Future Technology – Thermal Management Systems for Li-Ion Batteries

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Abstract

As we write (February 2013) the worldwide fleet of Boeing 787 Dreamliners has been grounded for 3 weeks and new deliveries are at risk of being delayed. Deborah Hershman (chairperson of the United States National Transportation Safety Board) has stated that that manner in which risks associated with the on-board Lithium-Ion (Li-Ion) batteries must be reconsidered. But what triggered this situation (a series of incidents including the fire in the Japan Airlines 787 at Boston Airport and the emergency landing of an All Nippon Airlines 787 outside Tokyo airport) is not new and nor is it entirely unexpected. The FAA has listed 132 previous aircraft incidents between 1991 and 2012 that involved “smoke, fire, extreme heat or explosion” in which battery powered devices were implicated. 86 of these were associated with cargo shipments and 21 involved small batteries in devices such as phones and laptop computers brought on board by passengers or crew. 62 of these incidents involved Li-Ion batteries. There are also well documented incidents of battery fires in electric and hybrid cars.

Process safety engineers are very well aware that, during scale-up, hazards (potential for harm) generally remain unchanged whereas risks (likelihood and consequences) become much greater. Not all battery manufacturers have fully appreciated this principle.

All batteries are carefully designed reactor systems: rechargeable batteries involve cyclic processes that are both endothermic and exothermic. Demand for batteries that are small, light, have a high power density and can supply power flexibly over a wide range of conditions mean that thermal management systems also have to be part of good battery design. Years of very serious exothermic runaway reaction incidents in the chemical industries, many involving fatalities, have led to widely adopted tactics and principles for assessing thermal hazards under both design and “worst-case” conditions. These are usually based on isothermal calorimetry (at the intended temperature) and adiabatic calorimetry (to simulated total absence, or loss of, cooling). Identical procedures (but using different equipment) can be used to define the thermal management system that must be an integral part of a large rechargeable battery system. In this paper we describe a Battery Testing Calorimeter (BTC) that can be operated safely, easily and flexibly to carry out tests on complete batteries and their components over a wide range of conditions. Typical tests and results on Li-Ion batteries will be presented: these include thermal runaways leading to explosion.