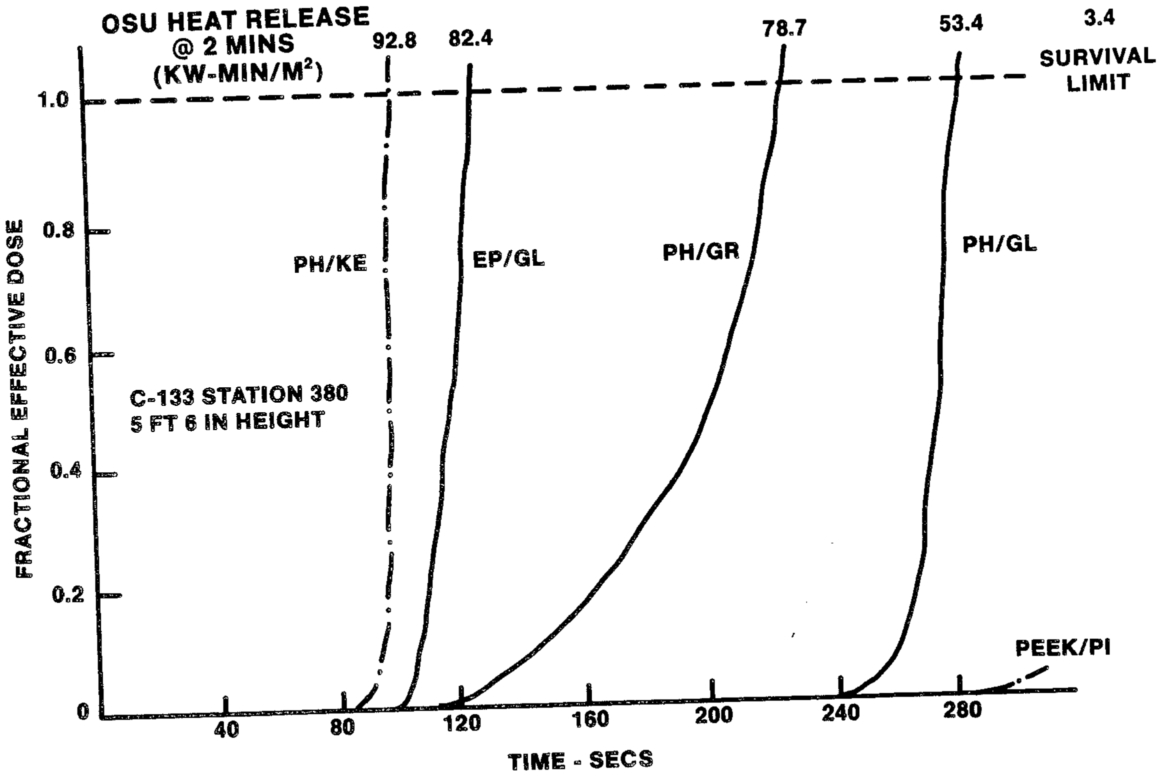

FIGURE 6. EFFECT OF COMPOSITE PANEL DESIGN ON FRACTIONAL EFFECTIVE DOSE

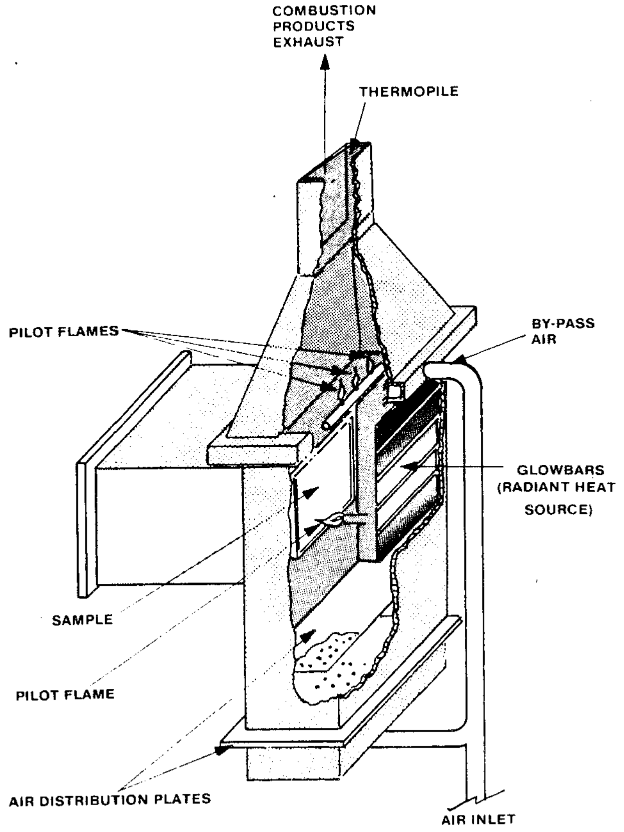

FIGURE 7. FAA OSU RATE OF HEAT RELEASE APPARATUS

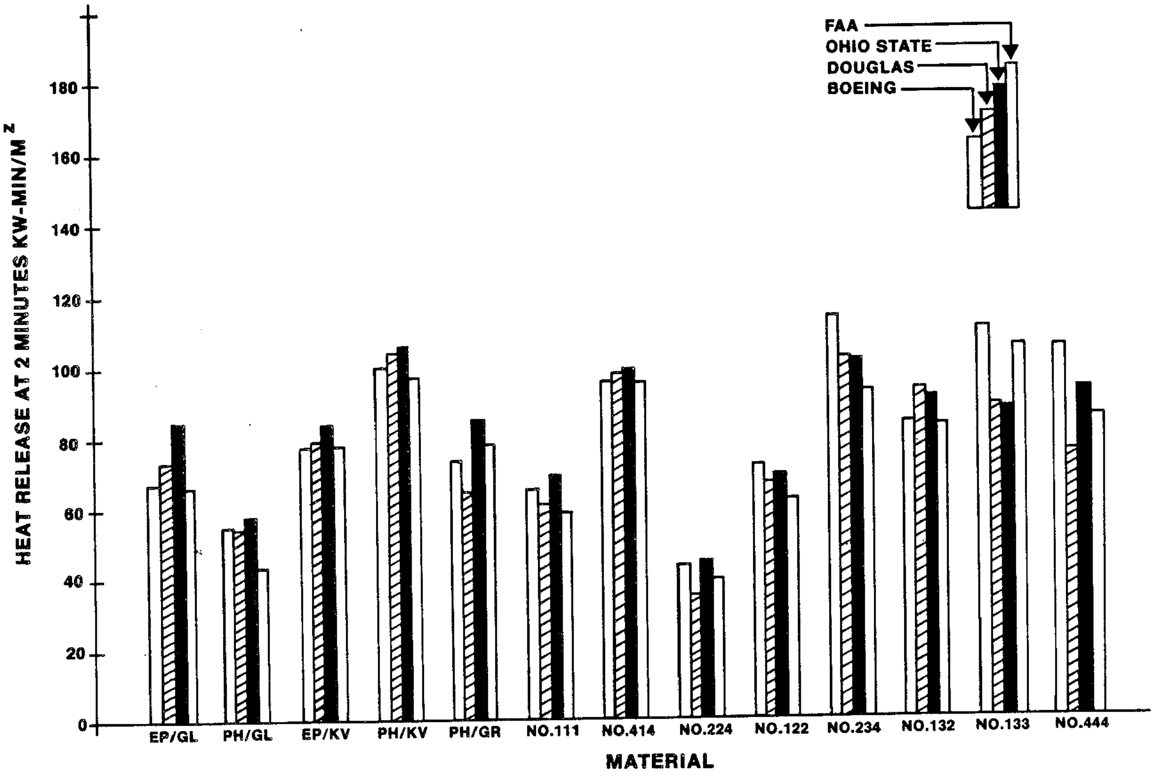

FIGURE 8. REPRODUCIBILITY OF HEAT RELEASE APPARATUS - FAA/AIA THIRD ROUND ROBIN

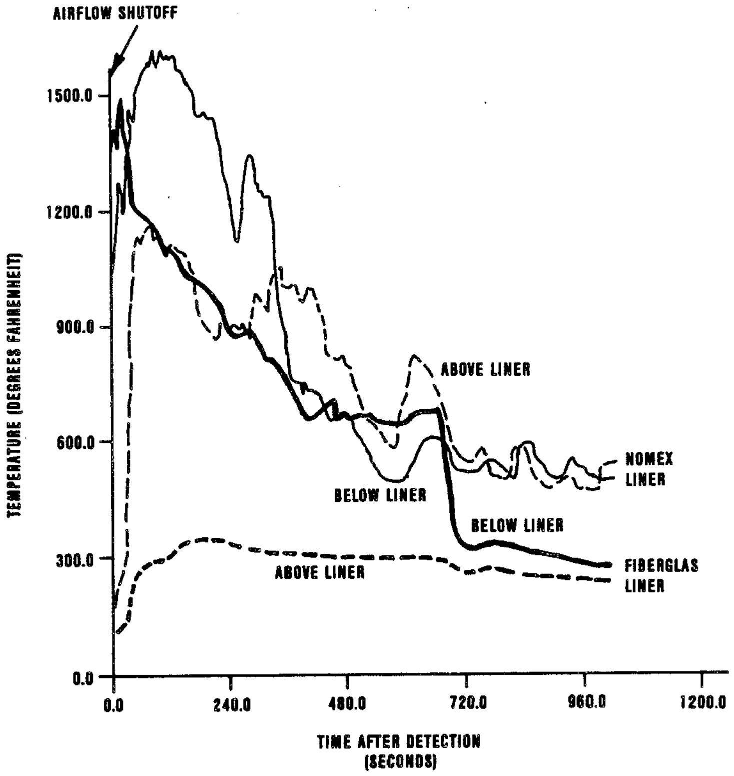

FIGURE 9. CARGO LINER RESISTANCE TO BURNTHROUGH

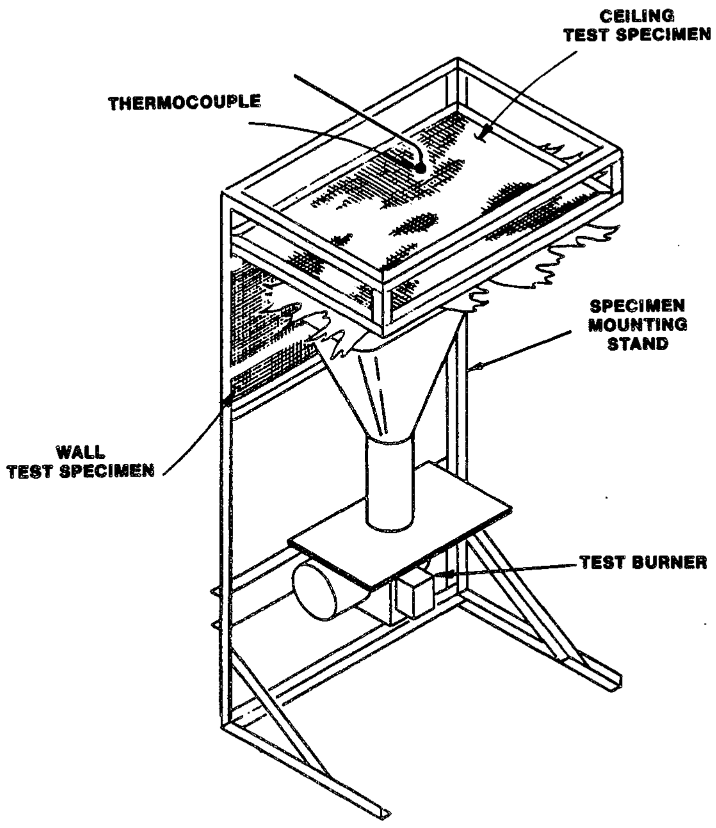

FIGURE 10. FAA CARGO LINER BURNTHROUGH TEST APPARATUS

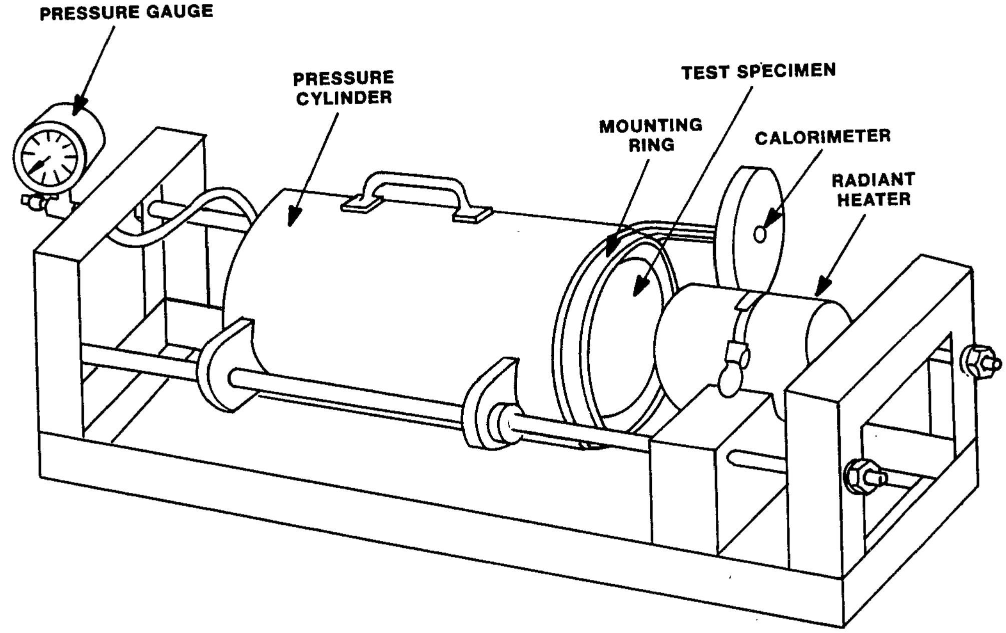

FIGURE 11. FAA EVACUATION SLIDE RADIANT HEAT TEST APPARATUS

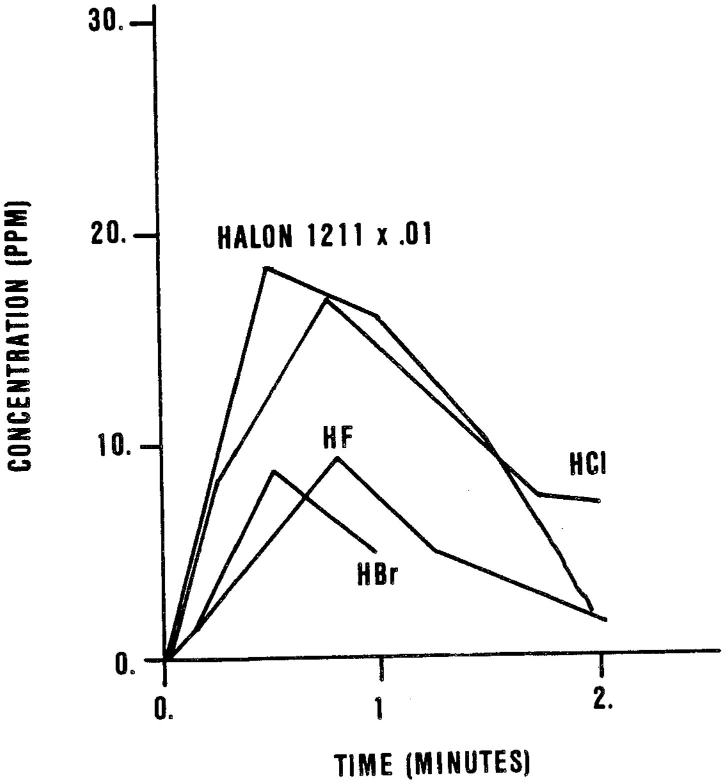

FIGURE 12. CABIN GAS PROFILES DURING HALON 1211 SEAT FIRE EXTINGUISHMENT

DISCUSSION

C. MOSES

Could you clarify which of the new fire-safety technologies you have discussed have been or are being retrofitted into aircraft already in use, and which will only appear in new aircraft?

AUTHOR'S REPLY:

The following fire safety improvements have been retrofitted into the U.S. commercial fleet: seat fire blocking layers, floor proximity lighting, lavatory detectors and extinguishers, halon extinguishers and additional hand-held extinguishers. Retrofit of burnthrough resistant cargo liners is required in approximately one year. The new regulation for low heat/smoke release panels primarily impacts production aircraft and has no retrofit provision; however, at the initial major refurbishment of the cabin interior the usage of low heat/smoke release materials is required.

G. COX

You are using the OSU apparatus to determine rate of heat release. Do you have any plans to move to the cone calorimeter?

AUTHOR'S REPLY:

We are pleased with the reproducibility of the OSU apparatus. Moreover, there are different difficulties in measuring heat release from aircraft materials with the cone calorimeter because of the small readings of oxygen depletion.

A. URAL

Have you consider the in-flight fire scenario where the ignition has taken place behind the wall panels, where the fatalities may arise due to smoke generation.

AUTHOR'S REPLY:

Yes. We are nearing completion of a project that examines the ignitability and fire growth in hidden or inaccessible cabin interiorlocations, such as behind sidewall panels, in lavatories, etc. We have simulated electrical fault ignition sources, overheated wiring and arcing, in these hidden areas and monitored the cabin conditions in a full-scale DC10 test article. Under these ignition conditions, the fire will self extinguish with barely detectable increased temperature or toxic gas levels measured in the cabin . During some tests slight smoke obscuration is measured.

B. TUCKER

The FAA rule requiring floor proximity lighting has been in effect for about 2½ years. However, it appears that most airlines do not include this feature in their passenger safety briefings. Has the FAA considered making mandatory the inclusion of information on floor proximity lighting in passenger briefings and/or safety information brochures.

AUTHOR'S REPLY:

MY own experience is that more airlines are now announcing the presence of floor proximity lighting in the passenger safety briefings. A new Advisory Circular on passenger safety briefings will be issued shortly by FAA with a recommendation that information on floor proximity lighting be included in the passenger briefing. I might also add that the function of floor proximity lighting in an emergency situation would be rather obvious to the passenger.

F. TAYLOR

Have you conducted any tests where you have a hole in the ceiling, either as deliberate venting or by natural burn through?

AUTHOR'S REPLY:

One postcrash fire test was conducted with the ceramic insulation removed in the area of the fuselage ceiling near the fuel fire ignition source. After the 12 min. test, the fuselage ceiling was not penetrated. Planned FAA tests will more thoroughly examine the effect of a fuselage "roof" opening.