



National Transportation Safety Board

Washington, D.C. 20594

Safety Recommendation

Date: NOV 16 1999

In reply refer to: A-99-80 through -84

Honorable Kelley S. Coyner
Administrator
Research and Special Programs Administration
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On April 28, 1999, a fire destroyed freight, including lithium batteries, on two aircraft cargo pallets at the Northwest Airlines cargo facility at Los Angeles International Airport. The pallets had been taken off an inbound passenger-carrying flight from Osaka, Japan. The aircraft was a Boeing 747, operated by Northwest Airlines as flight 0026. The National Transportation Safety Board's investigation of this incident revealed that lithium batteries likely present a serious fire hazard to air transportation requiring immediate attention. Currently, lithium batteries of the type involved in the April 28 fire can be transported on both passenger-carrying and cargo-only aircraft but are not classified as a hazardous material requiring appropriate identification, marking, labeling, and testing.

Flight 0026 arrived at Los Angeles International Airport about 1020 local time. At 1120, a Northwest equipment operator picked up a pallet loaded with lithium batteries from a dolly and tried to set it on the ground near the cargo facility. To get the pallet to slide off the forklift blades, the operator stopped his vehicle quickly. As the pallet came off the blades, it rolled onto its side against a pallet from another shipment.

The pallet was left resting against the second pallet until 1233, when two equipment operators separated the pallets and righted the pallet with the batteries by placing the forklift blades under the boxes. The operator who righted the pallet said that the pallet seemed to be "top-heavy" and difficult to maneuver. Another equipment operator, who was in the area shortly after the pallet was righted, stated that several batteries were on the ground near the area where the pallets had been separated, indicating that some of the boxes of batteries may have been damaged.

At 1457, the pallet that had overturned was picked up again and moved next to another pallet containing lithium batteries, along with other types of batteries and cargo. Three minutes later, at 1500, a Northwest equipment operator noticed smoke, followed quickly by a small fire on the back of the previously overturned pallet. Another equipment operator on a forklift moved that pallet away from the rest of the pallets to prevent the fire from spreading. While the pallet



was being moved, the fire spread to the adjoining pallet containing lithium batteries. Both pallets then erupted in flames. The lithium batteries were neither identified nor shipped as hazardous materials. Instead, they were shipped as ordinary freight under an exception to the hazardous material regulations.

The fire department was notified, and several Northwest employees began fighting the fire with portable extinguishers and a fire hose. The employees noted that each time they thought the fires were out, they flared up again. Several employees saw the lithium batteries "popping" or "jumping" in the fire. The fire department arrived at 1509 and by 1525 had extinguished the fires by separating the packages involved in the fire and deluging them with water.

Postincident examination revealed that the damage to the cargo on the pallets was generally limited to the lithium batteries and their packaging. These batteries showed signs of bursting and melting. Some damage occurred to the packaging of the other batteries and cargo on the two pallets, but no evidence was found to indicate that these items had been involved in the ignition or spread of the fire.

Interviews with Northwest employees revealed that the day after the April 28 fire, another small fire started when a lithium battery that had unintentionally been left on the floor of the cargo facility became lodged under a pallet and ignited as a forklift slid the pallet across the floor.

Employee interviews also revealed that it is not uncommon to accidentally overturn a pallet and that other loads of batteries have been damaged. One of the equipment operators who helped right the pallet involved in the fire stated that this was the third pallet that he had righted this year. Another operator stated that he had witnessed a pallet full of batteries turn completely upside down when it accidentally rolled off a dolly. A third operator reported seeing four crushed boxes of batteries on the bottom half of a pallet and "thousands" of small batteries spilling out as the pallet was taken off an international flight.

Aircraft pallets are flat aluminum plates with no channels for forklift blades. They are lifted from the ground by driving the blades under the edge and beneath the pallet, which often results in the operator sliding the pallet along the ground before it can be picked up. Consequently, unlike pallets with channels that will catch the forklift blades, these pallets can fall from the blades if they are unbalanced. Therefore, an operator must ensure that the pallet's center of gravity is securely on the blades to avoid dropping the pallet. Finally, when releasing an aircraft pallet, the operator cannot set it down and back out of the channels, but instead must lower the blades and stop rapidly or reverse the direction of the forklift so that the pallet tips forward, shifting the center of gravity and allowing the pallet to slide from the blades. If this procedure is done too quickly, or if the pallet is held too high above the ground or is top-heavy, the pallet may overturn.

Since the incident, Northwest Airlines has prohibited the transportation of lithium batteries on its aircraft unless the batteries are identified as a hazardous material and meet the

shipping requirements for a regulated material, including appropriate marking and labeling and proper identification on the shipping documents.

The two pallets involved in the fire contained 120,000 nonrechargeable lithium batteries: 120 12-kilogram (kg) packages containing 1,000 batteries in each package. These approximately 1-inch-long, ½-inch-diameter batteries each contained about 0.4 gram of lithium. Shipping documents indicated that they were "Not Dangerous Goods."¹

Lithium, which is contained inside each lithium battery, is a combustible alkali metal that ignites in air at 352° F. When exposed to water, lithium reacts exothermically and releases hydrogen, creating a dangerous fire risk. Fires involving lithium are extremely difficult to extinguish. Extinguishers using water, gas, or certain dry chemicals cannot control this type of fire. The Department of Transportation (DOT) classifies lithium metal as a division 4.3 material (dangerous when wet).² Lithium metal may not be shipped on passenger aircraft but can be shipped on cargo aircraft, provided each package weighs no more than 15 kg.

When lithium batteries were first developed, they were authorized to be shipped under DOT exemptions, which classified them as "flammable solid, dangerous when wet" (currently called division 4.3) because they contain lithium metal. According to the DOT's Research and Special Programs Administration (RSPA), in 1988, the United Nations (UN) reclassified lithium batteries in the belief that the lithium is hermetically sealed within the batteries and would not be exposed to water during normal handling in transportation, thus the "dangerous when wet" classification did not apply. Now the UN, DOT, and the International Civil Aviation Organization (ICAO)³ classify lithium batteries as a class 9, miscellaneous hazardous material. According to RSPA, lithium batteries are classified as a miscellaneous hazardous material because of the potential for an electrochemical reaction that generates heat and gas should a short circuit occur.

Exemptions were issued in the late 1970s allowing lithium batteries containing less than 0.5 grams of lithium per cell and no more than 1 gram of lithium per battery (like the batteries involved in this incident) to be transported exempt from certain hazardous materials regulations, according to RSPA. By 1979, these exemptions were incorporated into both U.S. (49 CFR 173.185) and international (ICAO) air transportation requirements as exceptions. Subsequently, lithium batteries containing limited amounts of lithium and meeting certain packaging requirements became "excepted" (excluded) from all regulations. The lithium batteries involved in the fire in Los Angeles International Airport met the criteria for exception from the hazardous materials regulations.

¹ "Dangerous goods" is an international term for hazardous materials.

² Title 49 *Code of Federal Regulations* (CFR) 173.124(c) defines division 4.3 (dangerous when wet) material as "a material that, by contact with water, is liable to become spontaneously flammable or to give off flammable or toxic gas at a rate greater than 1 liter per kilogram of the material, per hour, when tested in accordance with [the] *UN Manual of Tests and Criteria*."

³ DOT regulations allow the transportation of hazardous materials by aircraft to, from, and within the United States in accordance with ICAO's *Technical Instructions for the Safe Transportation of Dangerous Goods by Air*. For more information, see 49 CFR 171.11.

Lithium batteries not meeting the exception criteria must be transported as a regulated hazardous material and thus be properly identified on the shipping documents and have appropriately marked and labeled packaging. No more than 5 kg of batteries per package may be transported on a passenger-carrying aircraft, and the air carrier must notify the pilot-in-command that they are being loaded on the aircraft. Additionally, before transportation, batteries shipped as a regulated item must be tested in accordance with the requirements in the UN's *Transport of Dangerous Goods Manual of Tests and Criteria* to prove that they will not disassemble (break open) or cause a fire. The tests involve various combinations of simulated altitude, temperature change, vibration, shock, charging, discharging, low-capacity cells, and electrical shorts (external and internal). These tests do not address the potential risk of packages containing large quantities of tightly packed lithium batteries (like the packages involved in the incident) being involved in a cargo compartment fire or take into account possible conditions in an air cargo transportation environment, where lithium batteries may be exposed to rough handling, including being crushed or abraded open.

The Safety Board has been concerned for some time about the risks associated with fires in aircraft cargo compartments, especially fires involving hazardous materials. On October 24, 1988, as a result the Safety Board's investigation⁴ of a February 3, 1988, in-flight fire involving hydrogen peroxide solution (an oxidizer), the Safety Board issued Safety Recommendation A-88-127, which urged the Federal Aviation Administration (FAA) to consider the effects of authorized hazardous materials on cargo fires in all types of cargo compartments and to require appropriate safety systems to protect the aircraft and occupants. The FAA did not act on this recommendation, and therefore, on April 19, 1993, Safety Recommendation A-88-127 was classified "Closed—Unacceptable Action."

On February 17, 1998, in response to the May 11, 1996, ValuJet accident in the Florida Everglades, which involved an in-flight fire and resulted in 110 deaths, the FAA amended the Federal standards for cargo and baggage compartments. This amendment requires that inaccessible cargo compartments in new aircraft have fire or smoke detection and fire suppression equipment. However, the amendment does not require cargo compartments on existing aircraft to be retrofitted or converted to meet these standards until early 2001.

Also in response to the ValuJet accident, RSPA, in coordination with the FAA, initiated a study to assess the risks associated with the transportation of hazardous materials in aircraft cargo compartments. RSPA indicated that, based on the outcome of this study, it may ban certain hazardous materials from air transportation.⁵ Recent conversations with RSPA staff indicate that this study is nearing completion; however, lithium batteries were not included in the study. RSPA indicated that other hazardous materials, including lithium batteries, could be subjected to the same risk assessment.

⁴Hazardous Materials Accident Report—*In-Flight Fire, McDonnell Douglas DC-9-83, N569AA, Nashville Metropolitan Airport, Nashville, Tennessee, February 3, 1988* (NTSB/HZM-88/02).

⁵The Safety Board supported this study in its February 28, 1997, comments to a Notice of Proposed Rulemaking (NPRM), Docket HM-224A, *Prohibition of Oxidizers Aboard Aircraft*, December 30, 1996.

The rapid spread of the fire during the April 28 incident between the boxes of lithium batteries on the previously overturned pallet, some of which may have been damaged, and to the apparently undamaged boxes of lithium batteries on the adjoining pallet concerns the Safety Board. Although exactly how the fire spread is unclear, the circumstances of this incident raise the possibility that these batteries may be readily ignited by an existing fire and may be difficult to extinguish or may intensify an existing fire that otherwise might have been contained. The Safety Board is also concerned that some lithium batteries are excepted from testing that would demonstrate they will not disassemble or cause a fire under certain conditions. Therefore, the Safety Board concludes that lithium batteries may present an unacceptable risk to aircraft and occupants. The Safety Board believes that RSPA and the FAA should jointly evaluate the fire hazards posed by lithium batteries in an air transportation environment and require that appropriate safety measures be taken to protect aircraft and occupants. The evaluation should consider the testing requirements for lithium batteries in the UN's *Transport of Dangerous Goods Manual of Tests and Criteria*, the involvement of packages containing large quantities of tightly packed batteries in a cargo compartment fire, and the possible exposure of batteries to rough handling in an air transportation environment, including being crushed or abraded open. The Safety Board also believes that, pending completion of this evaluation, RSPA should prohibit the transportation of lithium batteries on passenger-carrying aircraft.

Additionally, the U.S. and the ICAO requirements for identifying packages as a hazardous material, including appropriate marking and labeling of packages and their identification in the shipping documents as a hazardous material, are, in part, designed to alert transportation personnel to their dangers so that they will handle them with greater care. However, when excepted from requirements to identify them as hazardous materials, lithium batteries are not easily distinguished from nonhazardous cargo. Given the rough handling and overturning of the aircraft cargo pallets preceding this incident, the evidence that aircraft pallets containing large quantities of batteries may be unusually susceptible to overturning, and the concern that lithium batteries damaged during handling and placed in a cargo compartment may result in an in-flight fire on an aircraft, the Safety Board concludes that, to improve handling safety, lithium batteries should not be excepted from identification as a hazardous material when transported by air. The Safety Board believes that RSPA should require that packages containing lithium batteries be identified as hazardous materials, including appropriate marking and labeling of the packages and proper identification in shipping documents, when transported on aircraft. Should RSPA's actions in response to this safety recommendation letter result in the prohibition of lithium batteries on passenger-carrying aircraft until the fire hazards posed by lithium batteries in an air transportation environment can be evaluated and appropriate safety measures are implemented, the recommendation to identify lithium batteries as a hazardous material would initially affect just cargo-only aircraft.

Further, the Safety Board believes that, pending completion of its evaluation of the fire hazards posed by lithium batteries in an air transportation environment, RSPA should notify the ICAO's Dangerous Goods Panel about the circumstances of the fire in the Northwest Airlines cargo facility at Los Angeles International Airport on April 28, 1999. The Safety Board also believes that, pending completion of its evaluation of the fire hazards posed by lithium batteries in an air transportation environment, RSPA should initiate action through the Dangerous Goods

Panel to revise the *Technical Instructions for the Safe Transportation of Dangerous Goods by Air* to prohibit the transportation of lithium batteries on passenger-carrying aircraft. Additionally, the Safety Board believes that RSPA should initiate action through the Dangerous Goods Panel to require that packages containing lithium batteries be identified as hazardous materials when transported on aircraft.

Therefore, the National Transportation Safety Board recommends that the Research and Special Programs Administration:

With the Federal Aviation Administration, evaluate the fire hazards posed by lithium batteries in an air transportation environment and require that appropriate safety measures be taken to protect aircraft and occupants. The evaluation should consider the testing requirements for lithium batteries in the United Nations's *Transport of Dangerous Goods Manual of Tests and Criteria*, the involvement of packages containing large quantities of tightly packed batteries in a cargo compartment fire, and the possible exposure of batteries to rough handling in an air transportation environment, including being crushed or abraded open. (A-99-80)

Pending completion of your evaluation of the fire hazards posed by lithium batteries in an air transportation environment, prohibit the transportation of lithium batteries on passenger-carrying aircraft. (A-99-81)

Require that packages containing lithium batteries be identified as hazardous materials, including appropriate marking and labeling of the packages and proper identification in shipping documents, when transported on aircraft. (A-99-82)


Pending completion of your evaluation of the fire hazards posed by lithium batteries in an air transportation environment, notify the International Civil Aviation Organization's Dangerous Goods Panel about the circumstances of the fire in the Northwest Airlines cargo facility at Los Angeles International Airport on April 28, 1999. Also pending completion of your evaluation of the fire hazards posed by lithium batteries in an air transportation environment, initiate action through the Dangerous Goods Panel to revise the *Technical Instructions for the Safe Transportation of Dangerous Goods by Air* to prohibit the transportation of lithium batteries on passenger-carrying aircraft. (A-99-83)

Initiate action through the Dangerous Goods Panel to revise the *Technical Instructions for the Safe Transportation of Dangerous Goods by Air* to require that packages containing lithium batteries be identified as hazardous materials when transported on aircraft. (A-99-84)

The Safety Board also issued a safety recommendation to the Federal Aviation Administration. Please refer to Safety Recommendations A-99-80 through -84 in your reply. If you need additional information, you may call (202) 314-6463.

Chairman HALL, Vice Chairman FRANCIS, and Members HAMMERSCHMIDT, GOGLIA, and BLACK concurred in these recommendations.

By:


Jim Hall
Chairman