

Boeing Dreamliner: Implications for Electric Vehicles

By Dr Peter Harrop, Chairman, IDTechEx

In November 2006, it took hours for fifty fire fighters to quench the blaze as it raged through the Securaplane Technologies building in Tucson, Arizona. The reason? A laboratory test on a lithium-ion battery had got out of control. Within hours, the Securaplane facility was reduced to smouldering debris. In 2007, the FAA asked Boeing to prove the safety of lithium-ion batteries before granting an airworthiness certificate to the new Dreamliner. At the time, the agency noted that “lithium-ion batteries are significantly more susceptible to internal failures that can lead to self-sustaining increases in temperature and pressure.” However, Boeing passed the tests and got the green light.

A similar battery, designed by GS Yuasa of Japan and using a Securaplane charger, powers the electrics of Boeing’s 787 Dreamliner today and that aircraft is in the news because it has suffered more than one serious conflagration apparently in a battery compartment.

Burning laptops also received publicity and resulted in recalls by manufacturers Sony and others. However, these were less than one-in-a-million incidents and they involved the simple lithium cobalt oxide cathodes. Very early on larger batteries such as traction batteries for electric vehicles, whether hybrid or pure electric, had moved to chemically safer “less cobalt” and “no cobalt” formulations. The typical GS Yuasa batteries were one of the former, having lithium nickel cobalt aluminium cathodes similar to those that have been used by market leaders Panasonic, AESC, Samsung, LG Chem and Primearth, a company now controlled by Toyota. The cathode plays the largest part in controlling the characteristics of a lithium-ion battery. Those leaders have shown some move to lithium manganese spinel cathodes but just about everyone uses flammable electrolytes. In “lithium polymer” versions, some offer semi-solid electrolytes that reduce the chance of leakage at some reduction in certain aspects of performance.

A fire on a Japan Airlines 787 in Boston was followed the week before last by smoke pouring from the same battery system on an All Nippon Airways plane, forcing it to make an emergency landing. On the Wednesday, America’s Federal Aviation Administration (FAA) issued an emergency directive, grounding all Boeing 787s operated by American airlines until the aerospace giant can prove the batteries are safe. Other regulators then followed suit.

“The battery failures resulted in release of flammable electrolytes, heat damage and smoke on two 787 airplanes,” the FAA said to journalists. “These conditions, if not corrected, could result in damage to critical systems and structures, and the potential for fire in the electrical compartment.”

The Dreamliner is the first airliner to rely on lithium-ion batteries for electrical power. It has two of these, about 10in wide, 14in long and 8in high. This is much smaller than the lithium-ion traction batteries used in a typical pure electric car, light aircraft or underwater vehicle. One is located in the rear electrical equipment bay, near the wings. It is used to start the auxiliary power generator, a small engine that is primarily used to power the plane when it is on the ground. The second battery powers up the pilot’s computer displays and serves as a back-up for flight systems. Other airliners use traditional mechanical and hydraulic systems that divert power from the engines to run electrical equipment. Where batteries are used they have been traditional ones

such as lead-acid or nickel-cadmium. The 787's electrical system is five times more powerful than that in the larger 777. It can produce enough electricity to power 500 homes.

It is the first time the FAA has grounded an entire model since 1979, when a DC-10 crashed in Chicago killing 270 people. The regulators' action also hit GS Yuasa, whose shares dropped 7.5% in Japan. This company is investigating whether the battery was at fault or the electrical system necessitated by the battery. It warned that tests could take months to complete. GS Yuasa is involved in traction batteries for Honda and Mitsubishi, but it does not deliver the quantities of traction batteries supplied by the leaders. Vehicle traction batteries are now the major part of the market for large lithium batteries, so leadership and experience here is very important.

IDTechEx analysts have ten years of experience of the lithium-ion traction battery business and they comment as follows on the implications for electric vehicles - land, water and airborne - of these Dreamliner batteries, that are not for traction, apparently misbehaving. After all, lithium-ion traction battery packs can be smaller, similar or larger than the Dreamliner batteries and they are similarly made and rely on similar Battery Management Systems BMS to keep them safe and performing optimally. IDTechEx reports on this include analysis of "138 Lithium-ion Battery Manufacturers" (www.IDTechEx.com/lithium) and "Electric Vehicle Traction Batteries 2012-2022" (www.IDTechEx.com/evtraction).

Our observations are these:

The larger a lithium-ion battery is, the more there is to go wrong. Those making safe small versions for phones or tablets cannot necessarily make safe big ones. To some extent, improved temperature performance from different cathodes etc. can correlate with improved safety though no lithium-ion cell is inherently fully safe. Boeing could probably have sacrificed some performance to use somewhat safer cells in this respect.

The Battery Management System BMS is the first line of defense, not the battery cells, when it comes to avoiding fires and explosions. A battery pack usually consists of the cells and the BMS in one container.

Perhaps Boeing should have used a supplier more experienced in lithium-ion battery packs and the BMS. Perhaps it should note how reliability, performance and life of similar power supplies in land vehicles are sometimes enhanced by wholly or partly replacing lithium-ion batteries with supercapacitors. The IDTechEx report, "Supercapacitor / Ultracapacitor Strategies and Emerging Applications 2013-2025" gives the detail.

There is now huge experience of large lithium-ion batteries from millions in e-bikes to over 100,000 in cars. There have been very few incidents beyond China where many suppliers have very poor quality control and even there, only a few lithium-ion batteries of this size or larger have burnt when in use, fewer than one in ten thousand.

The few modest-sized batteries on the tiny number of Dreamliners should never have behaved in this way, if it is indeed the batteries that are to blame. (Investigations are ongoing).

People have nothing to fear from famous brands of land, water and airborne electric vehicle where the manufacturers typically buy from the leading producers of large lithium-ion batteries and many of these vehicle manufacturers have considerable experience in-house of BMS design

and even make these batteries. Indeed, electric vehicle manufacturers Toyota and Nissan are examples where the vehicle maker has extensive intellectual property in lithium-ion battery design, rivalling that of any so-called battery manufacturer. However, the need to “play it safe” with lithium-ion battery suppliers, where large batteries are concerned, is underlined by the fact that there is now a steady stream of bankruptcies of smaller ones that cannot get down the experience curve to achieve consistently superlative quality, consistency of performance and cost. Then there is the fact that accelerated life tests and other laboratory assessments of prototypes have limited lessons for how volume-produced lithium-ion batteries will behave or vary.

One thing is certain, following a UPS plane crash landing earlier with its pilots dead from the toxic fumes from self-ignited lithium-ion batteries in its cargo, aviation regulators are now going to be extremely jumpy about such batteries. That is tough on the suppliers doing a good job, and that may possibly include GS Yuasa if the investigations prove the initial reports to be misguided.