technical note technical note

Effectiveness of Flight Attendants Attempting to Extinguish Fires in an Accessible Cargo Compartment

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16. Abstract

This technical note documents the results of a project to evaluate the ability of flight attendants to extinguish cargo fires in small Class B cargo compartments. Thirteen fire tests were conducted in a modified Shorts 330 airplane in which flight attendants attempted to extinguish cargo fires. Some of the selected test variables included the cargo compartment size, the width of the access door, the size and type of fire extinguishers available, the presence and absence of an unobstructed center aisle in the cargo compartment, the type of Protective Breathing Equipment (PBE), and the delay between the smoke detector alarm and the start of the firefighting efforts. The results of the testing indicated that in most cases the flight attendants were unable to successfully extinguish these fires.

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EXECUTIVE SUMMARY

This technical note documents the results of testing to determine the effectiveness of flight attendants attempting to extinguish fires in small Class B cargo compartments. The regulations defining Class B cargo compartments require (1) sufficient access in flight to enable a crew member to effectively reach any part of the compartment with the contents of a hand-held fire extinguisher; (2) no hazardous quantities of smoke, flames, or extinguishing agent in occupied areas; and (3) a smoke or fire detector system to give warning in the cockpit. An Airworthiness Directive had been issued by the FAA which eliminated the reliance on a crew member with hand-held fire extinguishers as the means to control fires in Class B cargo compartments of large transport category aircraft.

This project was undertaken at the request of a Class B Cargo Compartment Harmonization Working Group established by the Aviation Rulemaking Advisory Committee (ARAC) to determine if crew members with hand-held fire extinguishers were effective at controlling fires in Class B cargo compartments on smaller airplanes. Thirteen fire tests were conducted in a modified Shorts 330 test article. The Association of Flight Attendants organized a volunteer group of flight attendants to participate. Fires were ignited in an accessible cargo compartment in the aft end of the test article and the volunteer flight attendants attempted to extinguish the test fires. Some of the variables examined were the volume of the compartment, the width of the access door, the type and quantity of extinguishers, the presence and absence of an unobstructed center aisle in the compartment, the type of Protective Breathing Equipment (PBE), and the delay between smoke detection and the start of the firefighting effort. The results of the testing indicated that the flight attendants were unable to successfully extinguish the test fires in 10 of the 13 tests.

PURPOSE.

The purpose of this technical note is to document the results of testing to determine the effectiveness of flight attendants in extinguishing fires in small Class B cargo compartments using hand-held fire extinguishers and protective breathing equipment.

INTRODUCTION.

Federal Aviation Regulation 25.857 defines a Class B cargo compartment as one in which (1) there is sufficient access in flight to enable a crew member to effectively reach any part of the compartment with the contents of a hand-held fire extinguisher; (2) 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 (3) there is a separate approved smoke detector or fire detector system to give warning at the pilot or flight engineer station.

Class B cargo compartments are on a variety of aircraft ranging in size from commuters to wide-body transports. The Class B compartments on transport size airplanes are generally used on aircraft operated as a "combi." 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 types of 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 are generally permanent compartments of a fixed size that are accessible through a door or hatch leading from the cabin.

A review of the effectiveness of the Class B requirements was undertaken following the in-flight fire and subsequent crash of a South African Airways B747 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 crash and fatal injuries to all 159 occupants. The ignition source for the fire was never determined. Prior to that accident, there had never been a fire in a Class B cargo compartment that was not controllable. However, the occurrence of any fires in Class B cargo compartments has been extremely rare. The FAA published an Airworthiness Directive (AD) that applied to transport size aircraft manufactured by Boeing and McDonnell Douglas and operated as combis. This rule change eliminated the reliance on a crew member 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 existing narrow- and wide-bodied transport aircraft.

The logical 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 crew member with a hand-held fire extinguisher. A Class B Cargo Compartment Harmonization Working Group was established by the Aviation Rulemaking Advisory Committee (ARAC) 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 the 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.

TEST ARTICLE.

A modified Shorts 330 aircraft was used as the test article for this project. A door opening was cut into the aft cabin bulkhead to allow access to the aft cargo compartment. This compartment is located on the same level as the passenger cabin and is normally inaccessible in flight. The volume of the original cargo compartment was approximately 175 ft^3. 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. 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 shows the test article and instrumentation. A fan was mounted externally and was ducted into the existing aircraft ventilation ducts. The airflow into the cabin was 280 ft^3/min. 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.

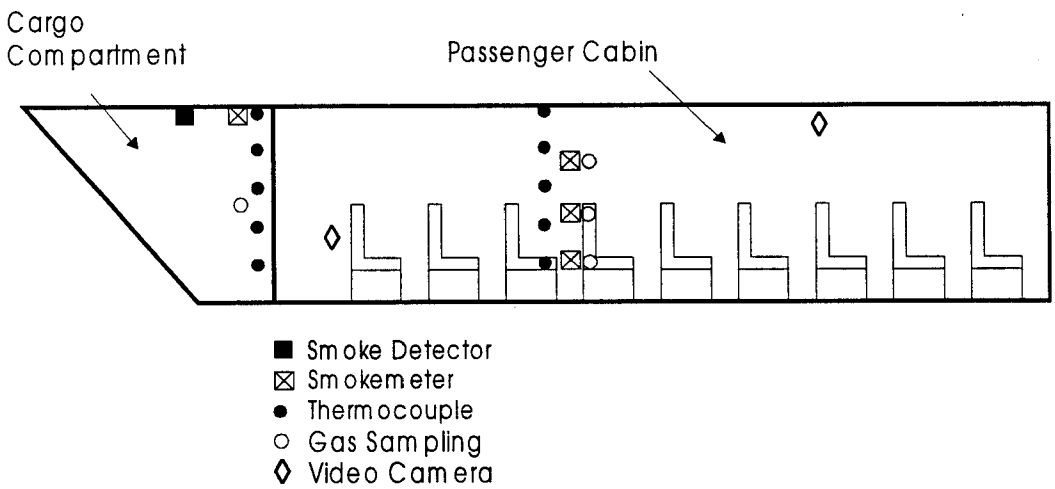

FIGURE 1. SHORTS 330 TEST ARTICLE

TEST SERIES.

Several of the 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 start of the firefighting effort, the number and type of hand-held extinguishers available, the type of protective breathing equipment 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 and 28 inches were selected. The 15 inch width is more representative of the door size found on commuter aircraft with small Class B compartments. The two volumes tested were the 175 ft^3 original volume and the modified 57 ft^3. The delay times chosen between the smoke detector activation and the start of firefighting were 1, 2, and 3 minutes. These times were meant to represent a range of times required to prepare to extinguish the cargo fire and includes activities such as notification of the flight attendant after the alarm in the cockpit, removal and donning of the protective breathing hood, removal of the fire extinguisher from its mounting bracket and removal of the safety pin, and moving to the location of the cargo door and opening it to start firefighting. The three choices for fire extinguisher availability were two Halon 1211 bottles, each with 2.5 pounds of agent; a 17-pound Halon 1211 bottle; and a 17-pound Halon 1211 bottle plus a 2.5-gallon water extinguisher. Commuter aircraft would normally only carry 2 of the 2.5-pound Halon 1211 extinguishers, one in the cockpit and one near the flight attendants station in the aft cabin. Protective breathing equipment manufactured by Scott, Pels, and Puritan Bennet 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 would sometimes self-extinguish even without firefighting actions. For the tests with luggage that extinguished, it was not possible to determine if the extinguishment was due to the firefighting effort or if 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 firefighting efforts. The fire load was meant to represent flammable packaging material that might be present in cargo compartments. The results presented here only include the tests with cardboard boxes filled with shredded newspaper as the fire load.

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 that participated were all currently employed at various airlines. They had all completed the required training on the use of hand-held fire extinguishers and protective breathing equipment. They used aircraft approved protective breathing hoods for respiratory protection. 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 felt were appropriate based on their experience and training. The fire testing focused on narrowing down the variables to determine what combination would be successful to consistently extinguish the test fires and did not include every possible combination of all the variables.

In addition to the fire tests, a series of time trial tests were conducted with the flight attendants. The times were recorded for 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 stated that if they were told by the flight crew that the cargo smoke detector had alarmed, the first thing they would do would be to feel the cargo compartment door to see if it was hot. This action was included in the time trials for the flight attendants who stated that they would perform that additional step.

TEST RESULTS.

Table 1 summarizes the results of the 13 fire tests.

TABLE 1. SUMMARY OF RESULTS

Test	Volume (ft^3)	Aisle	Door Width	Number and Type of Extinguishers	Delay Time (Mins)	Extinguished
1	175	No	15"	two 2.5-lb. Halon 1211	2	No
2	175	No	15"	two 2.5-lb. Halon 1211	3	No
3	175	Yes	15"	two 2.5-lb. Halon 1211	1	No
4	175	Yes	15"	two 2.5-lb. Halon 1211	2	No
5	175	Yes	15"	two 2.5-lb. Halon 1211	3	No
6	175	Yes	28"	two 2.5-lb. Halon 1211	1	No
7	175	Yes	28"	one 17-lb. Halon 1211	1	No
8	175	Yes	28"	one 17-lb. Halon 1211, one 2.5-Gallon Water	1	No
9[1]	57	No	28"	two 2.5-lb. Halon 1211	1	No
10[2]	57	Yes	28"	one 17-lb. Halon 1211, one 2.5-Gallon Water	1	Yes
11	57	No	28"	one 17-lb. Halon 1211, one 2.5-Gallon Water	1	No
12	57	Yes	28"	one 17-lb. Halon 1211, one 2.5-Gallon Water	1	Yes
13	57	Yes	28"	one 17-lb. Halon 1211, one 2.5-Gallon Water	1	Yes

Note 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 towards the cargo compartment, she felt that the visibility in the cabin had deteriorated to a point where 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 was very familiar with the location of the exits.

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

As can be seen in table 1, there was only one combination of variables that led to the successful extinguishment of the test fires. That was with a 57-cubic foot volume, a clear center aisle in the compartment, a 28" door opening, a 17-lb. Halon 1211 and a 2.5-gallon water extinguisher, and a 1-minute delay between smoke detection and the start of the firefighting effort. The fires were extinguished in all three of the tests conducted under these conditions. None of the other test fires were extinguished. This combination of variables necessary to extinguish the test fires are not normally found on existing commuter aircraft with Class B cargo compartments.

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

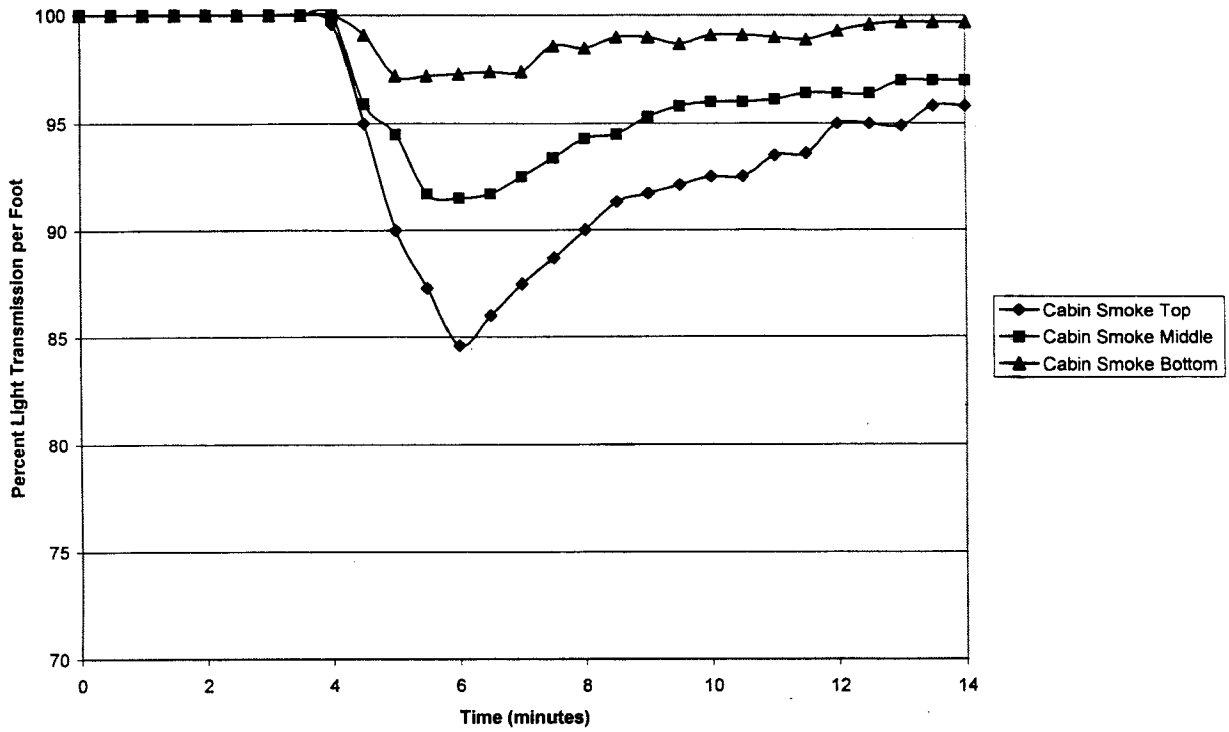

FIGURE 2. CABIN SMOKE LEVELS

Table 2 summarizes the flight attendant time trials for preparing to initiate the firefighting efforts.

TABLE 2. PROTECTIVE BREATHING EQUIPMENT (PBE) DONNING TIME

Flight Attendant	Experience (years)	PBE Manufacturer	Time (secs.)
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 Bennet	55
8	1.5	Puritan Bennet	60
		Average	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.

Following the fire tests and the time trials the flight attendants were asked to provide their comments regarding 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 firefighting training would be very valuable.
- The PBE was harder to remove from the mounting location and required more force to start the flow of oxygen than what they had expected. (The training they had received used training hoods that were not mounted as they would be in an aircraft and did not have oxygen generators or canisters.)
- Visibility was much worse than expected because of wrinkled face pieces and/or twisting of the PBE when they moved their head.
- They could not tell if they were seeing smoke or condensation inside the PBE.
- They could not hear or be heard as well as they had expected.
- It was difficult to unlatch the hand-held fire extinguisher and to find and remove the safety pin while wearing the PBE.
- Gloves should be available for firefighting.
- The participation in the fire testing gave them a much better appreciation of how rapidly visibility can deteriorate due to smoke from a relatively small fire.

CONCLUSIONS.

1. 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.

2. Improved and more realistic training procedures would better prepare flight attendants to more effectively fight in-flight cargo fires.

3. Opening cargo compartment access doors to fight fires allows products of combustion into the normally occupied areas of the fuselage.