National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: November 28, 2012

In reply refer to: A-12-68 through -70

The Honorable Michael P. Huerta
Acting Administrator
Federal Aviation Administration
Washington, DC 20591

In the past six years, the National Transportation Safety Board (NTSB) has conducted or participated in the investigations of three catastrophic in-flight cargo fires aboard cargo airplanes. These investigations and a recent cargo container fire study[1] conducted by NTSB investigators have revealed that current fire protection regulations for these aircraft are inadequate. As a result of these accident investigations and the study, the NTSB is issuing three safety recommendations to the Federal Aviation Administration (FAA) relating to cargo fires aboard cargo airplanes. These recommendations involve improving early detection of fires originating within cargo containers and pallets, developing materials standards for cargo containers to provide better fire resistance, and requiring active fire suppression systems in all cargo compartments or containers, or both.

Background

In-Flight Cargo Airplane Fires

On February 7, 2006, a McDonnell Douglas DC-8-71F, N748UP, operating as United Parcel Service (UPS) flight 1307, landed at Philadelphia International Airport, Philadelphia, Pennsylvania, after the crew reported a cargo smoke indication. Although the two crewmembers were treated at a local hospital for minor smoke inhalation, the aircraft was substantially damaged. On September 3, 2010, UPS flight 6, a Boeing 747-400F,[2] N571UP, crashed inside an Emirati army post approximately nine miles from Dubai International Airport (DXB), Dubai, United Arab Emirates (UAE). The flight crew encountered a "Fire Main Deck" warning about 22 minutes into the flight at a cruise altitude of 32,000 feet, declared an emergency, and initiated a return to DXB.[3] The two flight crewmembers were fatally injured; there were no ground injuries. The airplane was destroyed by the

[1] For information about the NTSB's cargo container fire study (NTSB Materials Laboratory Study Report 12-019), see case number DCA10RA092 on the NTSB's website at http://www.ntsb.gov/investigations/dms.html.

[2] The Boeing 747-400F is a Boeing 747-400 freighter.

[3] This information was taken from the April 3, 2011, UAE General Civil Aviation Authority (GCAA) Air Accident Preliminary Report, Boeing 747-400F/N571UP, GCAA Accident Report No. 13/2010 (accessed online May 4, 2011).

impact and postcrash fire. On July 28, 2011, a Boeing 747-400F, Korean registration HL7604, operated by Asiana Cargo as flight 991, crashed about 70 miles west of Jeju Island, Republic of Korea,[4] after the flight crew declared an emergency due to a cargo fire and attempted to divert to Jeju International Airport. Both crewmembers were fatally injured and the airplane was destroyed. The investigations of the latter two accidents revealed a relatively short interval between the time a fire warning indication was delivered to the flight crew and the onset of flight control and aircraft system failures.[5]

Current Regulations

The FAA regulations that address fire protection in cargo aircraft are the same regulations that address all transport category aircraft.[6] Although these regulations limit the flammability of construction materials used in cargo compartments and also specify minimum fire resistance requirements for cargo compartment liners, there is limited regulation concerning fire protection associated with cargo containers. The selection of materials used in the construction of cargo containers is only subject to a horizontal Bunsen burner test,[7] which does not prevent the use of highly combustible materials. Additionally, the effect of the use of containers and pallets to contain cargo is not factored into the current overall fire protection strategy or certification process.[8]

NTSB Cargo Container Fire Study

In August 2011, NTSB investigators conducted cargo container fire tests[9] as part of a study to better understand the characteristics of cargo container fires, the threats these fires pose to the aircraft, and whether the current fire protection strategy is suitable for those threats. The study concluded the following:

- Container design has a significant effect on the time it takes for an internal fire to become detectable to a smoke detector outside the container.

- Container construction materials have a significant effect on the total fire load[10] and energy release rate of a cargo fire.

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[4] The Government of South Korea is conducting the investigation of this accident. In accordance with Annex 13 to the Convention on International Civil Aviation, the NTSB is participating in this investigation, representing the State of Design and Manufacture.

[5] In the UPS flight 6 accident, the time between the first fire warning indication and the onset of loss of some aircraft systems was about 2 minutes 30 seconds. The Asiana 991 accident investigation is ongoing and timing information has not yet been released.

[6] The fire protection requirements can be found in Title 14 *Code of Federal Regulations* (CFR) 25.855, "Cargo or baggage compartments"; 14 CFR 25.857, "Cargo compartment classification"; and 14 CFR 25.858, "Cargo or baggage compartment smoke or fire detection systems."

[7] Paragraph (a)(1)(v) of Part I of Appendix F to Part 25 specifies a horizontal burning rate of no more than 4 inches per minute.

[8] The current certification process is done using an empty cargo compartment.

[9] The tests were conducted at the Fire Research Branch of the Federal Aviation Administration's Technical Center in Atlantic City, New Jersey, and at the Fire Research Laboratory of the Bureau of Alcohol, Tobacco, Firearms and Explosives. The results are presented in NTSB Materials Laboratory Study Report 12-019.

[10] Fire load is the amount of combustible material that can become involved in a fire.

- The time it takes for a fire detection system to detect a fire originating within a cargo container may easily exceed the 1 minute time frame specified in Title 14 *Code of Federal Regulations* (CFR) 25.858(a).

- The growth rate of container fires after they become detectable by the aircraft's smoke detection system can be extremely fast, precluding any mitigating action and resulting in an overwhelming fire.

Early Detection of Fires Originating Within Cargo Containers and Pallets

The NTSB used two types of containers to evaluate the time it takes to detect fires that originate from within those containers. The NTSB tested each type of container twice. The tests revealed that the elapsed time between fire initiation and detection ranged from 2 minutes 30 seconds to 18 minutes 30 seconds, all exceeding the 1 minute detection time required under current regulations. From the tests conducted in the study,[11] the fires grew very large, capable of causing significant damage to an aircraft, shortly after becoming a detectable fire (see figure 1). Based on the test data, the NTSB is concerned that when fires inside containers become detectable to the aircraft's smoke detection system, there is little time until the fires reach levels that can compromise the integrity of the cargo compartment and then threaten the structure and systems of the aircraft. The presence of containers and pallets prevent fires that start within them from being detected within 1 minute per 14 CFR 25.858, reducing the time to react.

Figure 1. Photo taken during the NTSB cargo container fire study depicting a polypropylene cargo container burning at a rate of 8.45 megawatts (MW), 132 seconds after becoming detectable to an aircraft-based smoke detection system.

[11] An "ordinary combustibles" fire load was used based on a "standard fire load" commonly used in aircraft fire research (see NTSB Materials Laboratory Study Report 12-019 for details).

On December 17, 2007, as a result of the UPS flight 1307 accident, the NTSB issued Safety Recommendation A-07-98, which asked the FAA to do the following:

> Ensure that the performance requirements for smoke and fire detection systems account for the effects of cargo and cargo containers on airflow around the detection sensors and on the containment of smoke from a fire inside a container and should establish standardized methods of demonstrating compliance with those requirements.

On September 6, 2010, the FAA responded that a test program had been completed[12] using a Boeing model 727 main deck cargo compartment to evaluate the effect of cargo containers on airflow around the smoke detectors. The FAA reported that although there was some variability in the test results, in general, smoke detectors sounded quicker in loaded compartments than in empty compartments. However, the FAA study addressed the effect of cargo containers on the airflow around the smoke detectors for only one type of aircraft configuration and did not address the issue of overall detection time of the fire, specifically with the effect of smoke confinement within the containers. NTSB's safety recommendation A-07-98 is currently classified "Open—Acceptable Response."

Based on the circumstances of the UPS flight 6 accident and the NTSB cargo container fire study, the focus of the delayed detection issue has shifted from the effect of airflow on smoke to reach detectors to the effect of smoke confined within a container or pallet to reach detectors. The NTSB study established that there could be a long time during which a fire originating inside a container produces smoke that does not exit the container. The NTSB study also found that due to this delay caused by the container concealing the smoke, once a fire becomes detectable to the aircraft's smoke detectors, it is not long until it burns through the container and becomes a substantial threat. The NTSB concludes that if the fire were to be detected while generating smoke inside the container, valuable time would be gained for alerting flight crews and mitigating the effects of the fire.

Accordingly, the NTSB reclassifies Safety Recommendation A-07-98 "Closed—Acceptable Action/Superseded," and recommends that the FAA develop fire detection system performance requirements for the early detection of fires originating within cargo containers and pallets and, once developed, implement the new requirements.

Cargo Container Standards

Currently, regulation of the flammability of materials used to construct cargo *containers* is very limited, although flammability limits are in place for materials used to construct cargo *compartments*. Accordingly, containers can add a significant fire load within the cargo compartment. This lack of regulation for cargo container materials reduces the effectiveness of the regulations at 14 CFR 25.855 for materials used in cargo compartments. The NTSB cargo container fire study identified collapsible type containers, which are constructed out of corrugated

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[12] *Effects of Cargo Loading and Active Containers on Aircraft Cargo Compartment Smoke Detection Times*, DOT/FAA/AR-09/52, Final Report (Washington, D.C.: U.S. Department of Transportation, Federal Aviation Administration, December 2009).

polypropylene, as significant contributors to the intensity of a fire. The NTSB concludes that some cargo containers do not provide adequate fire resistance, yet they are permitted to be used in cargo areas, which can significantly increase the intensity of a cargo container fire.

Therefore, the NTSB recommends that the FAA ensure that cargo container construction materials meet the same flammability requirements as all other cargo compartment materials in accordance with 14 CFR 25.855.

Active Fire Suppression Systems

The current fire suppression strategy in aircraft main deck cargo compartments is based on oxygen deprivation and fire resistant materials. Main deck cargo compartments are very large, and large fires can develop before passive suppression due to oxygen deprivation can help slow down the fire. For example, in the UPS flight 6 accident, the time interval between fire detection and the onset of aircraft system failures was about 2 minutes 30 seconds. The aircraft did not achieve depressurization until after system failures and flight control issues began to occur. Experiments performed at the FAA's William J. Hughes Technical Center in Atlantic City, New Jersey, have shown that although depressurization can suppress flaming combustion, the fire continues to propagate, increasing overall compartment temperatures and pyrolizing fuel, such that upon the reintroduction of oxygen (for example, as the aircraft descends for landing), the fire resumes at an even greater intensity.[13] Hence, experience from the UPS flight 6 accident as well as FAA experiments suggest that passive fire suppression in large cargo compartments due to oxygen deprivation may not be effective.

On December 17, 2007, as a result of the UPS flight 1307 accident, the NTSB issued Safety Recommendation A-07-99, which asked the FAA to do the following:

> Require that fire suppression systems be installed in the cargo compartments of all cargo airplanes operating under 14 *Code of Federal Regulations* Part 121.

On September 6, 2010, the FAA responded that it had completed a cost-benefit analysis for the installation of onboard fire detection and extinguishment systems in cargo airplanes.[14] The FAA determined that the cost to install compartment flooding fire suppression systems, such as those used in Class C cargo compartments, was not justified for the main deck cargo compartments of aircraft of any weight category. The FAA decided not to pursue additional rulemaking at that time. On April 27, 2011, the NTSB classified Safety Recommendation A-07-99 "Closed—Unacceptable Action."

The two catastrophic cargo airplane fires that occurred in less than a year, the UPS flight 6 accident and the Asiana Cargo flight 991 accident, occurred after the FAA's cost-benefit analysis concluded that the installation of fire suppression systems was not cost-effective. These accidents continue to demonstrate the critical need to suppress cargo

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[13] See http://www.fire.tc.faa.gov/2010Conference/files/Cargo_Fire/HillDepressurizationFreighter/HillDepressurizationFreighterPres.pdf.

[14] *A Cost-Benefit Analysis for the Installation of Fire Suppression Systems in Cargo Compartments of Cargo Airplanes*, DOT/FAA/AR-09/17, Final Report (Washington, D.C.: U.S. Department of Transportation, Federal Aviation Administration, April 2009).

fires. The NTSB cargo container fire study shows that cargo container fires have the potential to quickly grow to dangerous levels. Evidence from the UPS flight 6 accident indicates that depressurization as a means to mitigate a cargo fire is not effective. Advances in cargo fire suppression technologies, such as the aircraft-based system[15] implemented by Federal Express Airlines and in-container fire suppression systems currently being developed by industry,[16] indicate that there are alternatives to the compartment flooding suppression systems originally evaluated by the FAA in response to Safety Recommendation A-07-99. The NTSB concludes that the current accident experience of three hull loss accidents during the past 6 years, two of which resulted in fatalities, demonstrates that current fire protection requirements for aircraft cargo compartments do not reliably prevent cargo container fires from growing to dangerous levels.

Therefore, the NTSB recommends that the FAA require the installation and use of active fire suppression systems in all aircraft cargo compartments or containers, or both, such that fires are not allowed to develop.

The NTSB is concerned about the effectiveness of the current fire protection strategy employed in cargo airplanes. Results from investigations of in-flight cargo fires during the past 6 years and the NTSB's recent cargo container fire study provide strong evidence to support these recommendations. Therefore, the National Transportation Safety Board makes the following recommendations to the Federal Aviation Administration:

> Develop fire detection system performance requirements for the early detection of fires originating within cargo containers and pallets and, once developed, implement the new requirements. (A-12-68) *(This safety recommendation supersedes Safety Recommendation A-07-98, which is classified "Closed—Acceptable Action/Superseded.")*
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> Ensure that cargo container construction materials meet the same flammability requirements as all other cargo compartment materials in accordance with Title 14 *Code of Federal Regulations* 25.855. (A-12-69)
>
> Require the installation and use of active fire suppression systems in all aircraft cargo compartments or containers, or both, such that fires are not allowed to develop. (A-12-70)

[15] A description of the suppression system can be found at http://news.van.fedex.com/node/14867.

[16] An example of an in-container type of fire suppression system was demonstrated to the NTSB by Firetrace Aerospace, LLC.

In response to the recommendations in this letter, please refer to Safety Recommendations A-12-68 through -70. We encourage you to submit updates electronically at the following e-mail address: correspondence@ntsb.gov. If a response, including attachments, exceed 10 megabytes, please e-mail us at the same address for instructions. To avoid confusion, please do not submit both an electronic copy and a hard copy of the same response.

Chairman HERSMAN, Vice Chairman HART, and Members SUMWALT, ROSEKIND, and WEENER concurred in these recommendations.

[Original Signed]

By: Deborah A.P. Hersman
Chairman