Lithium Batteries
A Rising Risk In Aviation

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Safety Operating Systems
As of January 24, 2018, 191 air/airport incidents involving lithium batteries carried in cargo or baggage have been recorded since March 20, 1991. 

Note: These are recent cargo and baggage incidents that the FAA is aware of. This should not be considered as a complete listing of all such incidents. The incident summaries included here are intended to be brief and only reflect what the FAA has collected, not all investigative or enforcement actions taken. This list does not include three major aircraft accidents where lithium battery fires were highly visible but not proven to be the source of the fire: an Asiana Airlines 747 near South Korea on July 28, 2011, a UPS 747 in Dubai, UAE on September 3, 2010, and a UPS DC-8 in Philadelphia, PA on February 7, 2006.

32 were in 2016

46 were in 2017

A 44% Increase
As of December 15, 2018, 238 air/airport incidents involving lithium batteries carried in cargo or baggage have been recorded since March 20, 1991.

Note: These are recent cargo and baggage incidents that the FAA is aware of. This should not be considered as a complete listing of all such incidents. The incident summaries included here are intended to be brief and objective. They do not represent all information the FAA has collected, nor all investigative or enforcement actions taken. This list does not include three major aircraft accidents where lithium battery cargo shipments were implicated but not proven to be the source of the fire: An Asiana Airlines 747 near South Korea on July 28, 2011, a UPS 747 in Dubai, UAE on September 3, 2010 and a UPS DC-8 in Philadelphia, PA on February 7, 2006.
Japan Fires

• Tokyo, Jan. 24 (Jiji Press)--The number of cases in which laptops, smartphones and other devices with lithium-ion batteries became hot or ignited in the five years until fiscal 2017 came to 582, a survey by the National Institute of Technology and Evaluation showed Thursday.

• While the number of such incidents totaled 70 in fiscal 2013, the figure jumped to 175 in fiscal 2017.
December 23, 2018

China Southern A-321
WestJet forced to divert to Calgary due to this fire
A Royal Brunei Airlines Airbus A320-200N, registration V8-RBD performing flight BI-636 from Hong Kong (China) to Bandar Seri Begawan (Brunei), was enroute when a passenger's powerbank suffered a thermal runaway and emitted smoke. Flight attendants discharged a fire extinguisher onto the battery and put it into a secure container. The flight crew continued the flight to destination for a safe landing.
Changing Risk Profile

• Proliferation of lithium batteries
• Single Aisle jet with 140 passengers
  – Assume each has 4 lithium batteries
    • Watches, laptop computer, iPad or tablet, smart phone, games player, DVD player or recorder machine, CPAC, flashlight, camera or numerous other electronic devices
• 560 lithium batteries on board
• On a A380 or 747-8 over 1,000 possible
The Additional Risk Of Panic

- Suicide Bomb Scare At Chancery Lane Tube Station As Passenger's Laptop Overheats And Gives Off Smoke

- The Huffington Post UK | By Jack Sommers
- Posted: 19/06/2014 11:40 BST

- Dozens of commuters fled a busy Tube station in panic fearing a suicide bomber this morning after a passenger's laptop overheated, causing sparks and smoke to pour out of its owner's bag.

- Passengers screamed and ran out of Chancery Lane station in central London while others were in tears following the security scare at 9.30am.
Thermal Runaway in a Lithium-Ion Battery

1. Heating starts.
2. Protective layer breaks down.
3. Electrolyte breaks down into flammable gases.
4. Separator melts, possibly causing a short circuit.
5. Cathode breaks down, generating oxygen.

ANODE (CARBON)

PROTECTIVE LAYER

ELECTROLYTE
(lithium salt in organic solvent)

SEPARATOR

CATHODE (LITHIUM METAL OXIDE)
Causes of Thermal runaway

External Abuse Conditions
- External Heating
- Over-Charging
- Over-Discharging
- High Current Charging
- Structural damage
- Crush
- External Short

Causing or Energizing Internal Events or Exothermic Reactions
- Electrode-Electrolyte Reactions
- Lithium Plating
- Decompositions
- Internal Short Circuit
- Electrochemical Reaction

If Heating-Rate exceeds Dissipation-Rate
- Leak
- Smoke
- Gas Venting
- Flames

Main contributing factors
- Poor design
- Poor integration
- Poor safety monitoring/protection
- Poor manufacturing quality
- Poor handling/ storage/packing conditions
Demand

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

(1) Source: Takeshita, Battery Japan 2013 BJ-3 conference – Slide p 4
iPad vs. Seat
March 19, 2016

Thermal runaway on Alaska Airlines flight
Explosion from Tablet Battery
What A Li-Ion Fire Can Do
Flight Deck Fires
Class E Lithium Metal Video
Advisory Circular

Subject: In-Flight Fires
Date: 12/22/14
AC No: 120-80A
Initiated by: AFS-200
Change:

1. PURPOSE. This advisory circular (AC) updates information regarding the hazards and risks of in-flight fires on transport category aircraft. The information includes recommended crewmember procedures and training for combating in-flight fires. The National Transportation Safety Board (NTSB) issued Safety Recommendations A-11-87 through A-11-91 during the investigation of United Parcel Service (UPS) flight 6 accident on September 3, 2010 in the United Arab Emirates. The flightcrew encountered a “Fire Main Deck” master warning about 22 minutes into the flight; they declared an emergency and initiated a return to Dubai International Airport (DXB). The aircraft crashed inside an Emirates army post 9 miles from DXB, and both flightcrew members were fatally injured. NTSB findings revealed safety issues related to the training and use of oxygen mask; communicating with oxygen masks donned, and oxygen mask stowage and the smoke, fire, or fumes checklists. This revision to AC 120-80 is in response to NTSB recommendations A-11-88 through A-11-90. Specifically, this AC:

- Is applicable to operators certificated under Title 14 of the Code of Federal Regulations (14 CFR) parts 91K, 121, 125, and 135.
- Discusses the importance of flightcrew member initial and recurrent hands-on training, including the use of operable oxygen mask/goggles sets, the use of the regulator’s emergency selector, and the venting of smoke goggles.
- Discusses the importance of flightcrew member initial and recurrent hands-on training, including aircraft-specific training on establishing and maintaining internal cockpit communications when the flightcrew members don the oxygen masks.
- Emphasizes the importance of flightcrew members stowing their oxygen masks set to 100 percent.
- Provides guidance for operators’ smoke, fire, or fumes checklists to include, as the first step, that flightcrew members don their oxygen masks and verify that the regulator is set to 100 percent.
- Provides guidance to operators on addressing, through procedures and training, the unique characteristics of lithium battery fires.
- Discusses the dangers of in-flight fires, with particular emphasis on hidden fires that may not be visible or easily accessed by the flight or cabin crew. It discusses the importance of recognizing and quickly assessing the conditions that may be associated with hidden fires and the importance of taking immediate action to gain access to fires that are located behind interior panels.
SAFO

U.S. Department of Transportation
Federal Aviation Administration

http://www.faa.gov/other_visit/aviation_industry/airline_operators/airline_safety/safe

A SAFO contains important safety information and may include recommended actions. SAFO covers should be especially valuable to air carriers in meeting their statutory duty to provide service with the highest possible degree of safety in the public interest. Readers are encouraged to refer to the specific action recommended in a SAFO, an alternative action may be as effective in addressing the safety issue named in the SAFO.

Subject: Fighting Fires Caused By Lithium Type Batteries in Portable Electronic Devices

Purpose: To recommend procedures for fighting fires caused by lithium type batteries in portable electronic devices (PED).

Background: The two types of batteries commonly used to power consumer PEDs brought on aircraft are lithium batteries (rechargeable) and lithium-ion batteries (rechargeable). Both types are capable of ignition and subsequent explosion due to overheating. Overheating results in thermal runaway, which can cause the release of either molten lithium or a flammable electrolyte. Once one cell in a battery pack goes into thermal runaway, it produces enough heat to cause adjacent cells to go into thermal runaway. The resulting fire can form rapidly as each cell ruptures and releases its contents.

Discussion: Based on testing by the Fire Safety Branch of the Federal Aviation Administration (FAA) William J. Hughes Tactcal Center, the following procedures are recommended for fighting a fire of a lithium-type-battery powered PED. The procedures consist of two phases: (1) extinguishing the fire, and (2) cooling the remaining cells to stop thermal runaway.

1. Utilize a Halon, Halon replacement or water extinguisher to extinguish the fire and prevent its spread to additional flammable materials.

2. After extinguishing the fire, douse the device with water or other non-alcoholic liquid to cool the device and prevent additional battery cells from reaching thermal runaway.

WARNING: Do not attempt to pick up and move a smoking or burning device! Bodily injury may result.

WARNING: Do not cover the device or use ice to cool the device. Ice or other materials insulate the device, increasing the likelihood that additional battery cells will reach thermal runaway.

Reference Materials: The following are additional information related to lithium-type battery fires:

Additional information on lithium-type battery fires may be found by clicking on this link: SAFO 990135 UP vendors

The FAA has developed a training video to demonstrate effective techniques for fighting lithium-type battery fires. See the Video on Laptop Battery Fires at http://www.faa.gov/aviation/aviation_safety/subspecialties/lithium-battery-blowup/

Recommended Actions: Directors of safety, directors of operations, training managers, and crewmembers should collaborate to include these procedures in the operator’s manuals, operations, and training.

Approved by: AFSA-200

OPR: AFSA-220
The following information expands upon SAFO 09013.

Safety Alerts for Operators (SAFO) are posted at:

http://www.faa.gov/airports/aviation_industry/airline_operators/safety/safos/
Bags
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.
Advisory Circular

Subject: Hand Fire Extinguishers for use in Aircraft

This advisory circular (AC) gives you guidance for the fire-fighting effectiveness, selection and safe-use of hand fire extinguishers in airplanes and helicopters. It also tells you how to gain Federal Aviation Administration (FAA) approval of hand fire extinguishers for airplanes.

Sincerely,

David W. Termpe
Manager, Aircraft Engineering Division
Aircraft Certification Service

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AC 20-42D

((1)
Crew members should be trained not to use fire resistant burn bags to isolate burning Lithium batteries. Transferring a burning appliance into a burn bag may be extremely hazardous.)
Airbus A350 Checklist

**SMOKE / FIRE FROM LITHIUM BATTERY**

If necessary, transfer control to the flight crewmember seated on the opposite side of the fire.

CKPT / CABIN COM.................................. ESTABLISH STORAGE AFTER Li BAT FIRE cabin procedure........

...................................................... REQUEST INITIATION

- **If flames:**
  - CREW OXY MASK (PF).......................... USE
  - PBE (PM)........................................ USE
  - HALON EXTINGUISHER (PM).................. USE

- **If no flames or when flames extinguished:**
  - **If not possible to remove device from cockpit:**
    - WATER or NON-ALKOHOLIC LIQUID........
      - .................................................................. POUR ON DEVICE
      - .................................................................. MONITOR
  - **If possible to remove device from cockpit:**
    - DEVICE........................................ TRANSFER TO CABIN
Airbus A-320 Checklist

SMOKE / FIRE FROM LITHIUM BATTERY

If necessary, transfer control to the flight crewmember seated on the opposite side of the fire.

CKPT / CAB COM ........................................ ESTABLISH STORAGE AFTER Li BAT FIRE cabin procedure.........
............................................................................................ REQUEST INITIATION

● If flames:
  CREW OXY MASK (PF) ................................ USE
  SMOKE HOOD (PM) ........................................ USE
  HALON EXTINGUISHER ................................. USE

● If no flames or when flames extinguished:
  □ If not possible to remove device from cockpit:
    WATER or NON-ALCOHOLIC LIQUID ..............
    ................................................................ POUR ON DEVICE
    DEVICE .................................................. MONITOR
  □ If possible to remove device from cockpit:
    DEVICE ........................................ TRANSFER TO CABIN

● At ANY TIME of the procedure, if SMOKE becomes the GREATEST THREAT:
  REMOVAL OF SMOKE / FUMES procedure ........
  ....................................................................... CONSIDER

Refer to ABN-27 Removal of Smoke / Fumes

● At ANY TIME of the procedure, if situation becomes UNMANAGEABLE:
  IMMEDIATE LANDING ................................... CONSIDER
Billing Code: 4910-60-P

DEPARTMENT OF TRANSPORTATION

Pipeline and Hazardous Materials Safety Administration

49 CFR Parts 172 and 173

[Docket No. PHMSA-2016-0014 (HM-224l)]

RIN 2137-AF20

Issued February 27 2019


Transported by Aircraft (FAA Reauthorization Act of 2018)

AGENCY: Pipeline and Hazardous Materials Safety Administration (PHMSA), DOT.

ACTION: Interim final rule (IFR).

SUMMARY: PHMSA issues this interim final rule (IFR) to revise the Hazardous Materials Regulations for lithium cells and batteries transported by aircraft. This IFR (1) prohibits the transport of lithium ion cells and batteries as cargo on passenger aircraft; (2) requires lithium ion cells and batteries to be shipped at not more than a 30 percent state of charge aboard cargo-only aircraft when not packed with or contained in equipment; and (3) limits the use of alternative provisions for small lithium cell or battery shipments to one package per consignment. This IFR does not restrict passengers or crew members from bringing personal items or electronic devices containing lithium cells or batteries aboard aircraft, or restrict cargo-only aircraft from transporting lithium ion cells or batteries at a state of charge exceeding 30 percent when packed with or contained in equipment or devices.

Due to the FAA Reauthorization Act of 2018 requiring this rulemaking to be effective within 90 days of enactment of the statute, PHMSA finds that good cause exists
This IFR **does not** restrict passengers or crew members from bringing personal items or electronic devices containing Lithium cells or batteries aboard aircraft, or restrict cargo-only aircraft from transporting lithium ion cells or batteries at a state of charge exceeding 30 percent when packed with or contained in equipment or devices.
Subject: Risk Associated with the Use of Fire Containment Products by Title 14 of the Code of Federal Regulations (14 CFR) Part 91 subpart K (91K), 121, 125 and 135 Operators

Purpose: This INFO serves to clarify Federal Aviation Administration (FAA) policy on the use of fire containment products such as fire containment kits/bags and acceptable firefighting and containment procedures for inflight fires involving portable electronic devices (PED).

Background: A number of manufacturers are marketing fire containment products (kits/bags) that may consist of: a containment bag, sleeve or a containment box with or without additional tools such as fire gloves, a pry bar, and face protection/shield. Manufacturers have stated in their advertisement and marketing videos that their products are: “FAA certified,” “successfully tested by the FAA” or “meets FAA standards.” However, the Fire Safety Branch of the FAA William J. Hughes Technical Center and the Aircraft Certification Service emphasize that there are no FAA test standards for these containment products, nor is there a mechanism in place for the approval of these products.

Discussion: The FAA Flight Standards Service, in coordination with the Fire Safety Branch of the FAA William J. Hughes Technical Center and the Aircraft Certification Service, has examined FAA recommended procedures for inflight firefighting, as well as procedures associated with various containment kits/bags on the market. Regardless of how effective any of these containment kits/bags are once the battery is placed in them, the highest risk may lie in the transfer of a burning or overheated battery to the containment kit/bag.

The FAA does not object to the use of these containment products provided the procedures stated in the referenced SAFO and Advisory Circulars are used. The FAA does not support any manufacturer procedure that suggests moving a burning, smoking or hot device.

The FAA continues to recommend the firefighting procedures suggested in Safety Alerts for Operators (SAFO) 09013, dated 6/23/09, “Fighting Fires Caused By Lithium Type Batteries in Portable Electronic Devices,” Advisory Circular (AC) 20-42D, “Hand Fire Extinguishers for Use in Aircraft;”, and AC 120-80A. “In-Flight Fires.” While some manufacturers of certain containment bags may recommend that a crewmember move a burning, smoking or hot device associated with a lithium battery, the FAA continues to recommend that a crewmember should not move any device that is burning, smoking or exhibiting any evidence of overheating until that device has been thoroughly cooled. A device that is burning, smoking or hot is inherently unstable and therefore unpredictable. Any movement in that
Miami Air

Used risk analysis in their SMS to implement and alternative extinguishing systems to the FAA guidance. FAA approved
Sky Regional

Used risk analysis in their SMS to replace bags with the latest technology
Let’s 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?
Let’s 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?
SAFITA 2014

• 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.
SAFITA 2018

• Regulators should update and improve the guidance provided to flight crews and operators on the most effective methods of fighting a lithium battery fire. This guidance should include reference to the need for adequate protection of the crewmember/firefighter and the recognition that many newer devices are water resistant or waterproof thereby reducing the current guidance of pouring water on the device.

• Provide adequate protective equipment for crewmember/firefighters to fight a lithium battery fire. Protective equipment should provide a shield or barrier between the lithium battery fire and the crewmember/firefighter.
SAFITA 2018

• **Alternative extinguishing agents** and procedures should be identified for use in in-flight fires involving lithium batteries due to the use of water as a cooling agent becoming less effective on newer, more water resistant, devices.

• National Aviation Authorities and ICAO should require that all shipped lithium batteries to be classified as hazardous cargo requiring fireproof (fire resistant) containers. Shipment of lithium metal batteries should be prohibited on passenger aeroplanes.
• By-products of combustion of all types of lithium batteries include oxygen, ether, and hydrogen, among others. The organic vapour produced is highly flammable and is an irritant to mucous membranes. The chemical composition of the vapour creates a hazard to anyone in proximity to an overheated lithium battery, including crewmembers attempting to fight the fire. Crewmember protection must be considered when developing procedures to address lithium battery fires. Crewmember incapacitation is a serious concern due to the potential of burns received from the hot contents of a venting battery and/or vapour ingestion.
Four Closings Points

• Guidance
  – Current FAA guidance is inadequate

• Training
  – More standardized training

• Capture/extinguish
  – Safe extinguishment
    • Protect the crewmember/firefighter
  – Safe containment
    • Protect the crewmember/firefighter

• Containment
  – Capable of withstanding re-ignition with little or no vapor escape
Questions?