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Project Assesses Flight Attendants' Abilities To Fight In-flight Fires in Cargo Compartments

Tests prompt calls for improved training, but those who organized the project also say that the quantity of extinguishing agents used on commuter airplanes is insufficient to extinguish some fires.

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Class B cargo compartments are in a variety of aircraft, ranging in size from commuters to wide-body transports. U.S. Federal Aviation Regulations Part 25.857 defines a Class B cargo compartment as one in which there is sufficient access in flight to enable a crewmember to effectively reach any part of the compartment with the contents of a hand-held fire extinguisher; in which, when the access provisions are being used, no hazardous quantity of smoke, flames or extinguishing agent will enter any compartment occupied by the crew or passengers; and in which there is a separate, approved smoke-detector system or fire-detector system to give warning at the pilot station or flight engineer station.

The Class B compartments on transport-size airplanes are generally used on aircraft operated as "combi aircraft." Combi is an industry term used to denote aircraft that use the main deck for a combination of cargo space and passenger seating. Many of these combi aircraft are easily reconfigured to vary the ratio of cargo and passenger space or to convert to all-passenger configurations. Class B compartments on commuter aircraft generally are permanent compartments of a fixed size that are accessible through a door or a hatch leading from the cabin.

A review of the effectiveness of the Class B requirements was undertaken following the in-flight fire and subsequent descent of a South African Airways Boeing 747 into the Indian Ocean in 1987. The fire originated in the forward section of a main-deck Class B cargo compartment. The crew was not able to control the fire, which continued to grow and resulted in the accident and fatal injuries to all 159 occupants. The ignition source for the fire was never determined.

Before that accident, there never had been an uncontrollable fire in a Class B cargo compartment. The occurrence of any fires in Class B cargo compartments has been rare.

The U.S. Federal Aviation Administration (FAA) published an airworthiness directive (AD) that applied to transport

aircraft manufactured by The Boeing Co. and by McDonnell Douglas and operated as combis. The AD eliminated the reliance on a crewmember with hand-held fire extinguishers as the means of controlling a cargo fire. It provided the operators with a number of options, ranging from a total-flood fire-suppression system to covering all cargo pallets or containers with fire-resistant material. This AD effectively eliminated Class B cargo compartments on current narrow-body and wide-body transport aircraft.

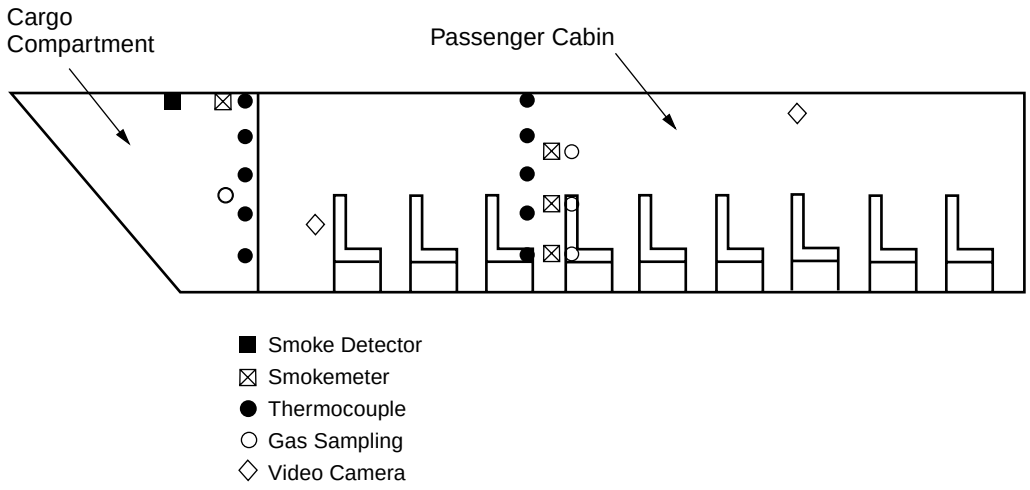
The question then arose as to whether there was some size, shape or configuration for a smaller Class B compartment in which a fire could be effectively controlled by a crewmember with a hand-held fire extinguisher. A Class B Cargo Compartment Harmonization Working Group was established by the FAA Aviation Rulemaking Advisory Committee to address this issue. The working group included representatives from regulatory agencies, aircraft manufacturers, airlines and aviation-related trade unions. The group was tasked with developing a draft notice of proposed rulemaking (NPRM) that would change the regulations for Class B cargo compartment fire-suppression capability. An NPRM is one of the procedures used by FAA to notify industry of the intention to make a rule change and to solicit industry input on the proposed change. An option available to the working group was to create a new category of cargo compartment, if warranted.

A modified Shorts 330 aircraft was used as the test article for this project. A door opening was cut in the rear cabin bulkhead to allow access to the rear cargo compartment. This compartment is located on the same level as the passenger cabin and normally is inaccessible in flight. The volume of the original cargo compartment was approximately 175 cubic feet (4.9 cubic meters). An aircraft-approved photoelectric smoke detector was installed on the ceiling of the cargo compartment. The alarm point of the detector was 94 percent light transmission per foot (per 30.5 centimeters). The interior of the passenger cabin, as well as the cargo compartment, was instrumented with thermocouples, smoke meters, gas analyzers and video cameras (Figure 1). A fan was mounted externally and was ducted into the existing aircraft ventilation ducts. The airflow into the cabin was 280 cubic feet (7.8 cubic meters) per minute. This airflow provided one change of cabin air approximately every 4.5 minutes. The airflow provided a slight positive pressure in the cabin relative to the cargo compartment. This was verified by generating a small amount of smoke from a theatrical smoke generator in the cargo compartment and then opening the door to the cargo compartment. The airflow into the cabin was sufficient to contain the smoke in the cargo compartment.

Several factors that would influence the ability to control cargo fires with hand-held fire extinguishers were varied in an attempt to determine what combinations of factors would be successful. These included the width of the door opening, the volume of the cargo compartment, the delay between smoke-detector activation and the beginning of the fire fighting effort, the number and type of hand-held extinguishers available, the type of protective breathing equipment (PBE) used, the presence or absence of an unobstructed center aisle in the compartment, the fire load, and the experience of the individual attempting to extinguish the fire.

Door widths of 15 inches (38 centimeters) and 28 inches (71 centimeters) were selected. The 15-inch width is more representative of the door size on commuter aircraft with small Class B compartments. The two volumes tested were the 175-cubic-foot original volume and the modified 57 cubic feet (1.6 cubic meters). The delay times chosen between the smoke-detector activation and the beginning of fire fighting

Shorts 330 Used in Fire Fighting Tests



Source: U.S. Federal Aviation Administration

Figure 1

were one minute, two minutes and three minutes. These times were meant to represent a range of times required to prepare to extinguish the cargo fire and to perform such activities as notifying the flight attendant after the alarm in the cockpit, removing and donning the protective breathing hood, removing the fire extinguisher from its mounting bracket and removing the safety pin, and moving to the location of the cargo door and opening the door to begin fire fighting. The three choices of fire extinguishers were two Halon 1211 bottles, each with 2.5 pounds (1.1 kilograms) of agent; a 17-pound (7.7-kilogram) Halon 1211 bottle; and a 17-pound Halon 1211 bottle, plus a 2.5-gallon (9.5-liter) water extinguisher. Commuter aircraft normally would carry only two of the 2.5-pound Halon 1211 extinguishers, one in the cockpit and one near the flight attendants' station in the rear cabin. PBEs manufactured by Scott, Pels and Puritan Bennett were used.

The fire loads tested were suitcases filled with rags and cardboard boxes filled with shredded newspaper. The initial tests used suitcases filled with rags that were ignited by a coil of electrical-resistance wire inside a closed suitcase. That scenario produced small smoldering fires that sometimes would self-extinguish even without fire fighting actions. For the tests with luggage in which fires were extinguished, it was not possible to determine if the fire was extinguished because of the fire fighting effort or because the fire self-extinguished. The fire load was changed to shredded newspaper in cardboard boxes to more reliably produce open flaming and to better gauge the effectiveness of the fire fighting efforts. The fire load was meant to represent flammable packaging material that might be present in cargo compartments. The results presented here include only the tests with cardboard boxes filled with shredded newspaper.

One of the representatives on the Class B Cargo Compartment Harmonization Working Group was from the Association of Flight Attendants (AFA). The AFA recruited volunteer flight attendants to participate in the testing. The flight attendants who participated were employed by various airlines at the time of the tests. They had completed the required training on the use of hand-held fire extinguishers and PBE. They were not told the location of the ignition source or coached on how to respond to the fire. They were asked to take whatever actions they considered appropriate based on their experience and training. The fire testing focused on reducing the variables to determine what combination would be successful to consistently extinguish the test fires and did not include every possible combination of the variables.

In addition to the fire tests, a series of time-trial tests was conducted with the flight attendants. The tests recorded the times required by the flight attendants to go from a simulated jump seat to the location of the protective breathing hood, to open and don the hood, to remove the fire extinguisher from its mounting bracket and pull the safety pin, and to open the cargo door. Some of the flight attendants said that if they were told by the flight crew that the cargo smoke detector had activated an alarm, the first thing they would do would be to feel the cargo compartment door to determine whether it was hot. This action was included in the time trials for the flight attendants who said that they would perform that additional step.

A summary of the results of the 13 fire tests (Table 1, page 4) shows that there was only one combination of variables that led to the successful extinguishing of the test fires. That was in a 57-cubic foot cargo compartment with a clear center aisle in the compartment; a 28-inch door opening; a 17-pound Halon 1211 extinguisher and a 2.5-gallon water extinguisher; and a one-minute delay between smoke detection and the start of fire fighting. The fires were extinguished in all three of the tests conducted under these conditions; none of the other test fires was extinguished. This combination of variables necessary to extinguish the test fires is not found normally on existing commuter aircraft with Class B cargo compartments.

In the tests, including those in which the fires were extinguished, smoke, carbon dioxide and carbon monoxide accumulated in the normally occupied cabin area. The smoke and gases produced by the cargo fire were buoyant and sufficiently hot to overcome the slight positive pressure caused by the ventilation system in the cabin. Figure 2 (page 5) shows the smoke obscuration levels in the cabin at three heights during a typical test.

Table 2 (page 5) summarizes the flight attendant time trials for preparing to initiate the fire fighting efforts.

Following the fire tests and the time trials, the flight attendants were asked for their comments about in-flight cargo fires and the onboard safety equipment available to them. The following are some of the comments that were received from one or more of the flight attendants:

- More realistic fire fighting training would be valuable;
- The PBE was more difficult to remove from the mounting location and required more force to start the flow of oxygen than the flight attendants had expected. (The training they had received used training hoods that were not mounted and did not have oxygen generators or canisters as they would in an aircraft.);
- Visibility was much worse than expected because of wrinkled PBE face pieces, or twisting of the PBEs when the flight attendants moved their heads, or both;
- They could not determine whether they were seeing smoke or condensation inside the PBE;
- They could not hear or be heard as well as they had expected;
- They had difficulty unlatching the hand-held fire extinguisher and finding and removing the safety pin while wearing the PBE;

Table 1
Summary of Results

Test	Volume	Aisle	Door Width	Number and Type of Extinguishers	Delay Time (Minutes)	Extinguished
1	175 cubic feet (4.9 cubic meters)	No	15 inches (38 centimeters)	two 2.5-pound (1.1 kilogram) Halon 1211	2	No
2	175 cubic feet	No	15 inches	two 2.5-pound Halon 1211	3	No
3	175 cubic feet	Yes	15 inches	two 2.5-pound Halon 1211	1	No
4	175 cubic feet	Yes	15 inches	two 2.5-pound Halon 1211	2	No
5	175 cubic feet	Yes	15 inches	two 2.5-pound Halon 1211	3	No
6	175 cubic feet	Yes	28 inches (71 centimeters)	two 2.5-pound Halon 1211	1	No
7	175 cubic feet	Yes	28 inches	one 17-pound (7.7 kilogram) Halon 1211	1	No
8	175 cubic feet	Yes	28 inches	one 17-pound Halon 1211, one 2.5-gallon (9.5-liter) Water	1	No
9[1]	57 cubic feet (1.6 cubic meters)	No	28 inches	two 2.5-pound Halon 1211	1	No
10[2]	57 cubic feet	Yes	28 inches	one 17-pound Halon 1211, one 2.5-gallon Water	1	Yes
11	57 cubic feet	No	28 inches	one 17-poundHalon 1211, one 2.5-gallon Water	1	No
12	57 cubic feet	Yes	28 inches	one 17-pound Halon 1211, one 2.5-gallon Water	1	Yes
13	57 cubic feet	Yes	28 inches	one 17-pound Halon 1211, one 2.5-gallon Water	1	Yes

[1] The flight attendant discharged the first extinguisher into the cargo compartment and then proceeded to the cockpit to get the second extinguisher, leaving the cargo door open in the process. After getting the second extinguisher and starting back toward the cargo compartment, she felt that the visibility in the cabin had deteriorated to a point that she was not willing to continue the test. She opened one of the forward emergency exits and exited the fuselage. This flight attendant had been assigned to flights that operated Shorts 330 aircraft, and she was familiar with the locations of the exits.

[2] The flight attendant was able to extinguish the fire using only the 17-pound Halon 1211 extinguisher. The water extinguisher was not used.

Source: U.S. Federal Aviation Administration

- Gloves should be available for fire fighting; and,
- The participation in the fire testing gave them a better appreciation of how rapidly visibility can deteriorate because of smoke from a relatively small fire.

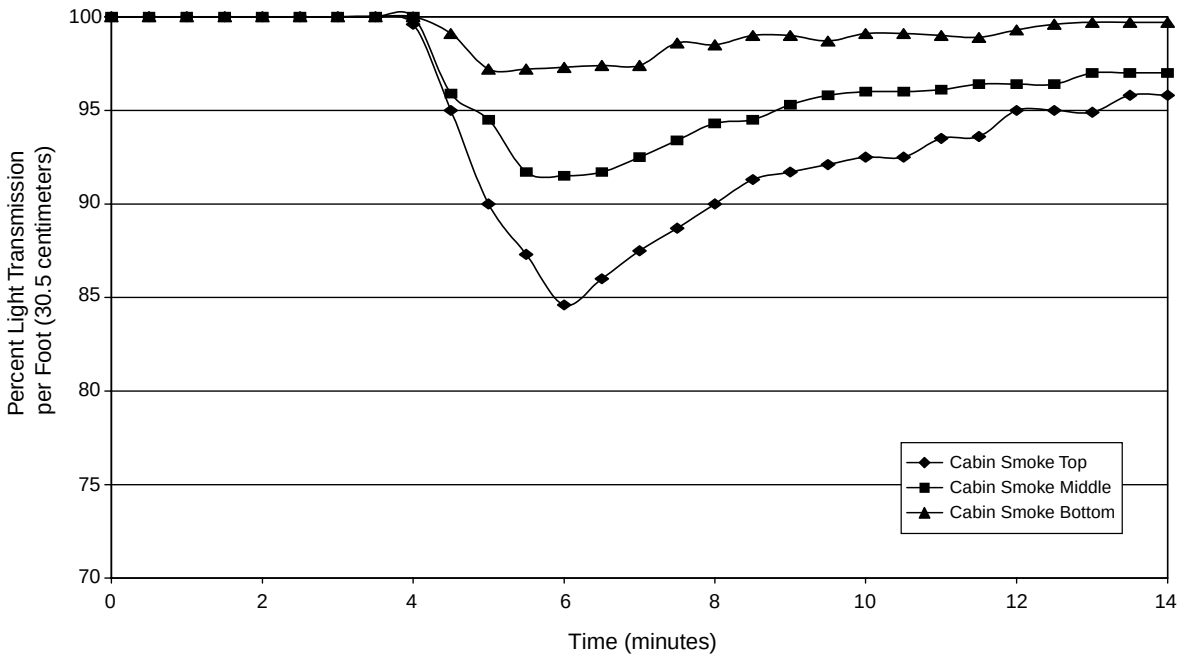
The project's conclusions were that:

- The quantity of fire-extinguishing agent normally carried on commuter aircraft is not sufficient to extinguish fires involving easily combustible packaging material in Class B cargo compartments;
- Improved and more realistic training procedures would better prepare flight attendants to fight in-flight cargo fires more effectively; and,
- Opening cargo compartment access doors to fight fires allows products of combustion into the normally occupied areas of the fuselage.♦

[FSF editorial note: This report is adapted from the U.S. Federal Aviation Administration's *Effectiveness of Flight Attendants Attempting to Extinguish Fires in an Accessible Cargo Compartment*, DOT/FAA/AR-TN99/29, April 1999. Changes were made for clarity and style.]

Further Reading from FSF Publications

Waldock, William D. "Uniform Materials Affect Flight Attendant Safety and Ability to Help Passengers Evacuate Burning Aircraft." *Cabin Crew Safety* Volume 33 (March–April 1999).



Source: U.S. Federal Aviation Administration

Figure 2

Table 2
Protective Breathing Equipment (PBE) Donning Time

Flight Attendant	Experience (years)	PBE Manufacturer	Time (seconds)
1	10	Scott	42
2	16	Scott	42
3	8	Scott	46
4	15	Scott	89*
5	27	Scott	46
6	14	Scott	45
7	4	Pels	30
8	1.5	Pels	50
8	1.5	Puritan Bennett	55
8	1.5	Puritan Bennett	60
Average time			50.5

* After several unsuccessful attempts to open the plastic box that housed the PBE, the box was opened by a test technician, and the flight attendant then continued with the trial.

Source: U.S. Federal Aviation Administration

Sarkos, Constantine P. "FAA Proposes New Rules on Cargo Compartment Fire Detection and Suppression." *Cabin Crew Safety* Volume 31 (November–December 1996).

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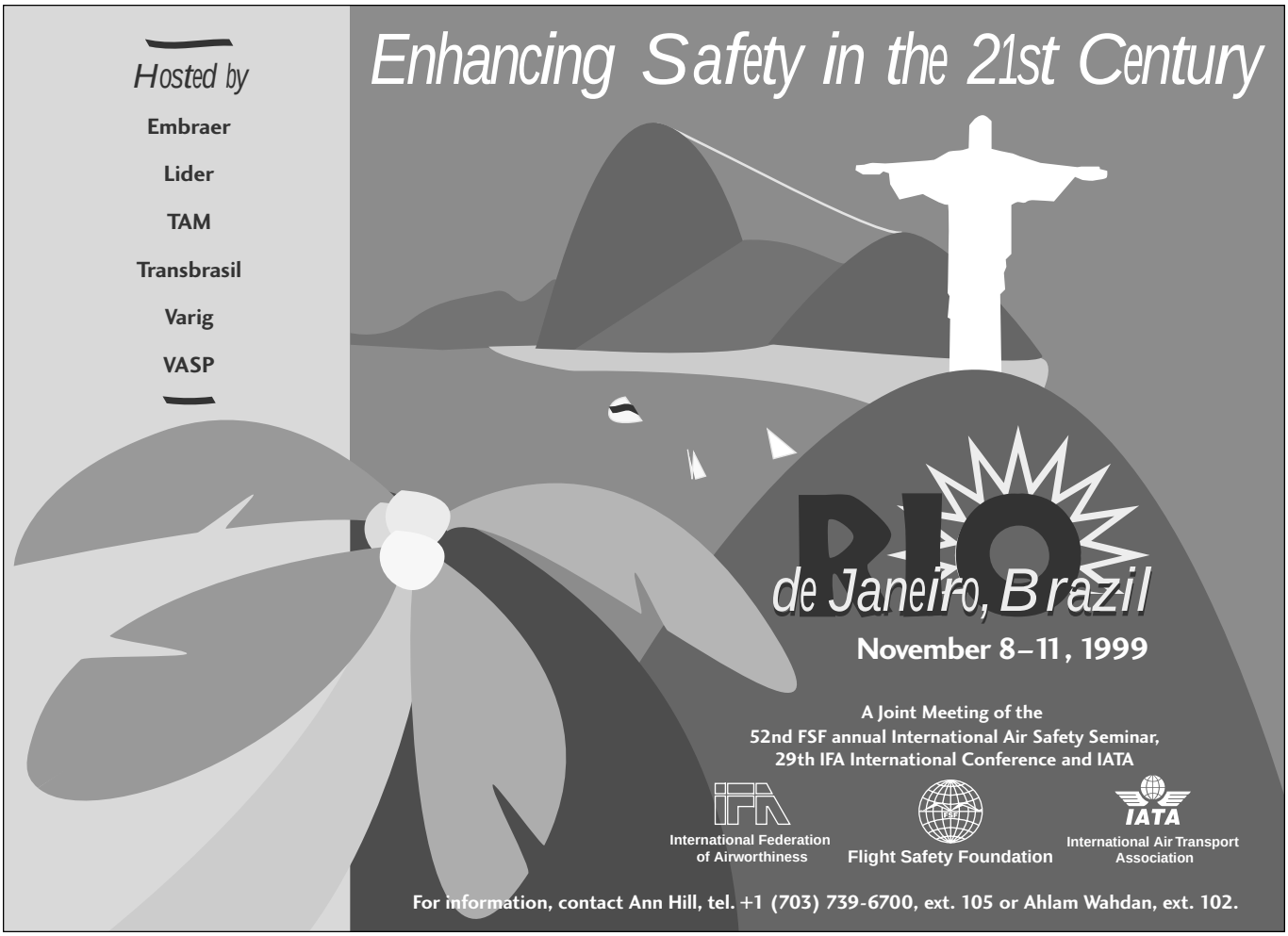

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