Title: Containment of Fire and Explosions from Failing Li-Ion Batteries

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Today, lithium-ion batteries are everywhere and power a myriad of devices, including critical aircraft components. As exemplified by the 2013 grounding of the Boeing 787 fleet, both dormant and operational hazards associated with heat, fire, release of toxic materials and pressurized explosions are major concerns when lithium-ion based energy storage systems are installed onboard aircraft. Safe packaging of these devices has lagged and energetic incidents have taken place, highlighting the need for better tools to manage and control a possible uncontrolled release of stored energy. ADA Technologies has developed and tested a rugged yet light ultra-safe enclosure designed to withstand fire and explosion risks associated with large-format lithium-ion batteries onboard US Navy ships. The enclosure combines the properties of several low-cost, lightweight and off-the-shelf materials in a laminate structure in a design capable to channel and contain released energy and protect nearby equipment and personnel. Further improving the safety of the enclosure and the surroundings is the inclusion of a pressure relief vent.

A key safety feature of the enclosure is its pressure relief mechanism. Because lithium ion battery can explode and ignite, it was necessary to characterize a notional worst case scenario, in particular in terms of overpressure and explosion strength. Battery fires have been extensively studied by several outfits including the FAA Technical Center, Sandia National Laboratories, Exponent, FM Global and others. However, little if any pressure data has been published. ADA Technologies made measurements in two explosion vessels of different volumes (10.5 gal and 1.9 gal) to demonstrate that the worst case explosion would develop in a sealed container or enclosure with a low packing factor. The high free volume inside the volume would provide a large quantity of oxygen for stoichiometric fuel/air mixtures, which upon ignition, could prove devastating. The design study resulted in the key conclusion that highly packed enclosures are desirable to limit oxygen availability and mitigate the risk of severe explosions should the battery pack malfunction and fail. Unique pressure data was acquired in this development project and informed the design of the pressure relief vent.

A lightweight 600 mm x 600 mm x 700 mm enclosure was built and abused tested under various scenarios to demonstrated its suitability to house high-energy and power density devices. Larger enclosures based on the same technology are being built in 2016 and will provide complete safety to large-format lithium-ion battery marine packs onboard Navy ships.