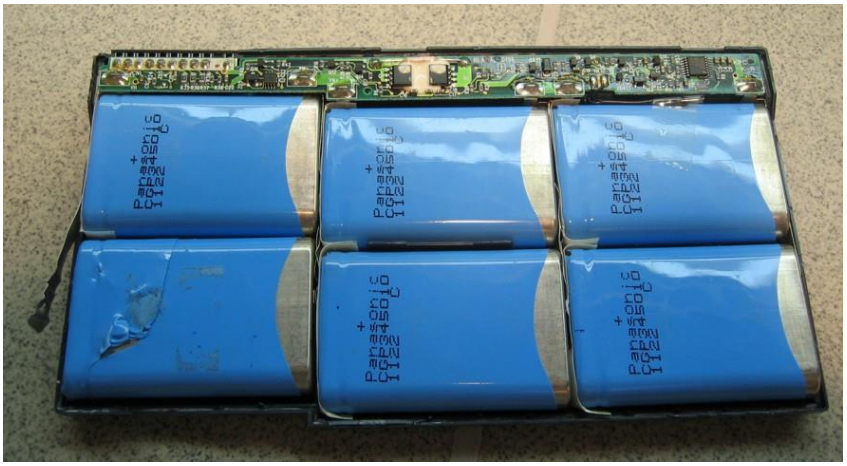
STAR 017 V5 – March 2016	**Lithium-ion Batteries**

Introduction

Not to be confused with **Lithium Batteries**, a **Lithium-ion Battery** (sometimes referred to as **Li-ion battery** or **LIB**) is a member of a family of rechargeable battery types which are common in consumer electronics including Portable Electronic Devices (PEDs). To elaborate, laptop computer batteries usually contain between six and nine Lithium-ion cells (see photo below).

Beyond consumer electronics, LIBs are increasing as a common replacement for lead acid batteries and can also be found in military, electric vehicle and aircraft components. For example, Lithium-ion batteries are used to provide power to the Emergency Locator Transmitters (ELT) in the Boeing 787 'Dreamliner'.

Lithium-ion batteries can be dangerous under certain conditions and can pose a safety hazard since they contain, unlike other rechargeable batteries, a flammable electrolyte and are also kept pressurized. If overheated (when the internal temperature reaches 350°F) or overcharged, the batteries may suffer what is called *thermal runaway.* This describes a process which is accelerated by increased temperature, in turn releasing energy that further increases temperature. The cell will overpressure causing the release of flammable liquid electrolyte and in extreme cases leads to the cell catching fire and exploding. Adjacent cells may then overheat and fail, possibly causing the entire battery to rupture or ignite. In the event of a fire, the device may emit dense irritating smoke which results in a secondary problem of toxic fumes. There have been reports of exploding mobile telephones, and in 2006 batteries from several mobile and notebook manufacturers were recalled because of fire and explosions.



Above: Example of a laptop battery containing Lithium-ion cells

Background

In recent years there have been some high-profile reported incidents involving fires onboard aircraft as a result of Lithium-ion Batteries self-combusting. In 2010 a Boeing 747-400 cargo flight operated by United Parcel Services (UPS) developed an in-flight fire. The fumes from the fire contaminated the cockpit and resulted in the aircraft crashing with the loss of both flight crew members. When the report of the crash was released in September 2013, the finding was that "with reasonable certainty"

the fire originated in a cargo container which held thousands of lithium-ion batteries.

There were several reported incidents during 2013 involving the Boeing 787 'Dreamliner'. On 7 January an Auxiliary Power Unit (APU) battery overheated and started a fire in an empty 787 operated by Japan Airlines (JAL) at Boston Logan International Airport (see photo below). This was followed two days later by United Airlines reporting a problem in one of its 787s with the same location as the battery fire on the JAL aircraft. On 16 January an All Nippon Airways (ANA) 787 made an emergency landing at Takamatsu Airport on Shikoku Island after the flight crew received a computer warning that there was smoke inside one of the electrical compartments. ANA stated that there was an error message in the cockpit citing a battery malfunction.

And in July 2013 a fire onboard an empty 787 operated by Ethiopian Airlines parked at Heathrow was identified as being linked to the lithium-ion battery in the Emergency Locator Transmitter (ELT).

Above: Photo of the burned APU battery unit from JAL Boeing 787

Lessons Learned

Extinguishing a Lithium-ion Battery fire is dangerous as lithium burns violently. When tackling such a fire the objective must be to not only extinguish the flames but also cool the battery pack, thus preventing additional cells from reaching Thermal Runaway. The preferred method for cooling the battery pack is to immerse the device in water (if possible).

There may be several alternatives on board an aircraft for extinguishing such a fire. These will usually include a Water Extinguisher, a Halon 1211 Extinguisher plus water, juice, sodas and other **non-alcoholic** liquids available from the drink cart. It is important to try and avoid covering the fire with ice or other smothering substances, as this will only act as an insulator which will contain the heat and increase the potential for adjacent cells to ignite.

For additional reference the U.S. Federal Aviation Administration (FAA) produced a short guidance video demonstrating the use of various extinguishing methods when dealing with a laptop fire on board an aircraft. The video is available to view on Youtube via the following link: http://www.youtube.com/watch?v=vS6KA_Si-m8

Personal Transportation Devices (Hoverboards)

In January 2016 IATA Cargo issued a notice in response to questions raised by operators regarding the acceptability of small vehicles powered by lithium-ion batteries (e.g. Hoverboards), in passenger

checked and/or carry-on baggage. Not to be mistaken with 'mobility aids', Personal Transportation Devices have greatly increased in demand and are now mass-produced, with in certain cases questionable quality control. As a result there is not only the risk that the lithium batteries pose, but also due to poor manufacture the devices have been reported to overheat, catch fire, or in extreme cases even explode.

The allowance for passengers or crew to have PED in their checked or carry-on baggage is determined by the capacity (Wh: Watt-hour rating) of the lithium-ion battery as follows:

- Where the lithium-ion battery does not exceed 100Wh passengers and crew may have these devices in either checked or carry-on baggage.
- Where the lithium-ion battery exceeds 100Wh but does not exceed 160Wh, passengers and crew may have these devices in either checked or carry-on baggage, although operator prior approval is required, and
- Where the lithium-ion battery exceeds 160Wh the device is forbidden from being in either passenger or crew checked or carry-on baggage.

The capacity of Personal Transportation Devices is normally in excess of 100Wh. However, poor manufacture and a lack of regulated testing have raised concerns that such devices could actually be in excess of 160Wh. EASA Safety Information Bulletin (SIB) 2016-04 dated 11 March 2016, alerts operators to this issue, in particular:

- Such devices should be carried in the cabin at all times, and not accepted as checked baggage.
- All staff handling such devices, and passengers, are made aware of the restrictions that apply.
- Such devices should be included within their dangerous goods related procedures, with an explicit mention in their manuals, and provide training.

If an operator is not sufficiently satisfied of the Watt-hour rating of a particular device, then as a precaution it should NOT be carried in either checked or carry-on baggage.

Recommendations for dealing with Lithium-ion Battery fires

- Do not attempt to pick up and move the object as there could be extreme danger of bodily harm.
- Isolate the object by relocate passengers away from the fire, thus allowing Cabin Crew to deal with the remaining effects of the emergency more effectively.
- If a water extinguisher is available this should be used as the primary method for tackling the fire. The water not only extinguishes the fire but also cools the battery pack thus preventing additional cells from reaching Thermal Runaway.
- Use of a Halon 1211 Extinguisher **should be followed** by an available water source. Halon 1211 will extinguish the fire plus prevent the spread to adjacent flammable materials, whilst the water cools the battery pack.
- Extinguishing the fire using a Halon 1211 Extinguisher will **not** prevent additional battery cells reaching Thermal Runaway.
- Avoid covering the fire with ice or other smothering substances.
- There are now fire containment cases available that are designed to protect people and property from Lithium-ion battery fires and smoke that can occur with PEDs. However, it must be noted that single Cabin Crew operations may have difficulty using this solution. Also certain articles would need to be in place for this to work effectively, such as protective clothing from fumes and heat for the Cabin Crew members, plus the appropriate training. It also must be noted that moving the object goes against current advice. Please follow the attached link for

further information: http://www.highwaterinnovations.com/products/planegard

Further guidance and information can be obtained via the following sources:

- http://www.ifalpa.org/downloads/Level1/IFALPA%20Statements/Dangerous%20Goods%20Committee/15POS25%20-%20Lithium%20Battery%20Fire%20Awareness.pdf
- https://www.youtube.com/user/UKCAA.
- http://ad.easa.europa.eu/ad/2009-22
- http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safo/all_safos/media/2009/safo09013.pdf;
- http://www.iata.org/publications/tracker/mar-2014/Pages/lithium-battery.aspx;
- http://flightsafety.org/files/RAESSFF.pdf
- http://aerosociety.com/Assets/Docs/Publications/SpecialistPapers/SAFITA%20Part%202_Training_1st%20Edition.pdf
- http://flightsafety.org/aerosafety-world-magazine/apr-2013/lithium-ion-batteries
- http://flightsafety.org/download_file_iframe.php?filepath=/asw/mar08/asw_mar08_p42-47.pdf
- http://www.skybrary.aero/bookshelf/books/2078.pdf
- Boeing Aeromagazine Q4 2013