Japan Transport Safety Board

The response from the FAA to the safety recommendation

The Japan Transport Safety Board received the response from the Federal Aviation Administration (FAA) of the United States of America to the safety recommendation issued September 25, 2014 as attached regarding a Serious Incident of JA804A (Boeing 787-8) operated by All Nippon Airways Co., Ltd. at Takamatsu Airport, Japan on January 16, 2013.

JTSB safety recommendation to the FAA

1 Actions to be taken by the FAA

The internal short circuit test by nail penetration method under the simulated on-board configuration with the battery ground wire demonstrated a thermal runaway, while the test without the ground wire did not.

Given the facts and analyses of other tests combined, in the serious incident the very likely sequence of scenario for the main battery thermal runaway is as follows:

- Cell 6 was the initiator of the thermal propagation;
- Cell 6 and the brace bar contacted with each other allowing high currents to flow through the battery box to cause arcing; and
- Arcing bolstered the thermal propagation leading to the thermal runaway.

It is very likely that the engineering test conducted during the developmental phase did not develop into thermal runaway because the battery box was not grounded with the ground wire. This demonstrates that it was inappropriate to exclude the internal short circuit test from the safety assessment based on the test result which was not conducted simulating the actual airplane configuration.

There is a possibility that present standards for airplane LIB do not appropriately address the electric environment although they stipulate environmental conditions such as temperature, humidity, inertia, and so on. In addition, the FTA in the safety assessment provided to the JTSB lacked the assessment of the thermal propagation risk.

The probability of LIB vent with smoke was estimated to be less than one out of ten million flight hours in the type certification; however, in reality three events of cell heat generation have occurred in less than 250,000 flight hours, resulting in the rate far exceeding the estimate. The calculation of failure rate in the type certification, which was done based on the failure records of similar LIB, was probably inappropriate.

In addition, contactor opening not expected in the design is very likely associated with

cell venting; therefore, the necessity for risk reassessment on the loss of all electric power should be examined.

The JTSB, in light of the serious incident investigation, makes the following safety recommendations that the Federal Aviation Administration of the United States of America should take the following mitigation actions.

The FAA should:

a. Provide instruction to airplane manufactures and equipment manufactures to perform equipment tests simulating actual flight operations.
b. Review the technical standards for LIB to ensure that the electric environment is appropriately simulated, and if necessary, amend the standards.
c. Review the LIB failure rate estimated during the 787 type certification, and if necessary, based on its result, review the LIB safety assessment.
d. Review the TC for its appropriateness on heat propagation risk.
e. Assess the impact of contactor opening after the cell vent on the flight operation and take appropriate actions, if necessary.

2 Measures to be Taken to Instruct The Boeing Company as a Designer and Manufacturer of the 787

Although this investigation could not conclusively identify the mechanism of the internal short circuit, low temperature during overnight stay possibly contributed to the internal short circuit as the three battery incidents (this serious incident inclusive) occurred in the midst of cold January and low temperature is said to be favorable for lithium metal deposition. In addition, there are reports of cell contamination deriving from manufacturing, which may be related to the cause of the battery event. Furthermore, this investigation found the unexpected BCU operation and contactor opening which are outside the design envelope in relation to the charging control.

In light of these facts, the Federal Aviation Administration should supervise Boeing to:

a. Continue the study of internal short circuit mechanism considering the effects of non-uniform winding formation and other factors deriving from manufacturing process; and continue efforts to improve LIB quality and its reliability, reviewing the LIB operational conditions, such as temperature.
b. Improve BCU and contactor operations which are not intended in the design envelop.

Attachment

U.S. Department
of Transportation
Federal Aviation
Administration

800 Independence Ave., S.W.
Washington, D.C. 20591

MAY 20 2015

Norihiro Goto
Chairman
Japan Transport Safety Board
2-1-2, Kasumigaseki
Chiyoda-ku, Tokyo, 100-8918
Japan

Dear Mr. Goto:

This is our initial and final response to Safety Recommendations 15.013 through 15.019 issued by the Japan Transport Safety Board (JTSB) on September 25, 2014. The Federal Aviation Administration (FAA) Office of Accident Investigation and Prevention received these recommendations through the National Transportation Safety Board on January 15, 2015. The JTSB issued these recommendations as a result of a serious incident that occurred on January 16, 2013. A Boeing 787-800 (B-787), operated by All Nippon Airways Co., LTD., registered JA804A, took off from Yamaguchi Ube Airport for Tokyo International Airport as its scheduled flight 692. When it was climbing through 32,000 feet over Shikoku Island, an Engine Indicating and Crew Alert System message of battery failure came on accompanied by an unusual smell in the cockpit. The airplane diverted and landed at Takamatsu Airport. An emergency evacuation was executed using slides on the taxiway. Four passengers of the 137 occupants (which included the Captain, seven crewmembers, and 129 passengers) suffered minor injuries during the evacuation. Although the main battery was damaged, it did not lead to a fire.

Incidentally, a similar incident occurred in the United States, on January 7, 2013, at Logan International Airport (BOS), Boston, Massachusetts. Additionally, about one year after the incident at BOS, a similar main battery incident occurred at Japan's Narita International Airport on January 14, 2014.

15.013. Provide instruction to airplane manufacturers and equipment manufacturers to perform equipment tests simulating actual flight operations.

15.014. Review the technical standards for lithium ion battery to ensure that the electric environment is appropriately simulated, and if necessary, amend the standards.

FAA Comment. The FAA worked with industry experts to develop new Lithium battery and battery system standards that require applicants to perform equipment tests simulating actual flight operations, including a simulation of the worst-case failure condition. On

December 18, 2013, these revised standards were released in Radio Technical Commission for Aeronautics (RTCA) DO-347, Certification Test Guidance for Small and Medium Sized Rechargeable Lithium Battery and Battery System. These standards are being applied to large batteries through the issue paper process pending final release of RTCA DO-311a by September 2015. RTCA DO-347 can be found at the following Web site:

http://www.rtca.org/store_product.asp?prodid=1124.

These standards were developed to ensure that the electric environment is appropriately simulated, and include testing based on in-service lessons learned that simulate actual aircraft installation and flight operation. The standards have been revised to include design review and testing processes intended to verify that the battery system meets all design and performance requirements for aircraft application.

15.015. Review lithium ion battery failure rate estimated during the 787 type certification, and if necessary, based on its result, review the lithium ion battery safety assessment.

15.016. Review the type certificate for its appropriateness on heat propagation risk.

15.017. Assess the impact of contactor opening after the cell vent on the flight operation and take appropriate actions, if necessary.

15.018. Supervise Boeing to continue the study of internal short circuit mechanism considering the effects of non-uniform winding formation and other factors deriving from the manufacturing process; and continue efforts to improve lithium ion battery quality and its reliability, reviewing the lithium ion battery operational conditions, such as temperature.

15.019. Supervise Boeing to improve Battery Charger Unit (BCU) and contactor operations which are outside the design envelope.

FAA Comment. The B-787 Main and Auxiliary Power Unit (APU) batteries, their associated systems, and enclosure were redesigned and are significantly different than what was certified during the initial B-787 type certification. Accordingly, approval of the redesigned system was based on a new lithium ion battery safety assessment.

Certification of the redesigned system and enclosure specifically addressed heat propagation risk. Two in-service battery cell thermal events on airplanes with the new battery and enclosures have not propagated beyond the battery enclosure, per design.

Certification of the redesigned system and enclosure specifically addressed cell venting events and subsequent isolation of the battery. The enclosure with overboard venting is designed to mitigate and contain a cell venting event. Loss of a Main or APU battery as a power source will not preclude continued safe flight and landing. Two in-service battery cell thermal events on airplanes with the new battery and enclosures have not had airplane level effects outside of the enclosure and have not had system level effects beyond loss of the associated battery as a power source, per design.

In an effort to continually improve the battery cell design, Boeing is continuing to study the internal short circuit mechanism and examining the build procedure for the lithium ion battery.

This included improvements to the Battery Charger Unit (BCU) and contactor operations. Two in-service battery cell thermal events on airplanes with the new battery and enclosures have not had airplane level effects outside of the enclosure and have not had system level effects beyond loss of the associated battery as a power source, per design. The BCU and contactor functioned per design.

Based on the actions noted above, the FAA does not intend to conduct any further review of the original lithium ion battery safety assessment.

I believe that the FAA has effectively addressed safety recommendations 15.013 through 15.019 and consider our actions complete.

The FAA would like to thank the JTSB for submitting FAA Safety Recommendations 15.013 through 15.019 and its continued interest in aviation safety. If you have any questions, or need additional information regarding these safety recommendations, please contact

(Name and Phone Number)

Sincerely,

(Original signed)

Director, Office of Accident Investigation
And Prevention