Will Boeing's Battery Fix Fly?

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Boeing has FAA clearance to restart its Dreamliner rollout. Some experts aren't convinced the giant plane maker has cut the risks on its lithium batteries far enough.

Bloomberg News: Joshua Roberts, top, Andrew Harrer

Boeing’s 787 Dreamliner, above, will be back in the air shortly following a spate of battery problems like those experienced by JAL, right.

All systems are go at Boeing in the wake of the Federal Aviation Administration's recent decision to accept the design changes in the two lithium-ion batteries aboard the 787 Dreamliner and allow airlines to resume flying them.
Some 50 Dreamliners had been grounded worldwide since Jan. 16, following two incidents within nine days that saw batteries overheat and burn. The first was at Logan International Airport in Boston when an aft battery being recharged caused a fire in a Japan Airlines (ticker: 9201.Japan) plane with no passengers aboard. Then an All Nippon Airways (9202.Japan) Dreamliner had to make an emergency landing in Japan after acrid fumes filled the cabin and a flight-deck instrument showed a problem with the lithium-ion battery in the forward electronics bay. The plane popped its hatches and deployed slides at the end of the runway to get passengers out.

Already, Boeing (BA) engineers are fanning across the globe to make the safety modifications on the state-of-the-art, fuel-efficient planes, and many are expected back in the air within weeks.

Boeing officials are understandably elated at the outcome following the three-month grounding, the first in nearly 35 years for a U.S. airline fleet. The company has a lot at stake with the Dreamliner. Boeing has to sell 1,100 of these planes to achieve profitability on this investment.

The situation had turned into a public-relations black eye, though customer airlines stood behind Boeing during the grounding. It’s also expected to cost Boeing between $400 million and $700 million, both in investigative costs and compensation to airlines, according to Jefferies analyst Howard Rubel, who has a Strong Buy on the stock. "It will cause barely a blip in their earnings trajectory, which is bolstered by an extraordinarily strong order book, expected productivity improvements, and ability to string out these extra costs over years," he adds. The shares are up 25% since the end of January.

INVESTORS SHOULD REALIZE that doubts remain about the use of lithium-ion batteries in the Dreamliner configuration, even after the many modifications Boeing is making. Obviously, two of what Boeing terms battery "events" in a little more than a week suggest the prior testing and certification process of the batteries was faulty. However, Boeing told Barron's Friday that the system was designed for continued safe flight if a battery failed and "nothing we've seen indicates that the system did not achieve that expectation."

Lithium-ion batteries, much prized for their light weight arising from their energy density, have had a history of going into spontaneous "thermal runaway" (a process that can result in fire and explosions) in everything from laptops to electric vehicles to an experimental U.S. minisubmarine in 2008.

Boeing has said it selected the lithium-ion battery because of its lower weight, higher-power and faster-charging capabilities, and improved storage life. The company added Friday "nothing that we've learned as the result of the ongoing investigations has caused us to change our decision to use lithium-ion batteries."

BUT SOME BATTERY CHEMISTS, physicists, and other experts contacted by Barron's expressed surprise at Boeing's choice of battery technology for a passenger airliner. Underscoring this skepticism was EADS' (EAD.France) quick decision after the Boeing battery accidents to substitute more-traditional nickel-cadmium batteries for lithium ion in its Airbus A350 aircraft now under development. An Airbus spokesman said that the swapped batteries would add about 220 pounds to the plane's weight but that the switch was necessary given the immaturity of lithium-ion-battery technology.

Several respected battery researchers mince few words about the Boeing batteries. "I'm shocked that Boeing was willing to stake its reputation on these batteries," says Elton Cairns, a professor at the Lawrence Berkeley National Laboratory and an expert in battery technology. The lab is supported by the U.S. Department of Energy and run by the University of California. "Even with the modifications, the individual cells of the battery are crammed too closely together and feature an internal chemistry that's far too volatile," says Cairns.
Echoes Michel Armand, a professor of chemistry at the University of Picardie and a research director at the French government's Centre National de la Recherche Scientifique: "Using these batteries in planes makes no sense, with all the lives potentially at stake. These batteries are unpredictable and prone to thermal runaway and fires."

The chief project engineer for Boeing has insisted that there is no chance of fire or thermal runaway in the battery with the modifications.

The unstable nature of lithium metal and lithium-ion batteries is well known. Because of its molecular structure, lithium can hold a far more powerful electric charge in a compact space than other compounds employed in batteries using nickel cadmium and lead acid. Since lithium reacts violently with water, these batteries require electrolyte fluids inside the battery that are potentially more flammable than water-based, fire-quenching fluids.

To be clear, the lithium-ion batteries on the Dreamliner are not responsible for the plane's electrical power in flight nor the thrust of its engines. Afloat, the plane's electrical system is powered by two generators on each engine. The two 63-pound lithium batteries serve only as a backup system far down the chain of redundancy built into the plane's electrical architecture. Called into service when the plane is on the ground, they will discharge their electrons into a circuit to, say, kick on the auxiliary power generators in the tail which, in turn, run the climate-control systems at the gate.

Yet, a battery fire is a menace to an airplane whether on the ground or in the air. And Boeing engineers remain stumped on what exactly caused the overheating of the batteries in the two incidents.

It's known, however, that batteries tend over many cycles of charging and recharging to grow microscopic filaments of pure metal called dendrites that can pierce the separators between the anode and cathode portions of the battery and cause powerful short circuits. Lithium dendrites can be particularly dangerous because of the amped-up power flowing through them.

The result can be thermal runaway, in which the electrolytes in an individual cell heat up dramatically, causing the combustion of materials in both the anode and cathode. A domino effect, or "fratricide" in engineering jargon, can then occur, as the heat and combustion spread from cell to cell.

The National Transportation Safety Board report on the Dreamliner fire at Logan airport said the original short appeared to start in the fifth cell, eventually spreading to the other seven cells, consuming the electrolytes in the entire battery. The NTSB found that some of the steel had vaporized and then condensed. That indicates temperatures exceeding 5,500 degrees Fahrenheit, notes Lew Larsen, a physicist in Chicago.
THE BATTERY MODIFICATIONS being made by Boeing are designed to head off any chance of a battery fire by containing the batteries in a stainless-steel box, venting all electrolyte gasses from cells that overheat through a special titanium pipe and altering the battery charger to power down the batteries somewhat.

Those modifications should make the batteries materially safer for travelers, says French lithium-ion expert Armand. But he says maintenance of the batteries will become a "nightmare" because of chronic cell failures. "Airlines will be required to take hours of time to remove one or two cells...gone bad, unbolting and rebolting the batteries' stainless-steel encasement," he predicts. Boeing said battery replacement, "regardless of the technology," is a fact of life on airplanes and that the company looks for "opportunities to extend the service life" wherever possible.

The battery changes made by Boeing are predicated on the assumption that by removing and venting heated-up electrolyte vapors and starving the batteries of oxygen, the chance of any thermal runaway and fire is totally negated. And Boeing may be right.

But that doesn't eliminate the possibility that tiny high-energy hot spots inside cells could ignite the lithium-cobalt-oxide material in the cathode, free up oxygen and liberating highly combustible lithium and cobalt out of compound before any prophylactic venting of the electrolytes takes place, says Larsen. The history of lithium batteries is studded with mishaps and accidents, though the makers of these rechargeable batteries have made great strides in improving their safety.

There's the case of the 747 cargo planes, one of which crashed in Dubai in 2010 and the other off the coast of South Korea in 2012, killing their two-man crews. Both were carrying pallets of new, lightly charged throwaway lithium-metal batteries used in various consumer products, and their crews reported heavy smoke and fire emanating from the cargo hold before they went down.

No definitive cause has been determined. But today, the government prohibits any such cargo from being carried on passenger planes over the U.S. Likewise, an FAA official at a recent congressional hearing issued the agency's estimate that at least one cargo jet would likely crash from lithium-metal battery-cargo fires in the next two years.

Of course, lithium-metal batteries are far riskier than their rechargeable lithium-ion counterparts. Yet the latter have their own lore of mishaps. Invariably lithium-ion-battery skeptics bring up the explosion of an experimental, electric-powered U.S. Navy minisubmarine when its lithium-ion batteries went into thermal runaway during charging at a Hawaiian test base.

The supplier of the charging unit for the 787's lithium-ion batteries, Securaplane Technologies, a division of Meggitt (MGGT_UK), suffered a fire that destroyed a 10,000-square-foot building at its Arizona facility when a test of its charger unit with a lithium-ion battery similar in composition to the Dreamliner's battery, made by GS Yuasa (6674.Japan), went into thermal runaway, venting hot electrolytes. Three sets of firefighters were unable to put the fire out. A Boeing spokesman insists that the mishap was the result of an improper setup of the test and neither a battery nor a charger problem. Local authorities could not determine a cause for the fire. Securaplane did not respond to a call for comment.

Mitsubishi reported recently that two lithium-ion battery packs, made by its joint venture with the company making Boeing's, caught fire. One of the batteries was being tested at a plant before being installed in its i-MiEV model electric car. In the second incident, a lithium-ion battery overheated in its Outlander PHEV plug-in hybrid electric vehicle, melting a cell and part of the battery pack.

The Dreamliner battery mishaps seemingly speak to a serious lapse in Boeing's technological choices. Was too much sacrificed for weight-savings and fuel-efficiency?

We can only wonder whether the venerable company has got it right this time.

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