INDEPENDENT
PILOTS ASSOCIATION

IPA PARTY SUBMISSION

To

NATIONAL TRANSPORTATION SAFETY BOARD

Accident Identification

Accident Number:	DCA06MA022
Operator:	United Parcel Service Flight 1307
Location:	Philadelphia International Airport (PHL), Philadelphia, PA
Date:	February 7, 2006
Time:	2359 Eastern Standard Time (EST)
Airplane:	DC-8-71F, N748UP

Party Coordinator:	Captain Gary A. Stephen
Accident Investigation Chairman:	Captain Shannon Jipsen
Safety Chairman:	First Officer Michael Moody Jr

IPA Party Statement

During the NTSB hearing for UPS Flight 1307 there were five distinct double standards that were discussed. They were:

1. Hazardous Material exemptions, quantities and carriage.
2. Airport Rescue & Fire Fighting (ARFF) requirements.
3. Fire Suppression requirements in cargo areas.
4. Exterior safety markings and placards.
5. Crew safety equipment.

With the double standards in safety regulations and requirements, the FAA indicates that the flight crew's safety is of greater importance only if they are carrying passengers. The public community would still be at risk should a large transport category cargo aircraft have a mishap, incident or accident. An accident of this type could be even more devastating due to the hazardous materials (HAZMAT) carried on these aircraft. Cargo aircraft carry greater quantities of HAZMAT and the HAZMAT onboard may be material that is banned on passenger aircraft. This is a concern of any airport and surrounding community that a cargo aircraft would utilize in the event of an emergency.

We must not have a myopic view of safety. On January 9, 2007 the FAA created a new double standard in allowing an increased ETOPS from 180 minutes to 207 minutes. In order to take advantage of this greater amount of time from an emergency airport, the aircraft fire suppression system must be improved and increased emergency oxygen supplies for crew and passengers must be provided. Cargo air carriers were exempted from this requirement. This double standard in safety regulations for Part 121 air carriers needs to stop.

The IPA, as a party to this investigation, is making ten recommendations. The order in which they are presented in no way indicates an order of importance. Our goal is to improve safety and to prevent similar events in the future.

Respectfully Submitted,

Captain Gary A. Stephen

Captain Shannon L. Jipsen

First Officer Michael L. Moody Jr

Recommendation 1

Prohibit the carriage of Primary Lithium Batteries (non-rechargeable) on cargo aircraft, in bulk or installed in equipment that is carried as cargo, until such time that Hazardous Classification and Packing Group can be established. And, further testing by the FAA Research and Development Division, Fire Safety Branch to determine that safety standards have been achieved so that a Primary Lithium battery fire on board a Transport Category Aircraft would not result in substantial structural damage or damage that would result in the loss of an aircraft.

Supporting Information

On December 5th, 2004, The Research and Special Programs Administration (RISPA) of the US Department of Transportation (DOT) issued a ruling prohibiting the offering for transportation or the transportation of primary (non-rechargeable) lithium batteries and cells as cargo aboard passenger carrying aircraft and equipment containing or packed with large primary lithium batteries.

The Federal Register notes that this action was prompted by four (4) factors:

1. An April 28, 1999 incident at (LAX) where a pallet of lithium primary cells had been damaged and subsequently self ignited and burned.

2. An FAA Technical Report on Primary Lithium Batteries (Flammability Assessment of Bulk-Packed, Nonrechargeable Lithium Primary Batteries in Transport Category Aircraft)

3. Additional incidents involving lithium batteries.

4. A September 29, 2004 petition to RSPA which requested the development of Packing Standards for Primary Lithium batteries similar to those currently in place for other commodities so that, in the event of a fire, both a suppressed and a non -suppressed cargo fire, would not result in the loss of an aircraft.

It is noted in HM224E (exhibit 17AA) that cargo aircraft could continue to carry these batteries as they could depressurize; giving the appearance that this would extinguish the primary lithium battery fire. In fact, this type of testing was not requested by the FAA, nor was it performed. As stated during the hearing it was a premise not supported by factual testing. Mr. Wilkening stated the following: “As this was being written, we did check with our Flight Standards Office, and we went through general procedures, not company specific procedures, but we do go through general premise on fire fighting on passenger planes versus cargo planes and this was a general premise, that this is applicable in cargo planes.”

The FAA Technical Report on Primary Lithium Batteries is Exhibit 17H. It however is an excerpt Power Point and lacks critical information that is contained in the twenty three (23) page report. (Reference Section 1 A)

Form DOT F1700.7 states the nature of the test was conducted to determine the flammability characteristics of primary lithium batteries and the dangers associated with shipping them in bulk form on commercial transport category aircraft. This started out as an aviation safety concern and turned into another double safety standard.

This report in its entirety shows that Primary Lithium batteries may be the Ultimate Hazardous Material.

A relative small fire source is sufficient to start a primary lithium battery fire. The outer plastic coating easily melts and fuses adjacent batteries together and then ignites, contributing to the fire intensity. This raised the battery temperature to the self-ignition temperature of 355 deg F. Once the lithium in a single battery begins to burn it releases enough energy to ignite adjacent batteries. This process continues until all batteries have been consumed. This process is possible with the way current lithium primary batteries are packaged for air shipment.
Multiple battery tests showed temperatures in excess of 1400 deg F. (Note: Aluminum melts at 1240 deg F.) In tests with 32, 64, and 128 batteries each showed no appreciable change in temperature, but with 128 batteries fire durations in excess of six (6) minutes were noted.

Halon 1301, the fire suppression agent installed in passenger aircraft cargo compartments and a few cargo aircraft, is not effective in extinguishing or suppressing a primary lithium battery fire. Testimony given stated that special chemicals are required to extinguish a primary lithium battery fire, and in addition the chemicals must blanket the lithium metal itself, not the packaging material.

The air temperature in a cargo compartment, not containing Primary Lithium batteries, that has been suppressed by Halon 1301, has a temperature range of 410 deg. F. to 664 deg. F. at the ceiling level of the compartment, with smoldering areas exceeding 1000 deg. F. This is well above lithium metal's auto ignition temperature of 355 deg F. Because of this, batteries that were not involved in the initial fire can auto ignite and propagate.

The ignition of a primary lithium battery releases burning electrolyte and molten lithium spray. The cargo liner material may be vulnerable to perforation by the molten lithium. If Halon 1301 is available to suppress the other cargo burning in the compartment, the perforations in the liner will allow the agent to leak out reducing the concentration and effectiveness. The holes may also allow flames to spread outside the compartment.

The ignition of Primary Lithium batteries releases a pressure pulse that will raise pressure in the cargo compartment of a Transport Category Aircraft. When an explosive test was conducted, using sixteen (16) Sanyo CR2 batteries, test data shows pressure increases of 2.7 psig. In another test using Panasonic PL123A batteries, the test had to be terminated at 16 batteries due to the explosive nature of these batteries. The pulse was strong enough to damage the test chamber door. As stated cargo compartments of transport category aircraft are only designed to withstand 1-psi pressure differential. Pressure pulses can compromise the integrity of the compartment by activating the pressure relief panels. This would have the same effect as perforating the cargo liner. If Halon 1301 is available to suppress the other cargo burning in the compartment, the open panels will allow the agent to leak out reducing the concentration and effectiveness.

Recommendation 2

Request that Congress change US Code 44706 (attached) to include aircraft that have a maximum gross take-off weight of 100,000 pounds or greater in the language as soon as possible (see HR 4123-attached). Also recommend to the FAA that once Congress changes this legislation, that the FAA quickly change the applicability of 14 CFR Part 139 (139.1) to include cargo air carrier aircraft so that Aircraft Rescue and Fire Fighting (ARFF) will be required for cargo air carrier sized aircraft.

Supporting Information

There is a double standard in aviation safety regarding ARFF for passenger and cargo air carrier aircraft. Many of the safety regulations were written in the early 1950's when cargo air carrier service was not available. Not until the 1970's did the airline industry change to include Part 121 cargo airline service. However, the regulations have not changed with industry changes.

The **FAA** has the statutory authority to issue airport operating certificates to airports serving certain air carriers and to establish minimum safety standards for those airports, including ARFF standards**. This authority is currently found in <u>Title 49, United States Code (U.S.C.) 44706</u>. However, this authority is limited to <u>land airports serving passenger operations</u>. See attached letter from the FAA. By their own explanation, the FAA cannot change Part 139.1 until Congress changes US Code 44706.**

- ***There are approximately 575 of the 6000 US airports that are certificated under 49 USC 44706 and Part 139 (FAA source)***
- ***Out of the 575 that are Part 139 certificated, approximately 144 are used by cargo air carrier sized aircraft (i.e. airports used by Airborne/DHL, Fed Ex & UPS)***
- ***ICAO*** (International Civil Aviation Organization) ***ARFF is based on the largest aircraft using an airport.***
- ***NFPA*** (National Fire Protection Agency) ***ARFF based on the largest aircraft scheduled into an airport***.
  - **No distinction between cargo or passenger aircraft…just aircraft size**
- ***While passenger flight growth is relatively flat, the cargo industry is growing***. The cargo airline industry began to grow in the early 1980's. According to the Boeing World Air Cargo Forecast 2000 / 2001 report, "***During the next 20 years, the freighter fleet is expected to double***… The Boeing World Air Cargo Forecast 2002-2003 reports, "The freighter fleet will increase over the next 20 years… History shows a doubling of the jet freighter fleet every 10 years to meet the air cargo sector's vibrant growth."
- From ***Air Cargo World, October 2006,*** "In its World Air Cargo Forecast 2006-2020, Boeing predicts carriers will order $<u>170 billion</u> worth of new cargo planes, of which a sizable portion will be widebodies."

Although many of the 144 airports that the cargo air carrier aircraft fly into do have ARFF, they are not required for cargo air carriers and the FAA does not require the airport operator to include the large cargo aircraft in the determination of the number of

ARFF vehicle(s) that are required to protect the airport & its surrounding communities. The FAA also does not require the airport operator to have the ARFF responders train on cargo aircraft. The FAA does not recognize training done on cargo aircraft (because the regulations don't recognize cargo air carrier aircraft as part of its applicability); therefore, any inspections the FAA does on ARFF training does not include cargo aircraft. Many airports have large cargo aircraft utilizing their facilities; however, should any kind of event or accident occur, many of the ARFF responders have not been properly trained on how to combat a cargo fire and therefore have not been able to respond properly. Listed below are recent cargo accidents:

- Federal Express DC-10 Sept. 5, 1996, Newburgh, NY (SWF)
- Federal Express MD-11 July 31, 1997, Newark, NJ (EWR)
- Federal Express DC-10 August 7, 1999, Memphis, TN (MEM)
- Emery Worldwide DC-8 Feb. 16, 2000, Rancho Cordova, CA (MHR)
- Federal Express MD-10 Dec. 18, 2003, Memphis, TN (MEM)
- UPS DC-8 February 8, 2006, Philadelphia, PA (PHL)

There are others, but these give examples how if the ARFF responders had been required to have training on large cargo air carrier aircraft the length of time the airport was closed may have been shortened (which is a an economic impact), the length of time the aircraft burned may have been shortened (also economic impact for the companies and customers – loss of goods on board), and most importantly their own awareness of how to approach and effectively combat a cargo fire would have been better. There is also concern for lack of knowledge amongst ARFF responders for how <u>known</u> HAZMAT is carried for each of the cargo air carriers. There is <u>**not**</u> a standard way of doing this and it can put the ARFF responder at risk. By not giving the FAA authority to include training on cargo carriers, ARFF lives may be at risk. The flight crews may also be at risk due to the lack of training by ARFF responders.

ARFF responders don't just respond to accidents, but they also respond to many incidents and emergencies. These responses are on a daily basis around the country. Here's a sample list of a few of the types of events ARFF responds to:

Incidents & Emergencies

- Smoke & Fumes
- Engine Failure
- Hot brakes / fire
- Cargo fire indication
- Hazmat (Hazardous Materials) incidents
- Flight Control problems
- Loss of Braking
- Rejected Take-offs
- Fuel leaks
- Landing Gear problems

Flying a large all cargo aircraft is different than a passenger aircraft due to lack of number of emergency exits. Should the structural integrity of the fuselage be compromised during landing the emergency exit(s) may not open. Therefore, the crew may be at the mercy of the ARFF responders to “CUT” them out. This is another double standard regarding the cut marking requirement for cargo aircraft vs. passenger aircraft. There are no requirements for there to be any markings on a cargo aircraft and therefore, the ARFF responders may not know where to cut the fuselage to rescue the flight crew and other passengers. This could cost lives…seconds count!

In 2001, the FAA put together an Aviation Rulemaking Advisory Committee (ARAC) to address the concerns of the need to re-write 14 CFR Part 139 and update the ARFF standards. (Note: to date the FAA has still not made public the recommendations of the ARFF ARAC) The Independent Pilots Association (IPA) was asked to participate in the ARFF ARAC to represent the concerns of cargo air carriers. Although the IPA voiced many concerns regarding the above mentioned items, the FAA could not include the IPA’s comments or suggestions in the final document because cargo air carrier aircraft currently cannot be recognized. There was also discussion during this ARAC regarding cost of adding cargo aircraft to the regulation. The FAA would not supply an answer to the ARAC Working Group regarding this question. However, there has been an estimated cost put together by the IPA by reviewing the 144 airports used by the cargo air carriers & using the Part 139 remission factor of five average daily departures of the largest cargo aircraft flying into each of those airports. After applying the factors from the current Part 139 requirement and reviewing the ARFF vehicle requirements at these airports, it has been determined that only two airports would need to purchase an additional vehicle in order to comply with current regulations. There would be approximately twenty-two airports that would need to change the Index, but additional vehicles would not be required at those airports under current Part 139 standards.

Although cost is always important, the cost to correct this double standard in safety is minimal and the two vehicles required would be mostly covered by already available FAA Airport Improvement Program (AIP) funds. Delaying this change to legislation may end up being quite costly, not only for the air carriers, but for the airports, the surrounding communities, and most importantly…lost lives! As cargo air carriers continue to grow, and as the amounts of “known” and “unknown” HAZMAT continue to increase, the next cargo air carrier accident may destroy property at the airport, close down the airport for many hours, spread hazardous material fumes to surrounding areas, and lives may be lost. There is an opportunity right now to be proactive in getting this regulation changed to require ARFF for cargo as well as for passenger operations rather than being reactive after lives are lost.

Recommendation 3

Require standards for ULD's (Universal Loading Device) to contain a fire within the ULD when subjected to temperatures and durations anticipated in a fire. And to retain fire integrity after being subjected to a pressure pulse of a magnitude as anticipated from hazardous materials explosion.

Supporting Information

As stated by witness Mr. Webster, of the FAA testing center, when Primary Lithium or Lithium-Ion batteries ignite they have a pressure pulse great enough to damage the fire integrity of the aircraft's cargo compartment. It is the IPA's recommendation that any cargo that has the potential to produce this type of pressure pulse be contained in a ULD capable of withstanding this pulse.

The witness Mr. Wickens from Federal Express stated that a fire on board a cargo aircraft must be contained within the ULD. If is allowed to escape you have the aircraft structure and flight controls exposed to the fire. As we saw with the UPS ULD design, the fire melted the lexan portion of the container allowing the fire to escape into the aircraft. Lexan has a melt temp of: Lexan Type1110 520-560 deg. F and Lexan Type 9112 & 9330 560-600 deg F. In this aircraft fire the Lexan melted and flowed together necessitating the use of a power saw to separate the bins to remove them from the aircraft. This design allowed the fire to propagate to adjacent ULD's. Referring to exhibit 20G the FAA in their recommendations for testing are allowing for fire temperatures that exceed the upper temperature range of Lexan.

Several designs and materials to comply with this recommendation are commercially available and in use today.

Recommendation 4

Thermal and rate of temperature rise sensors be installed in all Class C & E cargo areas in zone configuration, with visual and aural warnings in the cockpit.

Supporting Information

Thermal and rate of temperature rise sensors should be installed in all inaccessible cargo areas to provide an indication of the imminent hazard. As was demonstrated in this accident, odor was the first indication of the fire. FAA Advisory Circular 120-80 states this will most likely be the case.

Current standards in detecting a fire only rely on smoke. FAA tests included in the exhibits document that a smoldering fire can produce extreme heat with little smoke. With this accident odor was present a full 20 minutes before any indication of smoke was detected by the aircraft smoke detection system. This time delay can become catastrophic. The FAA states that from the first indication of a fire, the flight crew may have as few as 15-20 minutes to get the aircraft on the ground.

As stated above, current standards in detecting a fire rely on smoke, yet the quantity and method of generation of smoke to show compliance is not precisely defined and no guidelines for detecting fires by means other than smoke exist.

It is the IPA's recommendation to install a series of thermal sensors in Class C & E cargo areas. This type of system would detect a smoldering fire (heat with little or no smoke) giving the crew the additional time and information to make the decision to divert to the nearest suitable airport and which appropriate checklists to accomplish. We do not want to run a checklist that might induce more air flow / oxygen into this type of fire. These types of sensors will allow the crew to inform ARFF in the exact location of the fire on the aircraft.

Recommendation 5

Limit the carriage of Lithium-Ion (secondary) batteries to aircraft having containers and/or cargo areas that have Halon, or equivalent suppression capabilities, and Lithium-Ion batteries must be restricted to these areas only. Also, to include required notification to the crew.

Supporting Information

The FAA report on testing of Lithium-Ion batteries states, that Halon is effective in suppressing this type of fire. A Lithium-Ion fire exhibits burning properties more akin to a liquid than a metal fire, as is the case with Primary Lithium batteries. Given the extreme temperatures recorded during testing, a Lithium-Ion fire, in areas not protected by Halon or equivalent, could cause damage to the surrounding structure of the aircraft.

Recommendation 6

Elimination of compartment classification E and re-designation to Class C

Supporting Information

In FAA report RD-70-42, (Exhibit 20C) the FAA investigated the degree to which fire in a large cargo compartment may be suppressed by shutting off ventilation to the compartment. The test concluded that this action alone would not protect the fuselage of a large cargo aircraft from severe fire damage. This same report cites another FAA test where a section of a C-130 fuselage was used to simulate a large cargo area. It concluded: In large cargo compartments, fires can readily reach damaging proportions even though detection and airflow shutoff occur immediately.

Recommendation 7

Full face oxygen masks for required crewmembers and main entry emergency escape slides to be required for all Part 121 operations, to include aircraft in all cargo configuration.

Supporting Information

In the Group Chairman's Factual Report, Operations Group, the First Officer states, "There was no time to don the goggles." This answer was in response to a question as to why he donned the oxygen mask but not the goggles. With the old style two piece oxygen mask and separate goggles it requires two distinct and different operations to don both. In the case of the goggles you must find the holder, open it, remove the goggles, don them, and adjust the strap around your head. This is a two handed operation. The one piece oxygen mask and full face protection eliminates the time to don the goggles. In a later conversation the First officer said that had he taken the time as the flying pilot to don the goggles he might have had to do a go around. The time line of events after landing indicates this action could have had a catastrophic outcome.
This recommendation also addresses chemical spills while in flight. As indicated by the drill chart many chemicals cause eye irritation. Depending on the concentration the human body closes the eyes to avoid this irritant. Most pilots flying with the currently supplied goggle/mask combination feel they will not prevent smoke or fumes from irritating their eyes if needed in an emergency.

Unlike passenger operations, all cargo aircraft can defer the escape slide. This is to facilitate on time departures. In our collective 75 years plus of flying, we have never had hands on practice of using the escape tape or rope evacuation procedure. The training that is approved is to view a video of the procedure and to physically see the devices. Discussions in training tell the crew that without hand hold devices on the tape/rope, if you loose your grip, you will slide down the tape resulting in friction burns to the hands if you are able to hang on. We doubt that anyone who views an aerial trapeze procedure would feel confident trying the same operation many feet above a hard surface without a net. In the above mentioned report, the Captain and First Officer both commented about the dense smoke exiting the windows. Had the evacuation been accomplished with the use of the tape it would have been done equivalent to having your eyes closed.

As stated by RISPA testimony at the public hearing, if government agencies are going to operate under the assumption that cargo pilots must assume a different level of safety, the flight crew should have access to basic safety equipment such as emergency slides and integrated oxygen masks.

Escape slides must be operational for all flights. On aircraft converted from passenger operations the slides must be retained, for future aircraft designed for cargo use they must have an escape slide incorporated into the design.

Recommendation 8

Reclassification of Primary Lithium batteries to flammable metal and require packing requirements appropriate to the class.

Supporting Information

In the FAA report titled, Flammability Assessment of Bulk-Packed Nonrechargeable Lithium Primary Batteries in Transport Category Aircraft, the Executive Summary, Chapter 10 Conclusion, along with the testimony before the Board of Inquiry by Mr. Webster the author, attest that Lithium Primary batteries exhibit burning characteristics of a metal fire and that no product on board the aircraft, nor de-pressurization of the aircraft will extinguish the fire.

Recommendation 9

That cargo aircraft have exterior markings and instructions for entry. To include those used on passenger aircraft and additional markings for doors or entry hatches that have been deactivated.

Supporting Information

During testimony at the public hearing Captain Loesch stated that due to the wide variety of doors, and the way they operate that instructions help ARFF enter the aircraft more quickly as it gives step-by-step procedures.

When asked by Ms. Liedler if not having the markings hindered the ability to enter the aircraft, Captain Loesch replied, “It didn’t help. We had to take a best guess approach to try to get them open.”

Not all airports will have ARFF, and even those that do are not required to train with cargo aircraft. They may have mutual aid from the local fire department. When asked if having the placards and exterior outlines of the exits would be of benefit to responders, he stated it would.

Recommendation 10

Any future proposal, Interim or Final Rule Making submitted by the FAA or other government agency, directed toward FAR Part 121 air carrier operations be all inclusive and not differentiate between cargo and passenger operations.

REFERENCE SECTION

Recommendation 1

A. Exhibit 17H	File ID 350562	Flammability Assessment of Bulk-Packed Nonrechargeable Lithium Primary Batteries in Transport Category Aircraft
B. Exhibit 17AA	File ID 350672	Hazardous Materials; Prohibition on the Transportation of Primary Lithium Batteries and Cells Aboard Passenger Aircraft; Final Rule Page 6

Recommendation 2

A. FAA Letter on Applicability of US Code 44706 for Passenger Aircraft Only

B. HR4123

Recommendation 4

A. FAA Advisory Circular 120-80 In-Flight Fires Page 6 & 19

Recommendation 5

A. Ref. Recommendation 1A

Recommendation 6

A. Exhibit 20C File ID 350466 Characteristics of Fire in Large Cargo Aircraft (Phase II) Page 4

Recommendation 8

A. Ref. Recommendation 1A

RECOMMENDATION 1

EXHIBIT A

DOT/FAA/AR-04/26

Office of Aviation Research
Washington, D.C. 20591

Flammability Assessment of Bulk-Packed, Nonrechargeable Lithium Primary Batteries in Transport Category Aircraft

Harry Webster

June 2004

Final Report

This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161.

U.S. Department of Transportation
Federal Aviation Administration

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15. Supplementary Notes

16. Abstract

This report documents the findings of a series of tests conducted to determine the flammability characteristics of primary lithium batteries and the dangers associated with shipping them in bulk form on commercial transport category aircraft.

17. Key Words	18. Distribution Statement
Lithium, Battery, Flammability, Halon 1301, Cargo compartment	This document is available to the public through the National Technical Information Service (NTIS) Springfield, Virginia 22161.

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EXECUTIVE SUMMARY

A series of test were conducted to assess the flammability characteristics of nonrechargeable lithium primary batteries, both individually and as packaged for bulk shipment onboard cargo and passenger aircraft. The tests were designed to determine the conditions necessary for battery ignition, the characteristics of the battery fire, the potential hazard to the aircraft as a result of the fire, and the effectiveness of the standard Halon 1301 fire suppression systems in extinguishing the fire.

A relatively small fire source is sufficient to start a primary lithium battery fire. The outer plastic coating easily melts and fuses adjacent batteries together and then ignites, contributing to the fire intensity. This helps raise the battery temperature to the self-ignition temperature of lithium. Once the lithium in a single battery begins to burn, it releases enough energy to ignite adjacent batteries. This propagation continues until all batteries have been consumed.

Halon 1301, the fire suppression agent installed in transport category aircraft, is ineffective in suppressing or extinguishing a primary lithium battery fire. Halon 1301 appears to chemically interact with the burning lithium and electrolyte, causing a color change in the molten lithium sparks, turning them a deep red instead of the normal white. This chemical interaction has no effect on battery fire duration or intensity.

The air temperature in a cargo compartment that has had a fire suppressed by Halon 1301 can still be above the autoignition temperature of lithium. Because of this, batteries that were not involved in the initial fire can still ignite and propagate.

The ignition of a primary lithium battery releases burning electrolyte and a molten lithium spray. The cargo liner material may be vulnerable to perforation by molten lithium, depending on its thickness. This can allow the Halon 1301 fire suppressant agent to leak out of the compartment, reducing the concentration within the cargo compartment and the effectiveness of the agent. Holes in the cargo liner may also allow flames to spread outside the compartment.

The ignition of primary lithium batteries releases a pressure pulse that can raise the air pressure within the cargo compartment. The ignition of only a few batteries was sufficient to increase the air pressure by more than 1 psi in an airtight 10-meter-cubed pressure vessel. Cargo compartments are only designed to withstand approximately a 1-psi pressure differential. The ignition of a bulk-packed lithium battery shipment may compromise the integrity of the compartment by activating the pressure relief panels. This has the same effect as perforations in the cargo liner, allowing the Halon 1301 fire suppressant to leak out, reducing its effectiveness.

1. INTRODUCTION.

Primary lithium batteries are a popular power source for many small electronic appliances. Most of the batteries used in the United States are manufactured in Japan. The batteries are packed in bulk corrugated cardboard containers and stacked on pallets and shipped in the cargo holds of passenger and cargo aircraft. There has never been a known in-flight fire associated with shipping the batteries in this manner; however, a ramp incident involving palletized batteries has drawn attention to the flammability hazard of primary lithium batteries.

The ramp incident occurred at Los Angeles International Airport in April 1999. A pallet of batteries caught fire while being handled between flights. There was no known external ignition source. The nature of lithium fires makes them very difficult to extinguish, with all common extinguishing agents ineffective in controlling the fire.

The tests described in this report are an effort to assess the flammability characteristics of primary lithium batteries and the potential hazard associated with shipping them on transport aircraft.

2. TEST DESIGN.

2.1 SCOPE.

These tests were designed to determine the flammability characteristics of primary lithium batteries and any associated hazard to transport aircraft when shipped in bulk pallets in cargo compartments. Primary lithium batteries are defined as nonrechargeable batteries. The flammability parameters investigated included ignition source intensity, effect of battery quantity, fire propagation between batteries, effect of packing materials, temperature rise in the test chamber, pressure rise in the test chamber, effect of Halon 1301 fire suppression systems, and effect on cargo liner integrity.

Two common types of primary lithium batteries were used in this investigation: CR2 and PL123A, as shown in figure 1. These are small batteries often used in cameras and other small electronic appliances.

FIGURE 1. CR2 AND PL123A PRIMARY LITHIUM BATTERIES

2.2 TEST FACILITY.

A test chamber was constructed to measure the flammability of the subject batteries. The chamber was constructed of 1/8″ uninsulated steel sheeting and measured 4′ by 4′ by 4′, producing a 64-cubic-foot test facility. The entire front side opens for access and is fitted with a Plexiglas windowpane to allow videotaping of the fire test. The chamber was equipped with variable 1″ vent holes located on the centerline of the sidewalls, 2″ from the floor. Aluminum foil blowout panels were installed in the sidewalls near the ceiling. The facility was fitted with a Halon 1301 fire-extinguishing system designed to provide a 5 percent concentration of Halon 1301. This concentration is equal to that provided in a standard aircraft cargo compartment for initial fire knockdown. A basket was constructed from a 0.5″ square wire mesh and an aluminum angle framework to suspend the test batteries over the fire pan. Figure 2 shows a diagram of the test chamber.

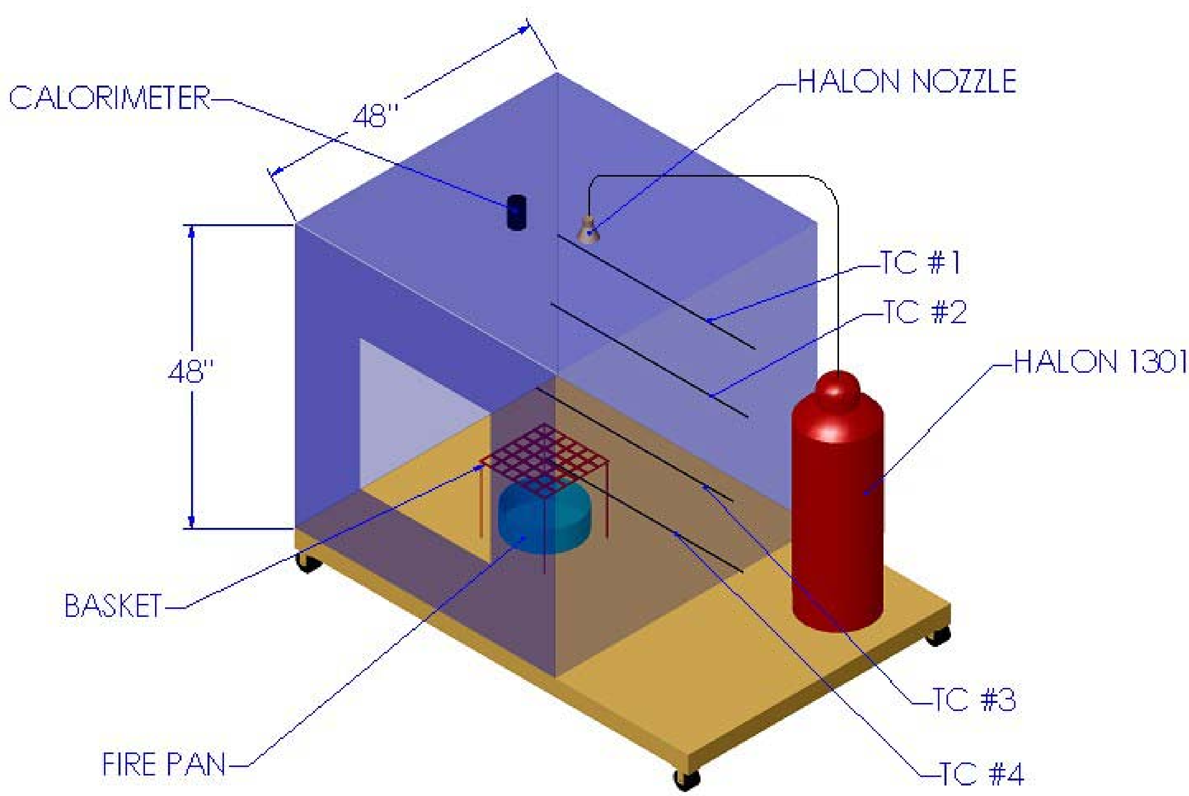

FIGURE 2. THE 64-CUBIC-FOOT TEST CHAMBER

2.2.1 Instrumentation.

The 64-cubic-foot test facility was fitted with four type C thermocouples located in the center of the chamber and spaced 12″, 24″, 36″, and 48″ from the floor. The thermocouples are numbered from the top, with the 48″ height assigned number 1 and the 12″ height assigned number 4.

These thermocouples measure the temperature rise in the chamber. In addition, two calorimeters were installed. One was centered in the ceiling of the chamber, assigned channel 5, and one in the right sidewall 12″ from the floor, assigned channel 6. The calorimeters were used to measure the heat flux produced by the ignition source fires and the battery fires.

A video camera was positioned outside the chamber and recorded the fire event through the Plexiglas door.

2.2.2 Ignition Fire Source.

The chamber was fitted with two different size fire pans to allow for different intensity ignition fires. The pans were circular with a 1″ depth. The low-intensity fire pan was 5.25″ in diameter with a surface area of 20.6 square inches, and the high-intensity fire pan was 10.75″ in diameter with a surface area of 90.7 square inches. The fire pans were centered on the chamber floor.

3. BASELINE TESTS.

The test facility was designed to simulate temperature conditions that are typical of a cargo compartment fire that has been suppressed with Halon 1301. Under these conditions, deep-seated fires can continue to smolder, producing isolated pockets of temperatures in the 1000° to 1200°F range. The air temperatures in a suppressed cargo compartment measured at the ceiling can range from 410° to 665°F [1]. The 10.75″ fire pan was designed to produce this temperature range, while the 5.25″ fire pan represents a less severe condition.

The facility was calibrated with a series of baseline tests. Fire intensity data were collected for the two fire pan sizes. 1-propanol (C3H7OH) was used as the fuel throughout these tests. The area of the fire pan determines the intensity; the volume of 1-propanol determines the duration of the fire. The amount of 1-propanol was adjusted to ensure a 3-minute ignition fire. The 5.25″ fire pan required 50 ml of 1-propanol, and the 10.75″ fire pan required 220 ml of 1-propanol.

3.1 THE 5.25″ FIRE PAN CALIBRATION.

The 5.25″ fire pan reached a peak temperature of approximately 725°F, measured 12″ above the fire pan. The temperature at the ceiling of the chamber only rose to 225°F. The heat flux measured at the top of the chamber peaked at 0.18 Btu/ft^2-sec. (figure 3). These numbers define a low-intensity fire.

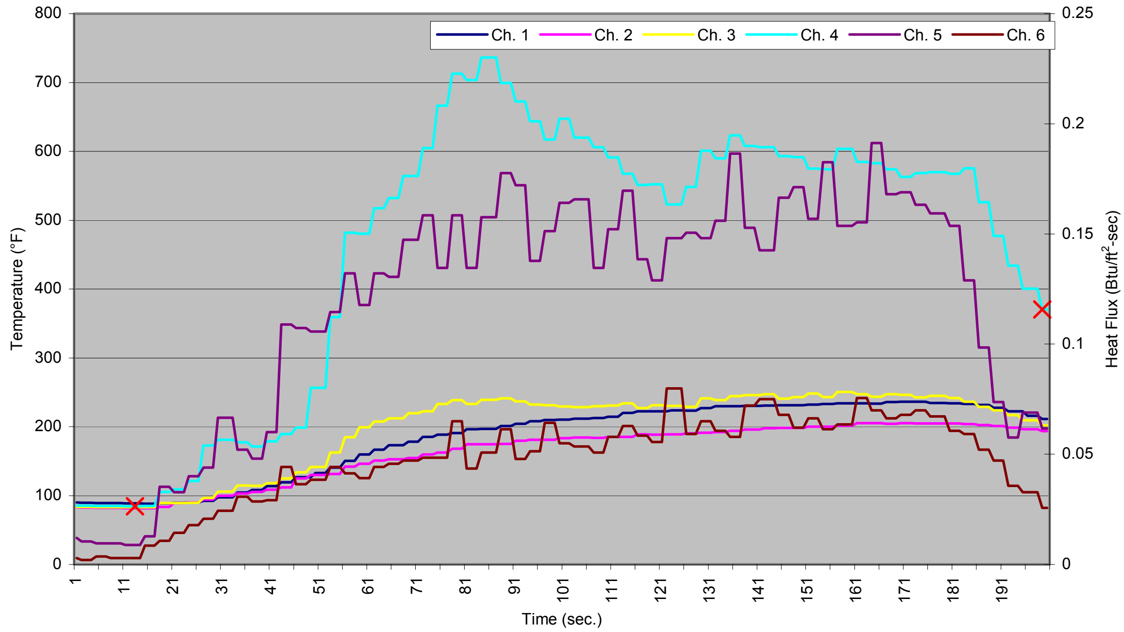

FIGURE 3. THE 5.25″ FIRE PAN CALIBRATION

3.2 THE 10.75″ FIRE PAN CALIBRATION.

The 10.75″ fire pan reached a peak temperature of 1150°F, measured 12″ above the floor of the chamber. The ceiling temperature peaked at 500°F. The peak heat flux measured at the ceiling was 0.8 Btu/ft^2-sec. This is a considerably more intense fire than the 5.25″ fire pan, more closely representing conditions found in a fully suppressed cargo fire (figure 4).

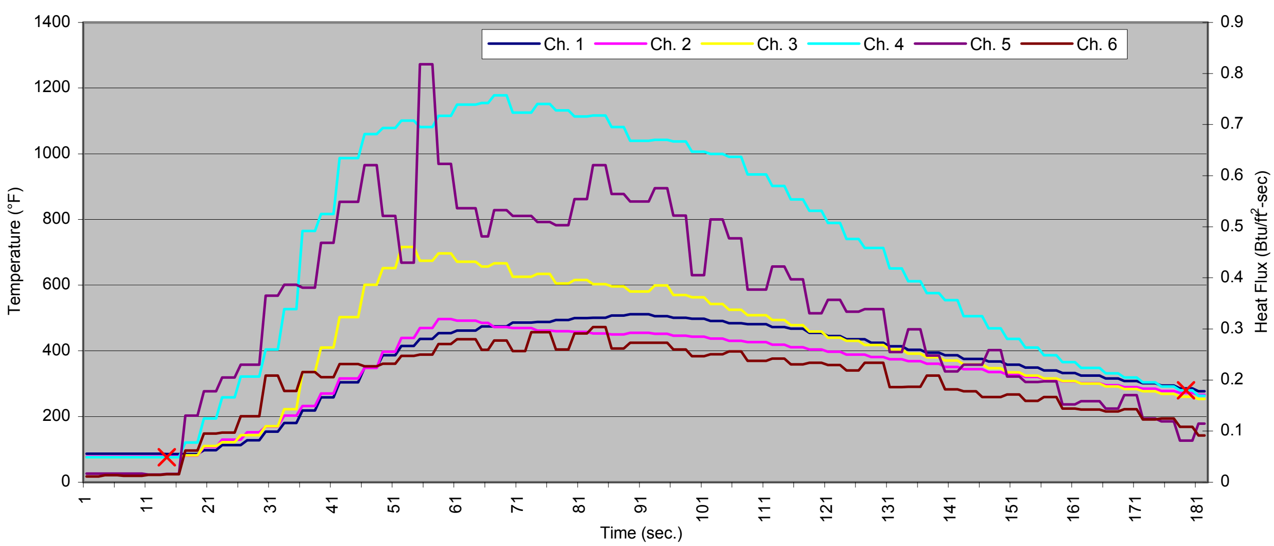

FIGURE 4. THE 10.75″ FIRE PAN CALIBRATION

4. SANYO CR2 BATTERY TESTS.

4.1 SANYO CR2 SINGLE-BATTERY FAILURE MODE.

A series of tests were conducted with the 5.25″ fire pan and a single Sanyo CR2 battery to determine the flammability behavior. The battery was suspended in a wire basket 4″ above the fire pan. The pan was filled with 50 ml of 1-propanol and ignited with a propane torch.

The battery initially vented electrolyte gas, usually at the positive electrode, when exposed to an 1-propanol fire. The electrolyte gas torched with a red flame and with some propulsive force accompanied by a small but noticeable pressure pulse, causing the Plexiglas viewing window to bulge. After the electrolyte burned off, the molten lithium burned explosively, spraying white-hot lithium through the vent holes. Unrestrained, the battery can bounce around in the test fixture.

Typically, battery failure followed the same pattern (all times are nominal), as shown below.

Time (min)	Event
0:00	1-propanol fire ignited
0:30	Plastic coating on exterior of battery bubbles and burns
1:00	Electrolyte vents and burns, producing a torch
1:30	Molten lithium fire
1:50	Battery expended

The batteries gave off a good deal of heat, raising the temperature 650°F above that produced by the low-intensity 1-propanol fire and, more significantly, sprayed white-hot molten lithium for a radius of several feet.

4.2 SANYO CR2 MULTIPLE-BATTERY FIRE TESTS.

A series of tests were conducted to determine the flammability characteristics of multiple Sanyo CR2 batteries. The tests were conducted using the 5.25″ fire pan with 50 ml of 1-propanol and a wire basket suspending the batteries 3″ above the fire pan. The number of batteries was varied from 1 to 16, doubling the number of batteries for each successive test. Each test resulted in a similar peak temperature, measured 12″ above the fire pan, of approximately 1375°F. The duration of the peak temperature increased with additional batteries, but the actual peak did not significantly vary. This is an increase of 650°F above the 1-propanol fire temperature of 725°F. The heat flux measured at the ceiling peaked at 0.55 Btu/ft^2-sec, which is about three times higher than the fire pan calibration. Figure 5 shows the temperature and heat flux profile generated by 16 CR2 batteries.

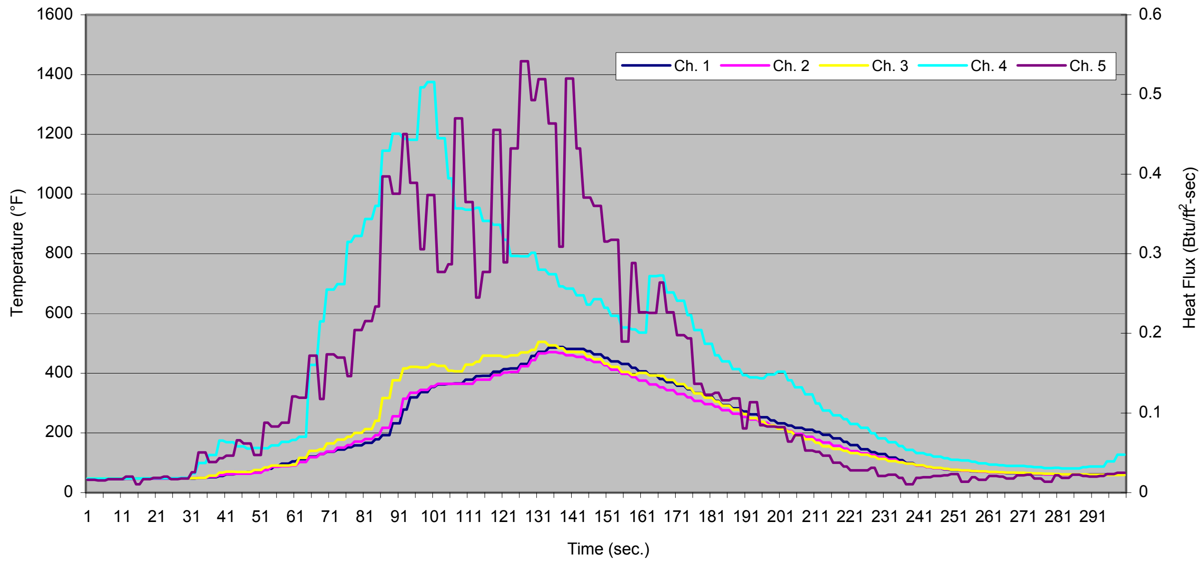

FIGURE 5. SANYO CR2 16-BATTERY TEST

It was noted during these tests that the ignition of a single CR2 battery generated sufficient heat to ignite adjacent batteries. The 1-propanol fire initially fused the batteries together by melting the plastic coating. This facilitated the chain reaction of adjacent battery ignition. Once a single battery was ignited, the heat generated would ignite an adjacent battery and the process continued until all the batteries were consumed. This process continued even after the 1-propanol fire went out.

4.3 SANYO CR2 PACKAGING MATERIAL TESTS.

A series of tests were conducted to determine the effect of the packaging materials on the ignition and propagation of CR2 batteries when exposed to a 1-propanol fire. The tests used corrugated cardboard cases, smooth cardboard separators, and polyurethane foam cushions from actual CR2 shipping boxes, as shown in figure 6. The batteries and shipping materials were suspended 3″ above the fire pan. Tests were conducted using 32, 64, and 128 CR2 batteries. The tests using 32 and 64 batteries used the 5.25″ fire pan and 50 ml of 1-propanol. The test using 128 batteries used the 10.75″ fire pan and 220 ml of 1-propanol. The 10.75″ fire pan allowed for better flame exposure to the test carton.

FIGURE 6. SANYO CR2 BATTERIES PACKED IN A STANDARD BULK SHIPPING CONTAINER

The packing material had several noticeable effects on the battery flammability compared to the multiple-battery tests conducted without packing material. The packing material is quite flammable, igniting easily when exposed to the 1-propanol fire. The packing material fire was sufficiently intense to ignite the CR2 batteries. It does, however, delay the ignition of the batteries by 30 to 60 seconds. In addition, the packing material kept the batteries in close proximity to one another, allowing the heat of the fire to fuse them together. This fusing facilitated the fire propagation between batteries once a single battery was ignited.

The peak temperatures generated by the 32-, 64-, and 128-battery tests were similar, but the duration of the peak temperature was greater with the higher number of batteries. The initial temperature peak is caused by the packing material burning and the second peak by the lithium batteries burning. Figure 7 shows the temperature profile generated by the 128-battery test.

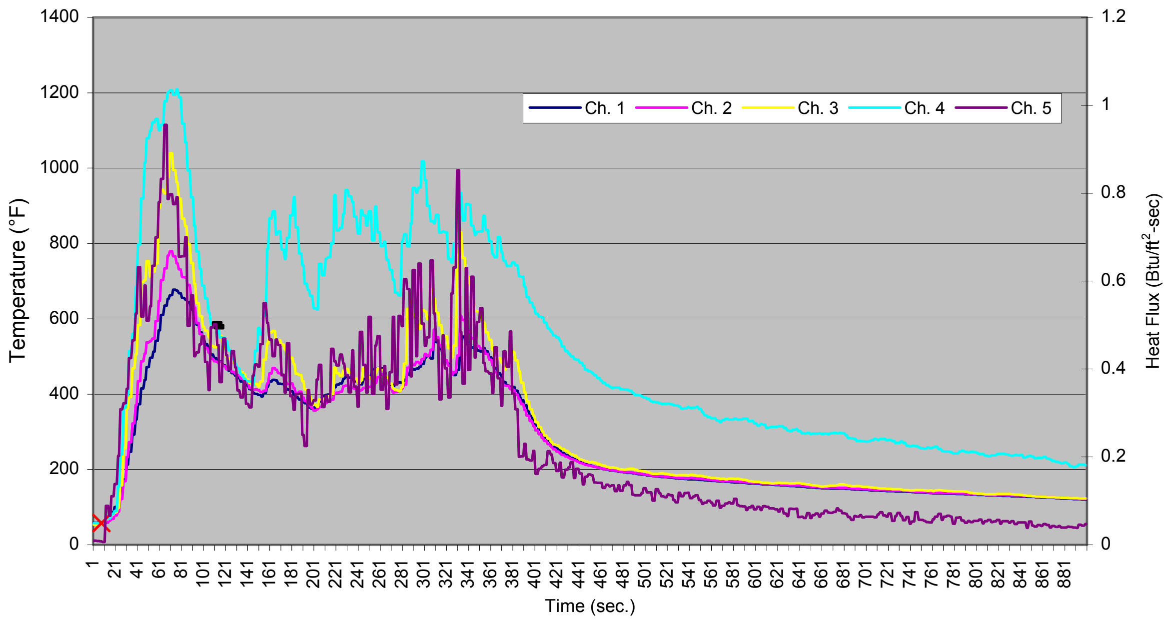

FIGURE 7. PACKING MATERIAL TEST, 128 SANYO CR2 BATTERIES

4.4 CARGO LINER INTEGRITY TESTS.

A series of tests were conducted to determine the effect of molten lithium on standard cargo liner material. The tests were conducted in the 64-cubic-foot chamber using the 5.25″ fire pan and 50 ml of 1-propanol. The tests were designed to maximize the exposure of the cargo liner to both the torching electrolyte and the spraying molten lithium.

The tests were configured by standing a 24″ high by 24″ wide piece of cargo liner vertically in a semicircle around the fire pan. Three groups of four batteries were wired to the support basket suspended over the fire pan. The batteries were arranged so that the positive ends were pointed at the cargo liner with about 3″ separating the batteries and the liner.

Tests were conducted using both a thin- and thick-wall fiberglass-based liner. The thick-wall liner consisted of two layers of fiberglass cloth, while the thin wall had only a single layer of fiberglass cloth.

In each test, the battery fire ignited the resin, causing a secondary fire fueled by the cargo liner. The molten lithium penetrated the thin-wall liner, burning small holes in the liner that ranged from pinpricks up to 0.5″ in diameter. The thick-wall liner was better able to contain the molten lithium, sustaining damage to the inner layer of fiberglass cloth but not penetrating the liner. Figure 8 shows the typical damage sustained by a thin-wall liner as a result of these tests.

FIGURE 8. THIN-WALL CARGO LINER PENETRATION

4.5 HALON SUPPRESSION TESTS.

A series of tests were conducted to evaluate the effectiveness of the standard cargo compartment fire suppression system in controlling a fire that is fueled by primary lithium CR2 batteries. The 64-cubic-foot test chamber was fitted with a Halon 1301 fire suppression system designed to flood the chamber and achieve a 5 percent concentration of Halon 1301. Cargo compartment fire suppression systems are designed to initially flood the compartment to a minimum of 5 percent Halon 1301 to knockdown the fire and then maintain 3 percent to keep the fire suppressed.

A charge of 1.3 pounds of Halon 1301 was required to achieve a nominal 5.5% concentration in the 64-cubic-foot test chamber. This was verified and monitored using an infrared gas analyzer.

Tests were conducted using 4, 8, 16, and 32 CR2 batteries, the 10.75″ fire pan, and 220 ml of 1-propanol. In each case, the results were identical. Discharging the halon prior to battery ignition resulted in the extinguishment of the 1-propanol fire and no battery involvement. However, discharging the halon after only one battery was ignited had no effect on stopping the propagation of the battery fire to adjacent batteries. The halon extinguished the 1-propanol fire immediately but had no effect on the lithium fire with the exception of turning the normally white sparks bright red.

The color change of the lithium sparks indicated that a reaction was occurring between the lithium and the Halon 1301. This reaction had no effect on the fire progression, neither hindering nor promoting the spread of the battery fire. The vented electrolyte fires, normally pale red in color, turned bright red when exposed to Halon 1301.

The battery fire continued to propagate until all batteries were consumed, continuing long after the 1-propanol fire was extinguished. The halon also had no effect on the peak temperatures in the test chamber, peaking at about 1400°F. This is similar to the peak temperatures exhibited in previous unsuppressed fires. However, the overall temperature profiles were lower, due to the extinguishment of the 1-propanol and battery plastic coating fires. Figure 9 shows the temperature profiles generated during the 32-battery test.

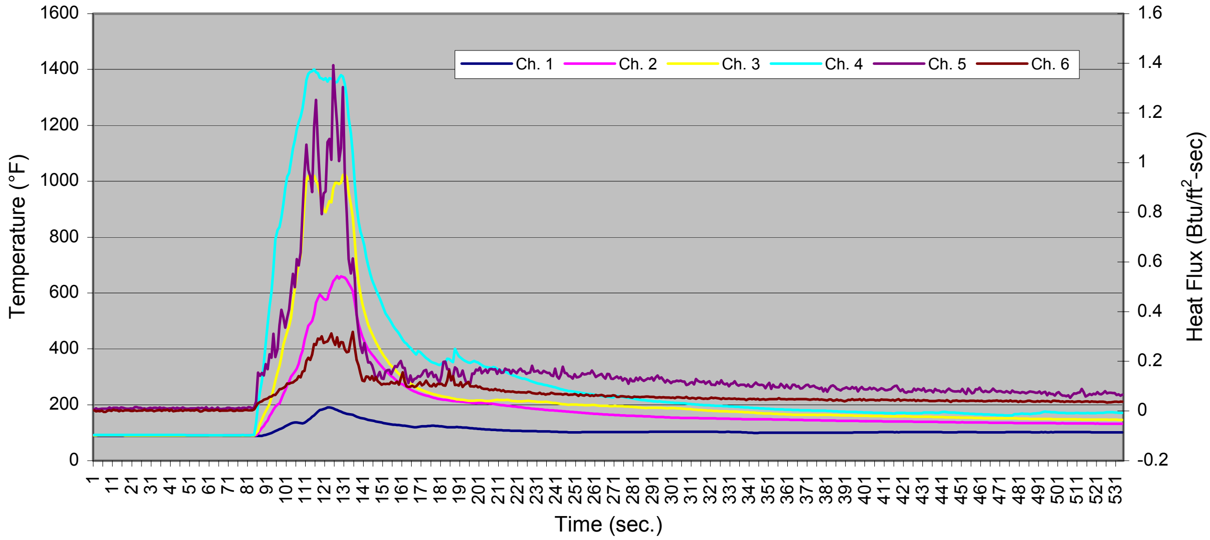

FIGURE 9. HALON 1301 SUPPRESSION TEST WITH 32 CR2 BATTERIES

5. DURACELL PL123A BATTERIES.

5.1 DURACELL PL123A SINGLE-BATTERY FAILURE MODE.

When exposed to a 1-propanol fire, the failure mode of the Duracell PL123A battery is very similar to the previously tested Sanyo CR2 battery. The battery initially vents electrolyte gas, usually at the positive electrode. The electrolyte gas torches with a red flame and generates some propulsive force along with a more pronounced pressure pulse. After the electrolyte burned off, the molten lithium burned explosively, spraying white-hot lithium through the vent holes.

5.2 DURACELL PL123A MULTIPLE-BATTERY TESTS.

A series of tests were conducted with 4, 8, and 16 Duracell PL123A batteries. The results were similar to the Sanyo CR2 tests. The ignition of a single battery provided sufficient energy to ignite adjacent batteries, propagating through the remaining batteries until all were consumed. A strong pressure pulse was noted at each electrolyte ignition, causing the Plexiglas viewing window to bulge. Peak temperatures were also similar to those noted in the Sanyo CR2 tests, approximately 1375°F, measured 12″ above the 1-propanol fire. Figure 10 shows the temperature profile generated by the 16-battery test.

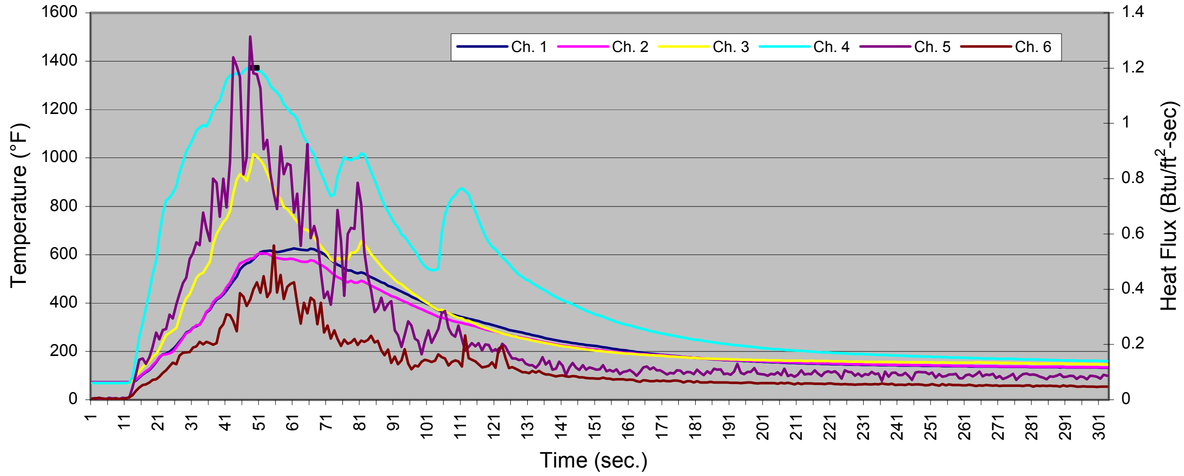

FIGURE 10. DURACELL PL123A 16-BATTERY TEST

5.3 DURACELL PL123A HALON SUPPRESSION TESTS.

Two tests were conducted in the 64-cubic-foot test chamber using the 10.75″ fire pan and 220 ml of 1-propanol. Each test was run using 16 Duracell PL123A batteries and 1.8 pounds of Halon 1301, which was discharged after the first battery was ignited. The results in each test were similar to those found in the halon suppression tests with Sanyo CR2 batteries. The halon immediately extinguished the 1-propanol fire and reduced the overall temperature profile in the chamber but did nothing to impede the progress of the battery fire once a single battery had ignited. The normally white molten lithium sparks turned bright red. The battery fire propagated until all batteries were consumed. Figure 11 shows the temperature profile generated by the 16-battery test suppressed with Halon 1301.

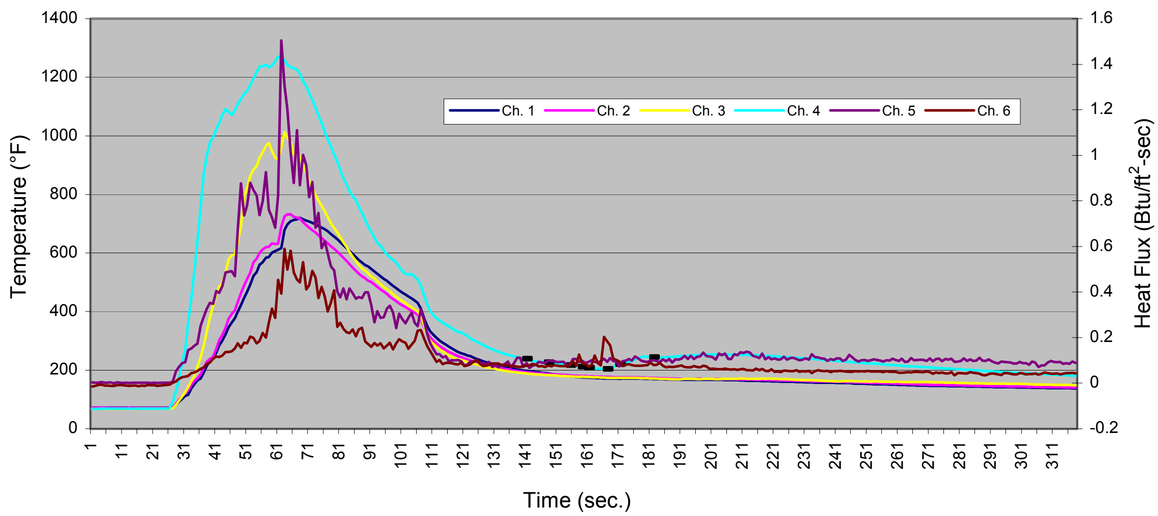

FIGURE 11. DURACELL PL123A 16-BATTERY HALON 1301 SUPPRESSION TEST

6. PANASONIC PL123A MULTIPLE-BATTERY TESTS.

A series of tests were conducted using 4, 8, 12, and 16 Panasonic PL123A batteries. The tests were conducted using the 10.75″ fire pan and 220 ml of 1-propanol in the 64-cubic-foot test chamber. These batteries proved much more explosive than the Duracell or Sanyo battery tests. The ignition mode and propagation were similar to the other batteries, but the pressure pulse exhibited appeared to be several times stronger. The tests were terminated at 16 batteries due to the explosive nature of these batteries; the pulse was strong enough to blow the clamps off the chamber door. Peak temperatures during these tests were somewhat lower than previous tests, possibly due to oxygen starvation. Peak temperatures were approximately 1175°F. No halon suppression tests were conducted with these batteries. Figure 12 shows the temperature profile generated by the 16-battery test.

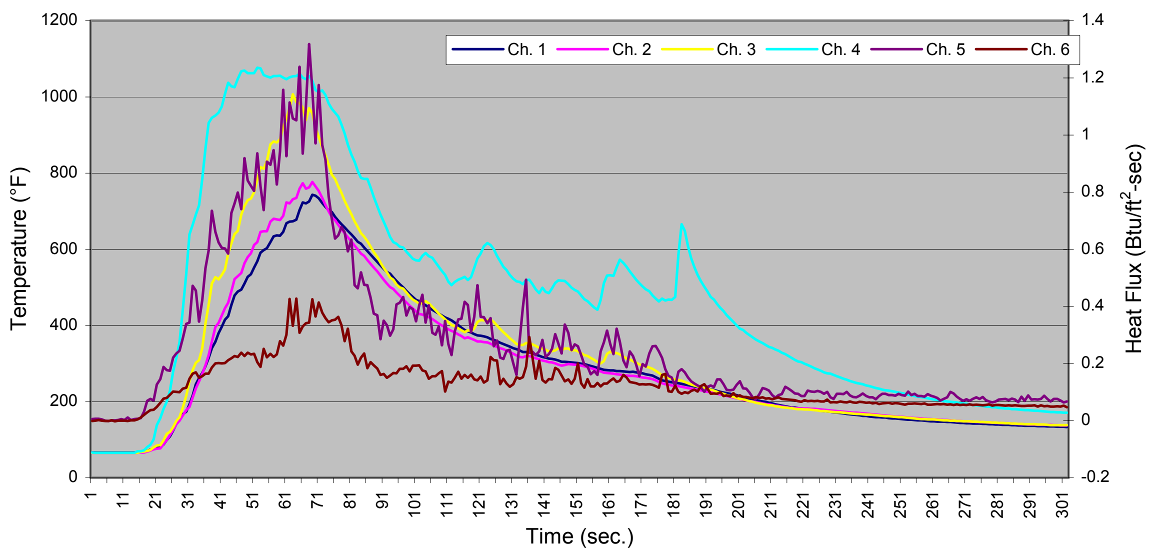

FIGURE 12. SIXTEEN PANASONIC PL123A BATTERIES, 10.75″ FIRE PAN, 220-ml 1-PROPANOL

7. EXPLOSION TESTS.

A series of tests were conducted to measure the explosive effects of three types of burning primary lithium batteries: Sanyo CR2, Duracell PL123A, and Panasonic PL123A. The tests were conducted in the Federal Aviation Administration Pressure Modeling Facility. This facility consists of a 10-cubic-meter airtight chamber that is fitted with pressure- and temperature-monitoring instrumentation. The pressure transducer sensor port and the thermocouples were located near the center of the chamber. The fire pan and the batteries were located near the end of the chamber.

7.1 SANYO CR2 BATTERIES.

Three tests were conducted with the Sanyo CR2 batteries, one test each of 4, 8, and 16 batteries. The ignition source for these tests was the 5.25″ fire pan and 50 ml of 1-propanol. Due to the airtight nature of the test chamber, each battery ignition raised the pressure in the vessel in an additive fashion: the pressure from each battery added to the total vessel pressure with no loss due to leakage. The four-battery test raised the pressure by approximately 1.1 psi (see figure 13). The eight-battery test raised the pressure in the vessel by 1.8 psi (see figure 14). The 16-battery test raised the pressure by 2.6 psi (see figure 15). In each test, the temperature in the vessel only increased a few degrees Fahrenheit, contributing little to the overall pressure rise.

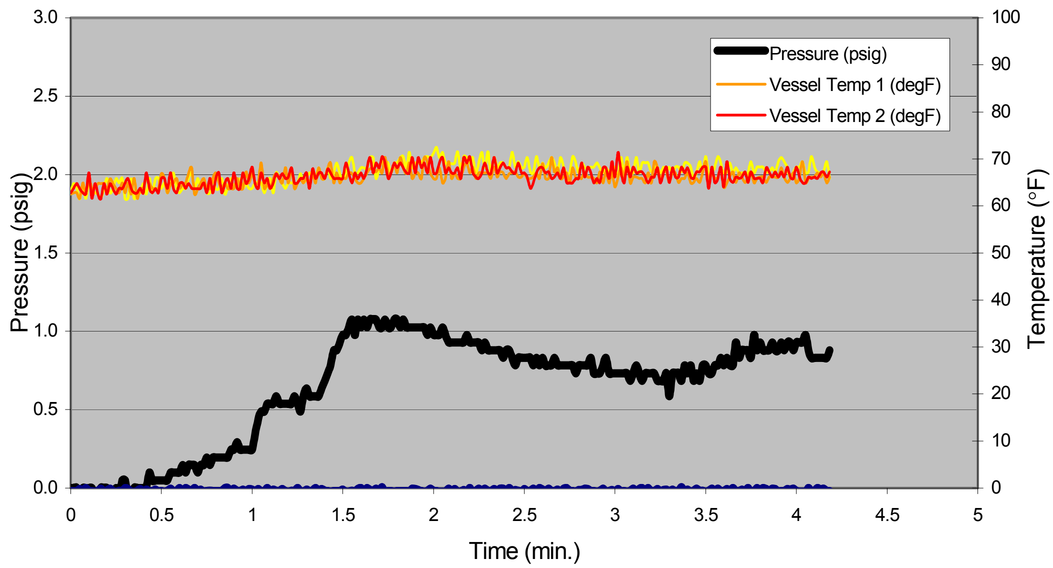

FIGURE 13. SANYO CR2 FOUR-BATTERY EXPLOSION TEST

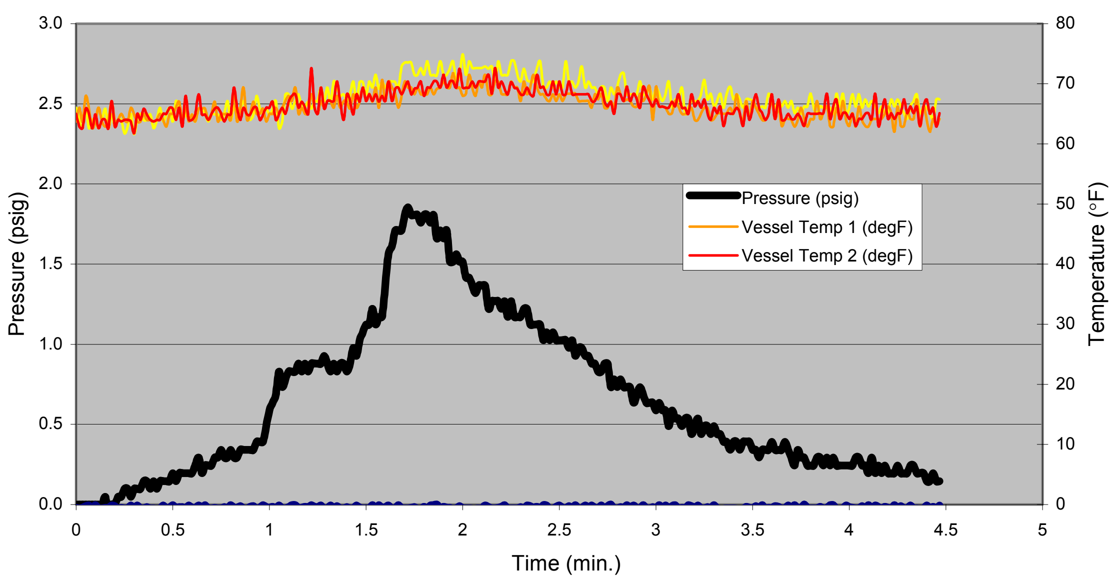

FIGURE 14. SANYO CR2 EIGHT-BATTERY EXPLOSION TEST

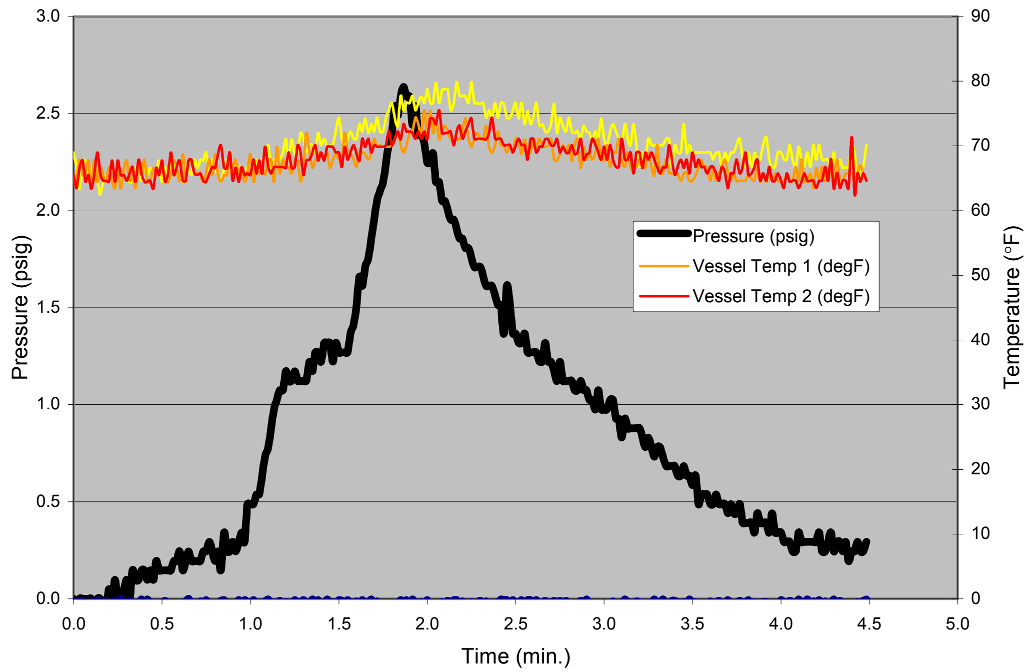

FIGURE 15. SANYO CR2 16-BATTERY EXPLOSION TEST

7.2 DURACELL PL123A BATTERIES.

One test was conducted with four Duracell PL123A batteries. The conditions were the same as the Sanyo CR2 battery test. The pressure rise in the chamber was approximately 1.2 psi (see figure 16).

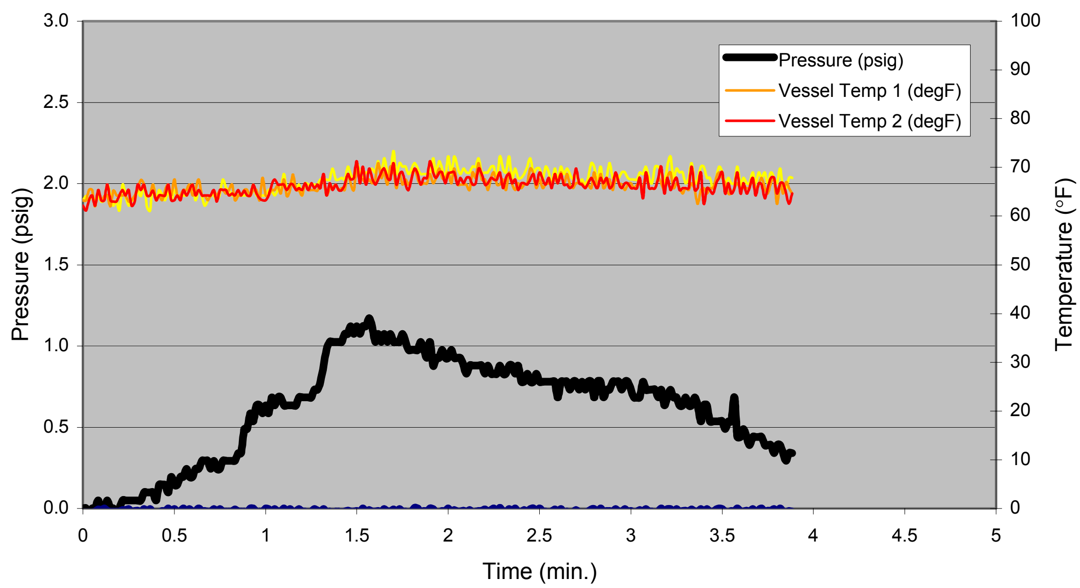

FIGURE 16. DURACELL PL123A FOUR-BATTERY EXPLOSION TEST

7.3 PANASONIC PL123A BATTERIES.

One test was conducted with three Panasonic PL123A batteries. The conditions were similar to the Sanyo CR2 and Duracell PL123A battery tests. The pressure rise in the vessel was 1.2 psi (see figure 17).

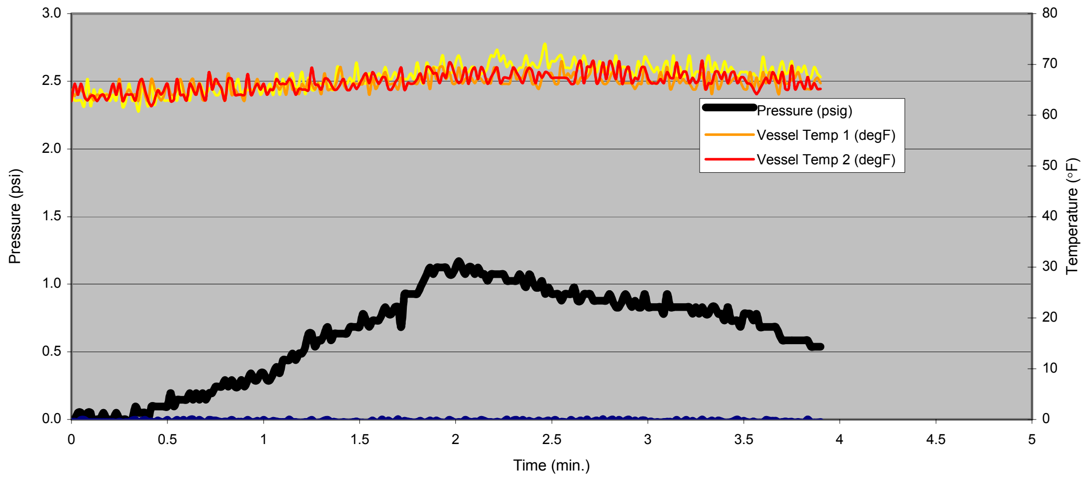

FIGURE 17. PANASONIC PL123A THREE-BATTERY EXPLOSION TEST

These results are significant. The cargo compartment is only constructed to withstand a 1-psi pressure differential in order to rapidly equalize pressure in the event of a depressurization. Anything over 1 psi would activate the blowout panels, compromising the cargo compartment's integrity. This would also allow the halon suppression gas to escape, reducing the suppression concentration and allowing the cargo fire to flare-up. Real cargo compartments differ from the test chamber in two significant ways—the volume is much larger and the compartments are not as airtight—which would tend to increase the number of batteries needed to raise the pressure above 1 psi in a cargo compartment fire. However, it appears that the cargo compartment could overpressurize due to a fire involving bulk-packed lithium batteries.

8. AUTOIGNITION TESTS.

The purpose of these tests was to determine the risk of battery ignition due to a smoldering suppressed fire in a cargo compartment. The temperature in a fully suppressed cargo compartment fire can locally exceed 1000°F in a smoldering fire, and the air temperature at the ceiling can range from 410° to 665°F [1]. The autoignition temperature of pure lithium is 355°F.

A 1-cubic-foot steel test chamber was constructed. The chamber was insulated and provided with an external propane heat source. The batteries were suspended in the center of the chamber. A thermocouple was installed near the battery to measure the chamber interior temperature.

Autoignition tests were conducted on two types of batteries, the Sanyo CR2 and the Panasonic PL123A. The battery was installed in the test chamber, and the propane burner was turned on. The temperature in the chamber was monitored, with the sudden rise in temperature signaling the ignition of the battery.

8.1 SANYO CR2.

Five tests were conducted with this battery. The average temperature when ignition occurred was 487°F. This resulted in an average temperature rise in the chamber of 524°F.

8.2 PANASONIC PL123A.

Five tests were conducted with this battery. The average temperature when ignition occurred was 524°F. This resulted in an average temperature rise in the chamber of 514°F.

These temperatures are within the range found in a suppressed cargo compartment.

9. RECHARGEABLE LAPTOP BATTERY TESTS.

Two fire pan tests were conducted with rechargeable laptop computer batteries in the 64-cubic-foot test chamber. Though outside the scope of this project, the limited results are interesting. The battery used for the test was a Compaq Presario Li-ion P/N 141161-B21, Hi Cap LiIon 14.4 V 3.2 Ahr, series CM2031. The state of charge was unknown at the time of the tests and, therefore, no conclusion can be drawn as to its importance.

The batteries were subjected to the 10.75″ fire pan with 220 and 300 ml of 1-propanol and tested in the 64-cubic-foot test chamber. The amount of 1-propanol was increased in the second test to provide an increased fire duration. In each case, the results were the same. The batteries did not burn with an open flame. The plastic case deformed and melted and eventually charred. There were some small amounts of venting and tiny sparks of lithium. The case did not self-sustain any fire once the 1-propanol was consumed. Peak temperatures, measured 12″ above the fire pan, were not significantly greater than those measured in a 1-propanol fire without batteries, peaking at about 1000°F. The shape of the temperature curve indicates that there was some heat release due to the charring of the battery case (see figure 18).

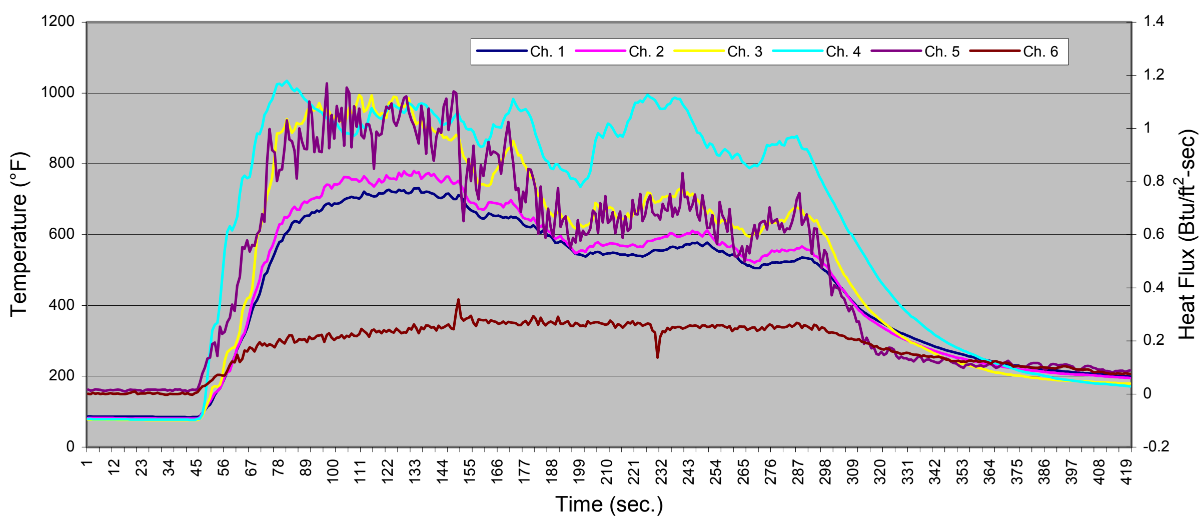

FIGURE 18. RECHARGEABLE COMPUTER LAPTOP BATTERY TEST

10. CONCLUSIONS.

A relatively small fire source was sufficient to start a primary lithium battery fire. The outer plastic coating easily melted and fused adjacent batteries together and then ignites, contributing to the fire intensity. This helped to raise the battery temperature to the self-ignition temperature of lithium. Once the lithium in a single battery began to burn, it released enough energy to ignite adjacent batteries. This propagation continued until all batteries were consumed.

Halon 1301, the fire suppression agent installed in transport category aircraft, was ineffective in suppressing or extinguishing a primary lithium battery fire. Halon 1301 appeared to chemically interact with the burning lithium and electrolyte, causing a color change in the molten lithium sparks, turning them a deep red instead of the normal white. This chemical interaction had no effect on battery fire duration or intensity.

The air temperature in a cargo compartment that had a fire suppressed by Halon 1301 can still be above the autoignition temperature of lithium. Because of this, batteries that were not involved in the initial fire can still ignite and propagate.

The ignition of a primary lithium battery released burning electrolyte and a molten lithium spray. The cargo liner material may be vulnerable to perforation by molten lithium, depending on its thickness. This can allow the Halon 1301 fire suppressant agent to leak out of the compartment, reducing the concentration within the cargo compartment and the effectiveness of the agent. Holes in the cargo liner may also allow flames to spread outside the compartment.

The ignition of primary lithium batteries released a pressure pulse that raised the air pressure within the cargo compartment. The ignition of only a few batteries was sufficient to increase the air pressure by more than 1 psi in an airtight 10-meter-cubed pressure vessel. Cargo compartments are only designed to withstand approximately a 1-psi pressure differential. The ignition of a bulk-packed lithium battery shipment may compromise the integrity of the compartment by activating the pressure relief panels. This has the same effect as perforations in the cargo liner, allowing the Halon 1301 fire suppressant to leak out, reducing its effectiveness.

11. REFERENCES.

1. Reinhardt, J. W., Blake D., and Marker, T., "Development of a Minimum Performance Standard for Aircraft Cargo Compartment Gaseous Fire Suppression Systems," FAA report DOT/FAA/AR-00/28, September 2000.

RECOMMENDATION 1

EXHIBIT B

DOCKET NO. SA-228

EXHIBIT NO. 17AA

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

HAZARDOUS MATERIALS; PROHIBITION ON THE TRANSPORTATION OF PRIMARY LITHIUM BATTERIES AND CELLS ABOARD PASSENGER AIRCRAFT

[DOCKET NO. RSPA-04-19886 (HM-224E]

Federal Register

Wednesday,
December 15, 2004

Part V

Department of Transportation

Research and Special Programs Administration

49 CFR Parts 171, 172, 173 and 175

Hazardous Materials; Prohibition on the Transportation of Primary Lithium Batteries and Cells Aboard Passenger Aircraft; Final Rule

of lithium batteries should be prohibited on both passenger-carrying and cargo-only aircraft. ALPA also requested that DOT perform additional testing of lithium ion batteries and lithium batteries contained in equipment.

In its petition, ALPA references the recent RSPA rulemaking published under Docket HM–224B on May 6, 2004 (69 FR 25469), which proposed a requirement for oxygen cylinders to be overpacked in a packaging that would allow the cylinder to withstand a temperature of 400 °F for 3 hours. ALPA states that current packaging standards for lithium batteries provide no such protection against a suppressed cargo fire.

IV. Interim Final Rule

The incident reports and test data discussed above indicate that primary lithium batteries and cells shipped as cargo on passenger-carrying aircraft pose an immediate risk to the traveling public. This information shows that a primary lithium battery that is involved in a fire in a passenger aircraft cargo compartment could overcome the safety features of the cargo compartment; that if primary lithium batteries are not properly packaged or handled, they are capable of initiating a fire that could have catastrophic consequences. Therefore, in this interim final rule, RSPA is prohibiting the transportation as cargo of primary (non-rechargeable) lithium batteries and cells on passenger-carrying flights. We are implementing this restriction by reference to new Special Provisions A100, A101, and A102 in the hazmat table for the lithium battery entries. The current package quantity limitations for secondary lithium batteries have been moved unchanged to new Special Provisions A103 and A104. The action is this interim final rule are consistent with the policies of several airlines (*e.g.*, Northwest Airlines and KLM) who have already prohibited the transport of lithium batteries aboard their aircraft We are also prohibiting the transportation of equipment containing or packed with large primary lithium batteries as cargo (*i.e.* batteries greater than 25 grams) on passenger-carrying aircraft. These prohibitions apply to both domestic flights and international flights.

A. Cargo Aircraft

These prohibitions do not apply to shipments of primary lithium batteries and cells on a cargo-only aircraft. After careful consideration of past experiences with hazardous materials, recent incidents with lithium batteries, and NTSB safety recommendations, RSPA and FAA agree that the greatest risk to public safety is on passenger-carrying operations. While it is certainly possible that an incident involving a primary lithium battery may occur on a cargo-only aircraft, the risk to public safety is much lower.

Generally speaking, the characteristics of all-cargo aircraft provide options to pilots that would allow them to stop airflow to cargo compartments while the aircraft remains at a high altitude. Such action, especially at high altitude, would reduce the amount of oxygen available to a fire. Stopping or reducing the amount of oxygen to a compartment would help mitigate a fire. On a passenger aircraft, it would be more difficult to isolate airflow to a cargo compartment without also isolating air flow to the passenger compartment. The FAA confirmed that at least two major all-cargo air carriers already advise pilots to use these types of procedures to help respond to a fire.

B. Passengers Carrying Batteries in Carry-on or Checked Baggage

This interim final rule does not prohibit a passenger from transporting devices containing lithium batteries for personal use (such as laptop computers, cell phones, cameras, etc.) in carry-on or checked baggage nor does it restrict a passenger from transporting spare lithium batteries for personal use in carry-on or checked baggage.

Under this interim final rule, consumer electronics or medical devices containing a lithium battery, together with spare batteries for the device, are also permitted in checked baggage because it is not clear at this time to what extent the surrounding piece of equipment provides protection for the battery and prevents propagation. For each installed or spare cell or battery, the lithium content of the anode of each cell, when fully charged, may not exceed five grams, and the lithium content of the anodes of each battery, when fully charged, may not exceed 25 grams.

It is RSPA's belief that this interim final rule will have little or no effect on those personal electronic devices that passengers currently carry aboard passenger-carrying aircraft. RSPA and the FAA may consider this issue and others for future rulemaking action.

C. Batteries Shipped in or with Equipment

The prohibition in this interim final rule does not apply to the transportation as cargo on passenger aircraft of small primary lithium batteries that are shipped with or installed in equipment for which they are intended to provide power. The risk associated with shipment of primary lithium batteries in or with equipment is currently unclear. Studies conducted by the FAA and other government agencies focused only on shipments of primary lithium batteries, not on batteries contained in equipment. RSPA and the FAA will continue to study small lithium batteries shipped with equipment and will initiate additional actions as necessary.

Those primary lithium batteries or cells we are continuing to allow to be transported as cargo aboard passenger-carrying aircraft when packed with or in equipment must: (1) comply with the requirements and limitations of § 173.185(b)(1), (b)(2), (b)(3), (b)(4) and (b)(6) or § 173.185(c)(1), (c)(2), (c)(3) and (c)(5); (2) the battery or cell or equipment containing the battery or cell, as appropriate, must be packed in strong packagings; (3) the package contains no more than the number of primary lithium batteries or cells necessary to power the intended piece of equipment; and (4) the total net weight of the primary lithium batteries in the package does not exceed 5 kg. Further, these types of lithium batteries are only allowed to be transported aboard passenger-carrying aircraft when packed with the piece of equipment for which they are intended to provide power.

The provisions in § 173.185(b) and § 173.185(c) deal, in part, with the size of the lithium battery or cell and require that the cell or battery be hermetically sealed and that the batteries and cells be packed to prevent short circuiting. Concerning size limitations, § 173.185(c)(1) restricts the lithium content of the anode of each cell, when fully charged, to not more than five grams and the aggregate lithium content of the anodes of each battery, when fully charged, to not more than 25 grams.

D. Secondary Lithium (Rechargeable/ Lithium Ion) Batteries and Cells

FAA and RSPA have similar concerns with lithium (rechargeable/lithium ion) batteries in that they appear to have similar self-ignition characteristics as primary lithium cells and batteries when subjected to thermal and physical abuse conditions. However, the risks associated with the shipment of secondary (rechargeable/lithium ion) lithium batteries, particularly with respect to their ability to burn in an atmosphere containing Halon, are currently unclear. Studies conducted by the FAA focused only on shipments of primary lithium batteries, not secondary (rechargeable) lithium batteries. RSPA and the FAA will continue to study the

RECOMMENDATION 2

EXHIBIT A

U.S. Department of Transportation
Federal Aviation Administration

800 Independence Ave., S.W.
Washington, D.C. 20591

FEB 2 2001

Mr. Robert M. Miller
c/o Independent Pilots Association
200 High Rise Drive, Suite 199
Louisville, KY 40213

Dear Mr. Miller:

This is in response to your October 6 letter, on behalf of The Coalition of Airline Pilots Association, in which you petitioned the Federal Aviation Administration (FAA) to amend part 139 of Title 14, Code of Federal Regulations. The amendment you request would require aircraft rescue and firefighting (ARFF) capability at airports serving large cargo aircraft.

The FAA has the statutory authority to issue airport operating certificates to airports serving certain air carriers and to establish minimum safety standards for those airports, including ARFF standards. This authority is currently found in Title 49, United States Code (U.S.C.) § 44706. However, this authority is limited to land airports serving passenger operations.

Because the FAA does not have the authority to require certificated airports to extend ARFF coverage to large cargo aircraft operations, we are unable to consider your petition for rulemaking; therefore, it is denied. Accordingly, Docket No. FAA-2000-8077 is being closed.

Sincerely,

Director, Office of Airport Safety
and Standards, AAS-1

RECOMMENDATION 2

EXHIBIT B

109TH CONGRESS
1ST SESSION

H. R. 4123

To amend section 44706 of title 49, United States Code, to require operating certificates for airports at which large cargo operations are conducted.

IN THE HOUSE OF REPRESENTATIVES

OCTOBER 20, 2005

Mr. WELDON of Pennsylvania (for himself, Mr. WILSON of South Carolina, and Mr. BROWN of South Carolina) introduced the following bill; which was referred to the Committee on Transportation and Infrastructure

---

A BILL

To amend section 44706 of title 49, United States Code, to require operating certificates for airports at which large cargo operations are conducted.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the ''Air Cargo Fire and Rescue Enhancement Act''.

SEC. 2. AIRPORT OPERATING CERTIFICATES.

(a) IN GENERAL.—Section 44706(a)(1) of title 49, United States Code, is amended—

(1) by inserting ''(A)'' before ''that serves'';

(2) by inserting "or" after the semicolon at the end; and

(3) by adding at the end the following:

"(B) that serves an air carrier operating aircraft that provide all cargo air transportation and have a maximum certificated gross take-off weight of 100,000 pounds or greater;".

(b) REGULATIONS.—The Administrator of the Federal Aviation Administration shall issue a notice proposed rulemaking to implement the amendment made by subsection (a) not later than 180 days after the date of enactment of this Act and shall issue a final rule to implement such amendment not later than 365 days after such date of enactment.

(c) IMPLEMENTATIONS.—

(1) IN GENERAL.—Subject to paragraph (2), the regulation issued under subsection (b) shall take effect on the 180th day following the date of its issuance.

(2) DELAYED IMPLEMENTATION.—An airport operator that is affected by the regulation issued under subsection (b) may request from the Administrator, and the Administrator may grant such operator, up to a 2-year period from the date the regula-

tion is issued to begin implementation of the regulation and the amendment made by subsection (a).

○

RECOMMENDATION 4

EXHIBIT A

U.S. Department
of Transportation
Federal Aviation Administration

Advisory Circular

Subject: IN-FLIGHT FIRES

Date: 1/8/04
Initiated by: AFS-210

AC No: 120-80

1. WHAT IS THE PURPOSE OF THIS ADVISORY CIRCULAR (AC)?

a. General. The National Transportation Safety Board (NTSB) conducted a review of commercial aviation accidents involving in-flight fires. The scope of the review was limited to transport category airplanes operated by U.S. and foreign air carriers during the period 1983 to 2000. That review prompted the NTSB to issue a number of safety recommendations to the FAA, including A-01-83 through A-01-87 (see Appendix 1). The NTSB recommended that an Advisory Circular (AC) be developed and issued by the FAA to address a number of issues linked to in-flight fires. The FAA agrees with the safety intent of those recommendations and has developed the guidance material that follows. Specifically, this AC:

- Discusses the dangers of in-flight fires, with particular emphasis on hidden fires that may not be visible or easily accessed by the 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.

- Provides guidance on how to deal with in-flight fires, emphasizing the importance of crewmembers taking immediate and aggressive action in response to signs of an in-flight fire while stressing the effectiveness of Halon extinguishing agents.

- Discusses the importance of appropriate crewmember training in dealing with hidden fires, the effective application of fire extinguishing agents behind interior panels, and the urgency of the crew's action in dealing with such fires.

- Complements guidance previously developed for crewmembers concerning the proper use of cabin fire extinguishers (AC 20-42C, Hand Fire Extinguishers for Use in Aircraft, and National Fire Protection Association (NFPA) 408, Standard for Aircraft Hand Portable Fire Extinguishers) and the most effective means of extinguishing fires that are readily accessible.

- Includes information from research conducted by the FAA's Technical Center. As additional information becomes available, it will be published in future revisions to this AC.

7. CAN HALON CAUSE HARM TO PASSENGERS AND CREW?

a. Generally speaking, no. Various publications, including AC 20-42C, caution against exposure to "high levels" of Halon in confined spaces, citing the possibility of dizziness, impaired coordination, and reduced mental sharpness. AC 20-42C also provides guidelines that describe what is meant by the term "high level" and further states that these levels should not be exceeded in ventilated or non-ventilated passenger compartments on aircraft. However, studies have shown that discharging all of the hand-held Halon extinguishers required by regulation in the passenger cabin of an air carrier aircraft will not exceed the maximum concentration levels of Halon vapor specified in AC 20-42C or by NFPA 408 guidelines.

b. NTSB investigations of in-flight fires indicate that crewmembers have been hesitant to use Halon extinguishers during flight because of mistaken ideas about adverse effects of Halon. In one instance, a flight attendant went to the flight deck to inform the flightcrew of a fire and asked the captain whether to spray Halon into a vent where she suspected a fire. The captain instructed her not to use the Halon extinguisher, indicating he was concerned about spraying Halon in the cabin. In another instance, an off-duty company pilot considered using a Halon fire extinguisher, but decided against doing so because he was concerned that the Halon "would take away more oxygen." In each instance, the crewmembers lost critical time and delayed the aggressive pursuit of the fire.

c. The NTSB has expressed concern that risks of exceeding the maximum recommended levels of Halon gas outlined in AC 20-42C have been overemphasized in crewmember training programs, especially when compared to the risks of an in-flight fire. The NTSB emphasizes "…that the potential harmful effects on passengers and crew [of Halon] are negligible compared to the safety benefits achieved by fighting in-flight fires aggressively." The toxic effects of a typical aircraft seat fire, for example, far outweigh the potential toxic effects of discharging a Halon fire extinguisher.

8. QUESTIONS FOR CREWMEMBERS TO CONSIDER.

a. How critical are small in-flight fires? In-flight fires left unattended, particularly those that are not readily accessible, may lead to catastrophic failure and have resulted in the complete loss of airplanes. Fire tests conducted by various regulatory authorities have shown that fires allowed to spread into the aircraft's overhead area may become uncontrollable in as few as 8-10 minutes.

Studies have also shown that a flightcrew may have as few as 15-20 minutes to get an aircraft on the ground if the crew allows a hidden fire to progress without any intervention. Appendix 3 provides various illustrations of the time from the first indication to the crew of the presence of a hidden fire until it becomes catastrophically uncontrollable. These studies and other experience indicate that flight crewmembers should begin planning for an emergency landing as soon as possible after the first indication of fire. Delaying the aircraft's descent by only a couple of minutes might make the difference between a successful landing and evacuation and complete loss of an aircraft and its occupants.

APPENDIX 3. TIME TO BECOMING NONSURVIVABLE [1]

The following chart depicts the time that various crews had from the first indication of the presence of a hidden fire, to the time that fire became catastrophically uncontrollable.

DATE	LOCATION	AIRCRAFT TYPE	TIME TO BECOME NON-SURVIVABLE (MINUTES)
07-26-1969	BISKRA, ALGERIA	CARAVELLE	26
07-11-1973	PARIS, FRANCE	B-707	7
11-03-1973	BOSTON, USA	B-707	35
11-26-1979	JEDDAH, SAUDIA ARABIA	B-707	17
06-02-1983	CINCINATTI, USA	DC-9	19
11-28-1987	MAURITIUS, INDIAN OCEAN	B-747	19
09-02-1998	NOVA SCOTIA, CANADA	MD-11	16

For aircraft with hidden fires, an approximate assessment is that only one third will reach an airfield before the fire becomes uncontrollable. [2]

[1] CAA PAPER 2002/02, (FAA Reference DOT/FAA/AR-02/50), "A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft, p." 6
[2] CAA PAPER 2002/02, (FAA Reference DOT/FAA/AR-02/50), "A Benefit Analysis for Enhanced Protection from Fires in Hidden Areas on Transport Aircraft," p. 20

RECOMMENDATION 6

EXHIBIT A

DOCKET NO. SA-228

EXHIBIT NO. 20C

NATIONAL TRANSPORTATION SAFETY BOARD

WASHINGTON, D.C.

CHARACTERISTIC OF FIRE IN LARGE CARGO AIRCRAFT (PHASE II)
(FAA-RD-70-42)

by

[Julius J. Gassman]

]

11 SEP 1970

Report No. FAA-RD-70-42

CHARACTERISTICS OF FIRE IN LARGE CARGO AIRCRAFT (PHASE II)

Julius J. Gassmann
National Aviation Facilities Experimental Center
Atlantic City, New Jersey 08405

SEPTEMBER 1970

FINAL REPORT

Availability is unlimited. Document may be released to the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151, for sale to the public.

Prepared for

FEDERAL AVIATION ADMINISTRATION

Systems Research & Development Service

Washington D. C., 20590

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		14. Sponsoring Agency Code
15. Supplementary Notes None		

16. Abstract

The degree to which fire in large cargo compartments may be suppressed by shutoff of ventilation was investigated. Results of the tests indicated that this action alone would not protect the fuselage of large cargo aircraft from severe fire damage.

Peak air temperatures occurring during fire increased significantly with increasing compartment size from 1,000 to 2,000 cubic feet and were similar with further increase in size to 5,000 cubic feet. Temperatures in the order of 1,800°F were reached in these larger compartments.

An increase in percent loading resulted in a more severe fire condition for compartment volumes of all the sizes used in this program.

A single cargo fire test indicated the use of bromotrifluoromethane at the time of detection and ventilation shutoff may be an effective means of greatly reducing peak temperatures and pressures and providing a longer control time.

17. Key Words Aircraft Fires, Aircraft Cabins, Fire Safety, Transport Planes		18. Distribution Statement Availability is unlimited. Document may be released to the Clearinghouse for Federal Scientific and Technical Information, Springfield, Virginia 22151, for sale to the public.	
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