Lithium Batteries – A Growing Threat

What are YOU going to do?

Wednesday, November 2, 2016 | 2:00 p.m. – 3:00 p.m.

PRESENTED BY:
John M. Cox – Safety Operating Systems
Lithium Battery Thermal Runaway
FAA Office of Security and Hazardous Materials Safety

• As of September 15, 2016, 129 air/airport incidents involving lithium batteries carried as cargo or baggage that have been recorded since March 20, 1991

• 22 (17%) in 2016 (4%)
FAA Office of Security and Hazardous Materials Safety

• Passenger's cell phone battery exploded in flight. Fire extinguished by crew.

• 7/6/2016
FAA Office of Security and Hazardous Materials Safety

- A rechargeable battery of a smartphone in a carry-on baggage located under the seat of a passenger of flight Skymark SKY/BC732 from New Chitose to Tokyo/Haneda, operated by a Boeing 737-86N, ignited and smoked just after take-off at 00:19 JST. The fire was immediately extinguished by the cabin crew. Two crew members suffered minor burn on their right arm or left hand fingers.

- 8/22/2016
September 23, 2016
Samsung Galaxy Note 2
September 25, 2016
Surface Tablet
October 5, 2016

Replacement Samsung Galaxy Note
How Hot Does It Get?
Unpredictable
Explosion from Tablet Battery
FAA Testing

Full Scale Battery Tests

- Mixed Cells
- Lithium-ion
- Lithium metal

Presented to: ICAO Dangerous Goods Panel
By: Harry Webster, FAA Fire Safety Br.
Date: October 31, 2013
FAA Testing

Capable of thermal runaway, through cell defect, cell damage, heat, rapid discharge, overcharging
– Thermal runaway results in high case temperatures, exceeding 1100 DegF
– Releases flammable electrolyte
– Generates sufficient heat to cause adjacent cells to go into thermal runaway
Airflow patterns within the aircraft can have significant impact on the behavior of the battery fire and smoke penetration.
Smoke In The Airplane
Passenger Smoke Hoods?

Without containment
This may be necessary

Visionsafe founder Bert Werjefelt designed the first smoke hood
Smoke Can Be A Major Concern
Tests have shown that even with a very high ventilation rate (1 air exchange/minute), a typical COTS Li-Ion battery could pose a significant hazard within the flight deck environment and could potentially present a catastrophic risk.
FAA 727 Flight Deck Fire –
How are you going to fly?

This is with an oxygen mask and goggles
How Are You Going To See?
UPS 006 CVR
The crew is wearing oxygen mask and goggles

15:17:19 (ATC) - Captain informed ATC that cockpit was full of smoke
15:17:39|RDO-CAPT: UPS six we are full,- the cockpit is full of smoke attempting to turn to flight to one thirty please have (men and equipment) standing by in Dubai.

15:17:38 CAPT - Comment about inability to see intra-cockpit
15:17:39|CVR|CAPT: Can you see anything?
15:17:40|CVR|F.O: No, I can't see anything.
The F.O. mentions on several occasions difficulty inputting the data based on the reduced visibility. However, the ILS was tuned to a frequency of 110.1 (The ILS frequency for DXB Runway 12L is 110.1)

15:18:00 | CVR|CAPT: Try and get Dubai in the flight management computer.
15:18:02 | CVR|F.O: I can’t see it [the FMC]
15:19:04 | CVR|BAE-C: UPS six expect one two left proceed direct to ah final of your discretion

• 15:19:08 | CVR|CAPT: Alright we're doing our best. Give me a heading if you can I can't see.
UPS 006 CVR

15:20:02 | CVR|CAPT: I got no oxygen I can't breathe.
15:20:12 | CVR|CAPT: Get me oxygen.
15:20:19 | CVR|F.O: I don't know where to get it.
15:20:23 | CVR|CAPT: You fly

15:20:41 | CVR|CAPT: I can’t see
The crew advised relay aircraft that they would stay on the Bahrain frequency as they could not see the ACP to change frequency.

15:21:24|PF: Sir we're gonna have to stay with you we cannot see the radios
15:25:42 | CVR|PF: I would like immediate vectors to the nearest airport I'm gonna need radar guidance I cannot see
15:33:01 | CVR|PF:sir we are flying blind, I have no visual my indicator says ten thousand feet, I cannot see out the window, we're gonna have to work together on this one, I’d like to descent to nine thousand feet.
The visibility should be sufficient to view the attitude indicator or primary flight display and to see outside the aircraft for landing. In addition, it is imperative that the crew be able to view the instruments to navigate and they must be able see to program the flight management computer and the audio control panels.

The checklist must be visible so that procedures can be followed to prepare for landing and manage the smoke/fire/fumes problem. Adequate visibility on the flight deck should be maintained during a smoke/fire/fume event.
UPS 006 Report
Industry Actions

- UPS installed EVAS throughout their entire fleet
- Other airlines have installed EVAS
- FAA installed EVAS throughout their entire fleet
- Many VVIP and VIP operators have installed EVAS
Continuous Smoke Accidents

- Federal Express 1406
- Swiss Air 111
- Air Tran 913
- UPS 006
- Asiana 991
- UPS 1307
AC 25-9A

• “Although the FAR does not require the consideration of continuous smoke generation/evacuation, the FAA recommends that the airframe design address this situation. Accordingly, paragraphs 12a (1) and 12e (3) recommend addressing continuous smoke generation/evacuation in the cockpit.”
Gulfstream 650 Meets The Recommendation

• The G-650 meets the FAA recommendation in AC 25-9A using EVAS

• No other manufacturer has met this recommendation
SMOKE, FIRE AND FUMES IN TRANSPORT AIRCRAFT
PAST HISTORY, CURRENT RISK AND RECOMMENDED MITIGATIONS

Second Edition 2013
Part 1: Reference

www.aerosociety.com
Royal Aeronautical Society Recommendations

• Revise AC 25-9A

• Smoke evacuation test should be conducted with smoke generated continuously

Source: SAFITA 2015
Royal Aeronautical Society Recommendations

• Vision assurance technology should be implemented to improve pilot visibility during continuous smoke in the flight deck

• Visibility in the flight deck should be good enough to see the attitude indicator or primary flight display and to see outside the aeroplane for landing

Source: SAFITA 2015
SAFITA 2014 and 2015

- One of the largest trends in the growth of in-flight fire is due to the transportation of lithium batteries
- Grey market batteries and chargers are a risk
- Thermal containment technology is available and should be considered for carriage in the cabin by all operators.
Test of Vapor Flammability
Current FAA Guidance

• WARNING: Do not use fire resistant burn bags to isolate burning lithium-type batteries.

• Transferring a burning appliance into a burn bag may be extremely hazardous. Do not move the device until you are certain the fire is extinguished and the device is cool.
Bag Limitations
Bag Limitations
SAFO 16001

FAA testing has shown that a single lithium battery (cell), whether metal or ion, in thermal runaway will spread to the neighboring batteries in the package and to adjacent packages. Thermal runaway is initiated by an internal short within the battery that may be caused by a manufacturing contaminant, battery damage during handling or from heat produced in the environment, such as by an adjacent fire.
Lithium Battery Demand

2000-2025 LIB market, M cells, by form factor (3C)

(1) Source: Takeshita, Battery Japan 2013 BJ-3 conference – Slide p 4
Different Types

Types of Lithium batteries

Lithium-metal batteries
- Usually, non rechargeable batteries used in watches, calculators, cameras...
- Cells contains lithium metal (highly reactive)

Lithium-ion / Lithium-polymer batteries
- Usually rechargeable batteries used in mobile phones, laptops, cars, cordless devices, ...
- Cells contains ionic lithium

Technology

Lithium-metal batteries
- Capable of self-ignition (thermal runaway)
- May worsen an independent controllable fire event
- Violent release of a flammable electrolyte mixed with molten lithium metal (large pressure pulse)

Lithium-ion / Lithium-polymer batteries
- Capable of self-ignition (thermal runaway)
- May worsen an independent controllable fire event
- Generation of heat and pressure, resulting (for Li-ion only) in a spray of flammable electrolyte

Associated Risk

Lithium-metal batteries
- Halon 1301 or water are not effective at extinguishing a lithium metal cell fire

Lithium-ion / Lithium-polymer batteries
- Halon 1301 is effective in controlling the open flame and the spread of the fire to adjacent materials
- Halon 1301 is not effective, but Water is effective at stopping the propagation of thermal runaway within the shipment

Fire fighting
Reconsider the FAA Guidance

• If the firefighter is protected is the FAA guidance appropriate?
• If the threat can be contained is the FAA guidance appropriate?
• If the threat can contained will it stop the panic?
Reconsider the FAA Guidance

• Is the recommendation not to move an overheating PED the best choice?
• What about in the flight deck?
• What about water into the IFE or other electronics?
Lithium Battery Overheating Flight Crew Guidance

When faced with a lithium battery powered Personal Electronic Device (PED) in which at least one cell has gone into thermal runaway, flight and cabin crews should first ensure all other personnel are moved away from the device to the maximum extent possible. If flames are present, they should be extinguished using the nearest fire extinguisher. After the fire is extinguished, the firefighting crewmember, with adequate personal protection, should pour water or other non-flammable liquid on to the PED to cool the device, reducing the likelihood of additional cells from thermal runaway. The device should not be covered with ice; tests show that ice increases the likelihood of additional thermal runaway.

A smoking or burning PED should not be moved to another part of an aircraft or for placement in a ‘burn-bag’ or other device unless adequate protection of the firefighting crewmember is assured and moving the device is the safest action in the professional judgment of the crew. Moving the device can coincide with the venting of a cell, or cells, causing the risk of serious injury to nearby persons, including the crewmember. Adequate protection includes, but is not limited to, heat resistant gloves, eye protection, and a means of shielding the crewmember from the device.

If in the judgment of the flight-crew moving the device is safer than attempting to cool the device in place, or if the device is inaccessible, use of personal protective equipment should be used to move the device to a location where it can be contained and cooled. If a containment device is required, the containment device should be placed as close as practical to the overheating PED. Containment technology should be considered for a safe place in which the device can be stored during and after a thermal runaway event.

If adequate protection is not available: After dousing the device with water and monitoring it for no additional thermal runaway for a minimum of fifteen minutes should the overheating device be moved and contained.

If the device is located in the cockpit, after the flight crew have donned oxygen masks and smoke goggles, the pilot-in-command must determine the advisability of moving a burning or smoking PED to a less-critical area of the aircraft to avoid damage from both the fire and fire-fighting activities. In general, moving the device should only be attempted when proper personal protective equipment is in place. A diversion to the nearest suitable airport or landing area should be considered unless the device is safely contained and clearly presents no additional threat.
Crew Training

What is wrong with this picture?

No cooling
None of these training scenarios are appropriate for a lithium battery fire.
Realistic, specific training for lithium battery fires
Mitigations

• Improve guidance to flight crew members
• Improve training of flight crew members
• Install Vision Assurance Technology
• Install Containment Technology that fully contains the PED and vapor