

Enterprise Lithium Battery Action Plan

I. BACKGROUND:

PHMSA and FAA have identified more than 92 transport related incidents and numerous additional non-transport incidents involving batteries and battery-powered devices. We are particularly concerned that many of the incidents have occurred aboard aircraft and that these incidents appear to be on the rise. Both agencies will continue to monitor and assess battery incidents when we become aware of them. FAA and PHMSA have drafted a plan of action to reduce the risk associated with the transport of batteries on aircraft both by passengers (i.e. in checked and carry-on baggage) and as cargo. The primary focus of this plan is lithium batteries of all types. We understand that other types of batteries also pose a risk in transportation and that risk must be managed accordingly. The transportation risks associated with all battery types is being addressed through a measured multi-faceted safety approach including rulemaking, enforcement and outreach. Many of the actions identified in this plan overlap with efforts being undertaken to address battery safety as a whole. The consequences of incidents involving lithium batteries are a primary concern because these batteries typically react more violently and are more difficult to extinguish. We believe lithium batteries pose unique risks in transportation and require a specific focused effort.

It is estimated that 3.3 billion lithium cells and batteries will be transported worldwide in 2008. This represents an 83 % increase since 2005. The estimated failure rate of all lithium batteries is in the range 1 failure per 10 million batteries manufactured. This figure is even lower in transport environments. While DOT understands the safety record associated with the transportation of lithium batteries is very good, the result of a lithium battery incident in the air mode could have catastrophic consequences. How to manage such a low probability, high consequence risk poses a great challenge to DOT. There is no one clear solution because the causal factors are varied and risk reduction requires a multi-faceted approach with the participation of a broad range of participants. While we don't want to compromise the American way of life by restricting the use of battery powered equipment, we need to educate the public and key players in the transport environment to implement effective measures that can be taken to reduce risk.

Lithium battery technology is inherently complex and has several known risks. The ever increasing expansion of lithium battery use in portable electronic and industrial applications introduces additional risks and challenges. There is a general opinion among lithium battery manufacturers that the root cause of most lithium battery incidents is short circuiting. A short circuit can result in thermal runaway; a situation characterized by excessive heat, exothermic side reactions and combustion that begins at higher temperatures, accelerating the thermal runaway. This condition can sometimes lead to explosion of sealed cells and fire. A short circuit can be induced through many means such as contamination during the manufacturing process, a defective cell or battery, poor cell or battery design, improper charging/discharging conditions in the equipment and abuse by end users such as exposure of batteries or a device containing batteries to high temperature environments. Not all experts agree or can pin point the exact causes for the

incidents that have occurred and that we continue to experience in the consumer, workplace and transport sectors.

DOT recognizes the increasing demand for higher performing portable electronic devices requires smaller, more powerful batteries. This forces battery manufacturers to pack more active material into the limited volume of a battery case. Increased production of smaller, more powerful batteries creates a situation where batteries are more susceptible to an incident. The DOT must account for all of these factors to develop an effective means of managing lithium battery risks. Part of this effort involves working with the battery industry to develop safety standards that are in line with the rapid change in demand for higher power batteries and devices and developing effective practices to reduce risk.

Extensive discussion with members of the lithium battery industry revealed that cell and battery manufacturers, assemblers and original equipment manufacturers have provided DOT and others with a better understanding of the contributing factors related to the recent increase in battery incidents. The industry has expressed their willingness to provide DOT additional assistance and expertise regarding technology advances, battery and product design and manufacturing. However, they remain less certain about the conditions and the environment a battery or device is subjected to once they are in the hands of secondary shippers and end users. Proper packaging can be credited with the prevention of external short circuits and aids in the prevention of internal short circuiting. Risks associated with lithium batteries can be mitigated largely by the initiation of better packaging standards and the use of proper packaging for their transport.

Counterfeit batteries and cells also present a significant challenge because many are not produced to industry standards or existing regulatory requirements. While the safety record associated with the transportation of lithium batteries is very good, DOT continues to observe incidents in all modes of transport and is especially concerned about the risk of battery-related fires aboard aircraft. DOT believes that the design and manufacture of batteries must be made inherently safe taking into account abuses that end users may inflict on batteries and equipment. DOT and its enterprise partners must develop a practical plan to ensure public safety while not impeding technology advancement and meeting the need for transporting batteries by all modes of transportation. This plan recognizes that no single entity can address this complex issue and the only through collaboration and contributions by all parties can we truly be successful in reducing and averting a serious transportation incident.

II. ANALYSIS OF INCIDENT DATA:

The DOT has analyzed the factors associated with aviation battery (lithium and non-lithium batteries) incidents based on information gathered by FAA from 1991 to present (2008)*.

The results are summarized as follows:

1. 27 % of the observed incidents involved lithium batteries and 68 % were non-lithium batteries.
2. For lithium batteries the factors associated with the causes of incidents were: 73 % short-circuiting (external and internal short combined); 12 % charging/discharging; 6 % unintentional activation of devices; 9 % others (malfunction of devices, improper handling of cargo and unknown causes).
3. For non-lithium batteries the factors associated with the causes of incidents were: 72 % short-circuiting (mostly external); 11 % unintentional activation of devices; 4 % improper handling, 13 % others (malfunction of devices, improper handling of cargo and unknown causes).

Between 1991 and 2007 the number of passengers on board US aircraft increased by approximately 37 %. In 2007, approximately 1.8 million passengers traveled on US airlines each day. (Source: Bureau of Transportation Statistics)

A. Most likely causes for lithium battery incidents (Lithium-ion battery and lithium metal battery):

We need robust data to pursue many of the actions we have outlined. DOT may consider implementing a program to determine the root causes of these incidents. This program would include working with partners in fire safety organizations (e.g. Consumer Product Safety Commission, National Association of State Fire Marshalls) and/or with the battery industry to share information.

Based on above analysis and other information gathered on some incidents, it is concluded that the most likely causes of lithium battery incidents are:

1. External short circuit — occurs when an exposed battery terminal contacts a metal object. When that happens, the battery will heat up and may cause ignition of the battery and/or the surrounding combustible materials.
2. In use situation — generally relates to improper “Charging” and/or “Discharging” conditions associated with the use of equipment (i.e., computer or cell phone). This also includes inadvertent activation and subsequent overheating (e.g. such as was the case when a power drill activated and burned in a passenger’s checked baggage).
3. Non-compliance situation — faulty design of the battery (cells or battery packs), false certification of compliance with regulatory testing/classification requirements, and improper packing and handling including some counterfeit batteries.

4. Internal short circuit — can be caused by foreign matter introduced into a cell or battery during the manufacturing process. An internal short circuit can also occur when a battery is physically damaged (e.g. dropped or punctured).

** A more in depth analysis of the incidents is expected to be completed by September 1, 2008.*

III. NTSB RECOMMENDATIONS

Fifteen Recommendations were issued to DOT following NTSB's investigation of the February 7, 2006 incident at the Philadelphia International Airport. UPS Flight 1307 landed at the airport after a cargo smoke indication in the cockpit. The captain, first officer, and a flight engineer evacuated the airplane after landing, sustaining minor injuries. The airplane and most of the cargo were destroyed by a fire. NTSB suspects lithium batteries as cause of fire. The following recommendations were issued as a result of the investigation:

Safety Recommendation A-07-97: Provide clear guidance to operators of passenger and cargo aircraft operating under 14 *Code of Federal Regulations* Parts 121, 135, and 91K on flight crew procedures for responding to evidence of a fire in the absence of a cockpit alert based on the guidance developed by the 2004 smoke, fire, and fumes industry initiative.

Safety Recommendation A-07-98: Ensure that the performance requirements for smoke and fire detection systems on cargo airplanes account for the effects of cargo containers on airflow around the detection sensors and on the containment of smoke from a fire inside a container, and establish standardized methods of demonstrating compliance with those requirements.

Safety Recommendation A-07-99: Require that fire suppression systems be installed in the cargo compartments of all cargo airplanes operating under 14 *Code of Federal Regulations* Part 121.

Safety Recommendation A-07-100: Provide guidance to aircraft rescue and firefighting personnel on the best training methods to obtain and maintain proficiency with the high reach extendable turret with skin-penetrating nozzle.

Safety Recommendation A-07-101: Require airport inspectors to ensure that Part 139 airports with cargo operations include cargo aircraft in their aircraft rescue and firefighting aircraft familiarization training programs.

Safety Recommendation A-07-102: Require cargo operators to designate at least one floor level door as a required emergency exit and equip the door with an evacuation slide, when appropriate.

Safety Recommendation A-07-103: Require all emergency exits on cargo aircraft that are operable from the outside to have a 2-inch contrasting colored band outlining the exit.

Safety Recommendation A-07-104: Require aircraft operators to implement measures to reduce the risk of primary lithium batteries becoming involved in fires on cargo-only aircraft, such as transporting such batteries in fire resistant containers and/or in restricted quantities at any single location on the aircraft.

Safety Recommendation A-07-105: Until fire suppression systems are required on cargo-only aircraft, as asked for in Safety Recommendation A-07-99, require that cargo shipments of secondary batteries, including those contained in or packed with equipment be transported in crew-accessible locations where portable fire suppression systems can be used.

Safety Recommendation A-07-106: Require aircraft operators that transport hazardous materials to immediately provide consolidated and specific information about hazardous materials on board an aircraft, including proper shipping name, hazard class, quantity, number of packages, and location, to on-scene emergency responders upon notification of an accident or incident.

Safety Recommendation A-07-107: Require commercial cargo and passenger operators to report to the Pipeline and Hazardous Materials Safety Administration all incidents involving primary and secondary lithium batteries, including those contained in or packed with equipment, that occur either on board or during loading or unloading operations and retain the failed items for evaluation purposes.

Safety Recommendation A-07-108: Analyze the causes of all thermal failures and fires involving secondary and primary lithium batteries and, based on this analysis, take appropriate action to mitigate any risks determined to be posed by transporting secondary and primary lithium batteries, including those contained in or packed with equipment, on board cargo and passenger aircraft as cargo; checked baggage; or carry-on items

Safety Recommendation A-07-109: Eliminate regulatory exemptions for the packaging, marking, and labeling of cargo shipments of small secondary lithium batteries (no more than 8 grams equivalent lithium content) until the analysis of the failures and the implementation of risk-based requirements asked for in Safety Recommendation A-07-108 are completed.

Safety Recommendation A-08-01: In collaboration with air carriers, manufacturers of lithium batteries and electronic devices, air travel associations, and other appropriate government and private organizations, establish a process to ensure wider, highly visible, and continuous dissemination of guidance and information to the air-traveling public, including flight crews, about the safe

carriage of secondary (rechargeable) lithium batteries or electronic devices containing these batteries on board passenger aircraft.

Safety Recommendation A-08-02: In collaboration with air carriers, manufacturers of lithium batteries and electronic devices, air travel associations, and other appropriate government and private organizations, establish a process to periodically measure the effectiveness of your efforts to educate the air-traveling public, including flight crews, about the safe carriage of secondary (rechargeable) lithium batteries or electronic devices containing these batteries on board passenger aircraft.

IV. MANAGAEMENT PLAN ACTIONS:

This plan aims to reduce the risks arising from the different categories of incidents. The plan is multi-faceted and does not rely on any single solution. Overall, this plan includes eight major action areas that aim to provide protection through depth—layered defenses (prevention, isolation, detection, suppression, etc.) that should have a multiplicative effect on reducing risk. Each action, to some extent, is inter-related.

1. **Safer batteries and devices:** Work with battery manufacturers to expand and expedite efforts to: (1) Design and manufacture safer batteries, (2) Enhance quality control and/or certification measurement, (3) Develop safety test methods for detecting potential defects of batteries before they are placed in the market, (4) Include, cell and battery manufacturers, device manufacturers and battery users in the process.
 - Work with industry to incorporate more robust safety features in cells, batteries and electronic devices. Consider whether additional measures need to be incorporated into regulations to focus on those manufacturers that are not taking necessary steps to produce safe batteries and may be imposing short cuts that are contributing to the rising prevalence of incidents.
 - Work with appropriate stakeholders to develop test methods to detect potential defects in cells and batteries before they are placed in the market.
 - Encourage industry to harmonize testing and certification standards.
 - Emphasize the safety limitations of lithium battery technology and place greater emphasis on the interaction between the cell, battery, device and user (e.g. IEEE 1625).
2. **Outreach:** Continue our ongoing focus on alerting the general public to safe use and handling of batteries and devices containing batteries. Develop a set of criteria to measure the effectiveness of our efforts.

- Promote partnerships to print and distribute battery safety information.
 - Tailor publication efforts to targeted audiences (e.g. secondary and downstream shippers including online auction vendors).
 - Optimize internet resources to disseminate safety information to people when they travel with or purchase electronic equipment.
 - The FAA will develop audible public service announcements for use at airports and consider other media options. Coordinate efforts with the Transportation Security Administration the appropriate airport authorities.
 - Examine alternative methods other than text and signage to transmit safety messages.
 - Show the implications of battery incidents to modify passenger behavior.
 - Include battery safety information with portable electronic devices.
 - Encourage industry to include safety information printed on battery packaging.
 - Develop a webcast and brochure on the proper shipment and handling of batteries and cells
 - Develop a safety message branding campaign to simplify and enhance the recognition and effectiveness of the safety message. Utilize multiple media resources. Involve airports, airlines, ticket agents, manufacturers and others in the effort.
3. **Compliance with regulatory requirements:** Continue our ongoing enforcement efforts to ensure shippers of lithium batteries comply with classification, packaging and handling requirements. When applicable, gather incident information for further analysis and determination of future course of action.
- Continue multimodal inspection and training efforts.
 - Implement an approach to examine all parts of an operation to identify errors in shipping, packaging etc. Revise and enhance inspection protocols based on lessons learned. Identify deficiencies, unsafe practices and trends to appropriate standards setting bodies.
 - Encourage shippers and carriers to share relevant best practices with each other.

- Develop guidance to highlight common mistakes, misunderstandings and other sources of non-compliance based on enforcement data and findings.
 - Continue information sharing and cooperation with Customs and Border Protection, Underwriters Laboratory and the battery industry to identify and combat the prevalence of counterfeit batteries.
 - Share inspection/investigation findings with national and international authorities, when appropriate.
 - Educate secondary buyers, cell assemblers, and battery recyclers on the safe handling of batteries.
4. **Amend Regulations:** The impact of a lithium battery incident aboard an aircraft is far greater than the impact of a similar incident in another transport mode. More restrictive regulatory requirements may be warranted including: (1) Prohibit lithium-ion batteries from transport on passenger carrying aircraft, (2) Require enhanced packagings or overpacks and unit load devices when transporting lithium batteries aboard aircraft (e.g. metal packagings have been shown to be effective at significantly reducing risk), (3) Enhance hazard communication for carriers, pilots and workers, and (4) Develop loading and handling requirements for bulk shipments.
- Reexamine the current lithium battery regulations. Determine if comprehensive revisions should be made based on a complete cost benefit and risk analysis. Conduct cost benefit analysis on the impact of regulating all lithium batteries as Class 9 material when transported by aircraft.
 - Identify general battery safety issues to be addressed in the HMR.
 - Require reporting of all battery transport incidents.
 - Examine the effects of charging batteries and battery powered devices on board aircraft (FAA).
 - Clarify importers' responsibilities for ensuring batteries meet all applicable HMR requirements.
 - Enhance quality control in manufacturing batteries including certification of design type and production testing prior to distribution.
 - Develop a test protocol to better understand the risks posed when transporting lithium batteries and battery powered equipment aboard aircraft. Factors include battery size, package size, and number of packages.

- Consider measures for enhanced pilot notification requirements that lithium batteries are present and their location onboard the aircraft.
 - Promote knowledge of the UN Tests throughout the world as well as initiate additional safety and risk testing protocols to increase quality assurance and control criteria to enhance battery safety. Provide guidance and FAQs to clarify common misperceptions.
 - Require notification of completion of UN design type tests to each person a battery is transferred.
5. **Fire extinguishing method and capability on board a passenger aircraft:** The FAA will initiate a project to establish fire extinguishing methods and procedures that are effective in putting out small fires involving lithium batteries or equipment containing lithium batteries that may occur in passenger cabins.
- Continue testing of effective extinguishing methods and provide training videos illustrating effective responses to lithium battery fires.
 - Provide guidance on effective methods of how to fight lithium battery fires in the cabin areas.
6. **Fire detection and suppression capability on cargo only aircraft:** The FAA is the lead agency on this initiative. The capability of detecting and suppressing a fire on board a cargo aircraft will affect decision making on requirements for bulk shipment of lithium batteries. The FAA's fire safety R&D activities to address specific NTSB recommendations are as follows:
- Examine the adequacy of current certification methods to demonstrate that a cargo aircraft detector system will detect a fire within one minute.
 - Examine the effectiveness of depressurization to control an in-flight freighter fire. Tests will be conducted inside an altitude chamber to determine the effectiveness of depressurization on extinguishing and the impact of re-pressurization as the aircraft descends on the suppressed fire.
 - Conduct a cost/benefit analysis of the installation of on-board fire detection and extinguishment systems in freighters.
 - Coordinate lessons learned from FedEx and others regarding new fire suppression technologies.
7. **Develop better fire resistant containers for transport of lithium batteries as cargo by air:** In the longer term DOT should develop performance criteria for packaging that is more fire resistant than current packaging.

- Continue testing the available technology.
 - In coordination with PHMSA the FAA will analyze aircraft cargo compartments and container designs, location, as well as possible internal detection and suppression methods and their effectiveness on the control or containment of lithium battery fires. This would include the pressure effects of burning (exploding) batteries and the possible penetration of compartment liners and containers by high temperature fragments.
8. **Continue open dialogue with industry:** Continue our efforts to maintain an open dialogue with cell, battery, battery pack, and device manufacturers to better understand steps incorporated by the manufacturers in their respective products to enhance safety and quality control process at manufacturing. Based on information gathered in these efforts DOT will be in a better position to work with stakeholders on improving the overall safety measures for transport of lithium batteries and equipment containing lithium batteries.
- Initiate communications with other countries about the safety concerns of allowing counterfeit battery manufactures to continue to flood the world market with inferior batteries, which could cause an onboard fire and loss of life. This is an extensive problem that presents significant challenges.
 - Participate in the continued development of consensus standards for the safe production, transport and use of batteries. Expedite efforts to publish revised standards.
 - Sponsor (or co-sponsor with industry) workshops designed to promote the free exchange information with those involved in managing lithium battery risks in other countries to pave the way for developing globally harmonized regulations.
 - Form a check-off organization to promote battery safety research and conduct continuous outreach activities.
 - Submit a proposal to the UN Subcommittee of Experts on the Safe Transport of Dangerous Goods to reexamine the testing requirements for lithium batteries. Form an international working group to take a holistic approach to review and enhance lithium battery requirements and to engage our international partners.
 - Develop a protocol to provide guidance for notification, evidence preservation, root cause analysis, chain of custody procedure including what information from the carrier the passenger/holder of battery or device must be obtained.

- Communicate lithium battery concerns with other federal agencies and industry sectors that may not be familiar with the incidents observed.