

Boeing's 787 battery eggs: All in one lithium basket

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Excuse the tortured metaphor, but the old advice about not putting all your eggs in one basket applies to engineering as well as to other fields. The implication is that if the basket with all your eggs slips and falls, you've lost everything. Boeing hasn't lost everything, but the battery troubles besetting its new 787 Dreamliner could not have come at a worse time.

The 787, the latest-model wide-body jetliner from Boeing that seats up to 290 passengers, has been in commercial service since October 2011, less than a year and a half. It boasts the latest high-tech advances such as a mainly carbon-fiber airframe for reduced weight and fuel consumption, and mostly electrical control systems, rather than the older pneumatic or hydraulic actuators. Consequently, its electrical power requirements are about triple that of earlier comparable airliners, and so the electrical power system of the 787 was boosted accordingly. Like a car, the engines (or turbogenerators driven by engines) provide most of the electrical power in flight, but for emergencies and times when the generators aren't running, the 787 needs batteries, also like a car. But lead-acid or even nickel-cadmium batteries were seen to be too heavy for the advanced jet, so designers chose to use two 60-some-pound auxiliary power units (battery banks) that employed lithium-cobalt batteries.

Now, lithium batteries have both virtues and vices. Their main virtue is that they have the best energy-weight ratio of just about any commercial type of battery, meaning you get more stored energy in a 60-pound lithium battery than you would in the same weight of nickel-cadmium or lead-acid batteries. So far, so good. But lithium is one of the more reactive metals, and the chemistry of lithium batteries is very touchy with regard to storage temperatures, charging rates, and defects such as little metal needles that sometimes grow through insulating layers and short the things out. When any of these problems happen to a severe enough degree, the battery can catch fire. And once a lithium battery is on fire, there's very little you can do except to wait till it burns itself out, because all the ingredients for the fire are already inside the battery. Even the FAA recognizes this because it doesn't

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require any fire-fighting equipment to put out lithium-battery fires—just adequate ventilation to make sure the hazardous fumes from the fire don't harm passengers or crew, and don't spread the fire to other parts of the plane.

But there is evidence that in the two lithium-battery fires that occurred on 787s in the last couple of months, even these safety systems didn't work properly. After these fires in Boston and Japan, the FAA and most other national air-safety agencies grounded the entire fifty-plane fleet of 787s until the battery problem is resolved.

This problem clearly could have been worse. The planes could have crashed, but in the incidents so far, the pilots discovered the problem in enough time to land the planes safely. In the past, lithium-battery fires in a plane's cargo compartment have caused the loss of the plane, and that is why you are not allowed to carry loose non-rechargeable lithium-ion batteries in checked luggage on air flights. (Didn't know that, did you?) But anybody who owns or leases a multi-million-dollar investment like a 787 knows that every day you can't fly it is a big hole in your pocket, and also seriously disrupts flight schedules that were made assuming the new 787s would be available.

It looks like the planes were designed almost in the expectation that the batteries would catch fire some time or other, even though the ventilation systems apparently didn't work as well as planned. The fix is likely to be a challenge, because the plane's entire electrical system is designed around lithium batteries. Substituting an older type of battery is feasible, but will involve a major redesign, adding weight and probably space and a lot of certification tests to ensure that the fixes aren't worse than the original problem.

We may be getting ahead of the game if we assume the lithium batteries are going to come out of the 787s altogether. The fact that the fires happened so close in time, after over a year of service, says to me that there may have been some kind of well-controlled slipup either in the manufacture of those particular batteries, or the design of those particular planes. If engineers and investigators can isolate—and ideally, reproduce—the cause of these fires, and it turns out to be fixable, then it may be a simple matter of making sure those particular conditions don't happen again, and the planes can fly safely again with the lithium batteries they were originally designed for.

The trouble with these investigations is that once you get a lithium fire going, there isn't a lot left to pick through to see what started it. In the "Sources" section at the end of this blog, I've put a URL for a little video that I must say about at the outset, "Kids, don't try this at home." It shows a guy taking apart an ordinary consumer lithium battery and setting fire to it. After you watch that video, you may have second thoughts about buying a lithium anything, though most people don't go around taking propane torches to their batteries.

We can be thankful that the battery incidents did not result in any fatalities, and I for one hope that the problem turns out to be discoverable, reproducible under controlled conditions, and fixable. But in any case, Boeing has some lithium-colored egg on its face for the time being, and has about fifty reasons—equal to the number

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of 787s sold—to get to the bottom of the problem and solve it to everyone's satisfaction.

Sources: I referred in the preparation of this piece to an article in the Tacoma, Washington News-Tribune by John Gillie published online on Jan. 27, 2013 at <http://www.thenewstribune.com/2013/01/27/2451132/787-battery-fire-correction-may.html> [1]. I also referred to the Wikipedia articles on Boeing and the Boeing 787 Dreamliner. The lithium-fire-from-battery video can be viewed at <http://www.youtube.com/watch?v=BliWUHSOaIU> [2].

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<http://www.ecnmag.com/blogs/2013/01/boeing%E2%80%99s-787-battery-eggs-all-one-lithium-basket>

Links:

[1] <http://www.thenewstribune.com/2013/01/27/2451132/787-battery-fire-correction-may.html>

[2] <http://www.youtube.com/watch?v=BliWUHSOaIU>

[3] <http://engineeringethicsblog.blogspot.com/2013/01/boeings-787-battery-eggs-all-in-one.html>