Flammability Assessment of Primary Lithium Batteries

Primary lithium batteries are a popular power source for many small electronic appliances. Primary lithium batteries, as shown figure 1, are defined as nonrechargeable, single-use batteries.

Figure 1. CR2 and PL123A Primary Lithium Batteries

The batteries are packed in bulk-corrugated cardboard containers, stacked on pallets, and shipped in the cargo holds of passenger and cargo aircraft. Thirty thousand batteries or more may be contained on a single pallet. The packaging allows close contact between individual batteries in each row with only thin cardboard separating the rows. The packaging itself is flammable. There has never been a known in-flight fire associated with shipping the batteries in this manner; however, a ramp incident involving palletized batteries has drawn attention to the flammability hazard of primary lithium batteries.

The ramp incident occurred at the Los Angeles International Airport in April 1999. A pallet of batteries caught fire while being handled between flights. There was no known external ignition source. The nature of lithium fires makes them very difficult to extinguish. All common fire-extinguishing agents are ineffective in controlling a lithium fire, including the onboard Halon 1301 fire suppression systems installed in aircraft cargo compartments. Based on this incident, the Fire Safety Branch was asked to conduct a series of flammability tests on primary lithium batteries.

The flammability tests were conducted to assess the flammability characteristics of primary lithium batteries and the potential hazard associated with shipping them on transport aircraft.

A relatively small fire source was found to be sufficient to start a primary lithium battery fire. The outer plastic coating easily melts and fuses adjacent batteries together and then ignites, contributing to the fire intensity. The burning plastic coating helps raise the battery temperature to the self-ignition temperature of lithium. Once the lithium in a single battery begins to burn, it releases enough energy to ignite adjacent batteries. The propagation continues until all batteries have been consumed.

Halon 1301 is ineffective in suppressing or extinguishing a primary lithium battery fire, though it extinguishes any burning packaging materials.

The air temperature in a cargo compartment that has had a fire suppressed by Halon 1301 can still be above the autoignition temperature of lithium. Because of this, the batteries that were not involved in the initial fire can still ignite, and the fire can propagate.

The ignition of a primary lithium battery releases burning electrolyte and a molten lithium spray. Depending on its thickness, the cargo liner material may be vulnerable to perforation by the molten lithium. The

perforation of the cargo liner can allow the Halon 1301 fire suppressant agent to leak out of the compartment, reducing the agent concentration within the cargo compartment and the effectiveness of the agent. Holes in the cargo liner may also allow flames to spread outside the compartment.

The ignition of primary lithium batteries creates a pressure pulse that can raise the air pressure within the cargo compartment. The ignition of only a few batteries was sufficient to increase the air pressure by more than 1 psi in an airtight pressure vessel with a volume of 10 cubic meters. Cargo compartments are only designed to withstand approximately a 1-psi pressure differential. The ignition of a bulk-packed primary lithium battery shipment may compromise the integrity of the compartment by activating the pressure relief panels. The opening of the pressure relief panels has the same effect as perforations in the cargo liner, allowing the Halon 1301 fire suppressant to leak out, reducing its effectiveness.

In summary, the presence of a shipment of primary lithium batteries can significantly increase the severity of an in-flight cargo compartment fire. An FAA technical report, "Flammability Assessment of Bulk-Packed, Nonrechargeable Lithium Primary Batteries in Transport Category Aircraft," DOT/FAA/AR-04/26, Webster, H., was published in June 2004 and describes tests conducted by the Fire Safety Branch to assess the danger posed to passenger and cargo aircraft by the shipment of bulk-packed primary lithium batteries.

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