DOT/FAA/TCTN-23/63

Federal Aviation Administration
William J. Hughes Technical Center
Aviation Research Division
Atlantic City International Airport
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Lithium Battery Detecting Canine Demonstration

September 2023

Technical Note

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1. Report No. DOT/FAA/TCTN-23/63	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle Lithium Battery Detecting Canine Demonstration		5. Report Date September 2023 6. Performing Organization Code ANG-E211
7. Author(s) Steven Rehn		8. Performing Organization Report No.
9. Performing Organization Name and Address Federal Aviation Administration William J. Hughes Technical Center Aviation Research Division Atlantic City International Airport, NJ 08405		10. Work Unit No. (TRAIS) 11. Contract or Grant No.
12. Sponsoring Agency Name and Address		13. Type of Report and Period Covered Technical Note 14. Sponsoring Agency Code ANG-E2
15. Supplementary Notes		

16. Abstract

This report summarizes a short test conducted by the Federal Aviation Administration (FAA) to determine the effectiveness of a trained canine to detect lithium batteries hidden inside of boxes. Fifteen identical cardboard boxes that either contained different types of lithium batteries, or were empty, were spread out around a building for the canine to inspect. On the initial quick scan, the dog was correct on 11 out of the 15 boxes, with more accurate results on lithium-ion batteries than lithium metal. On a second more thorough inspection, the canine was 100% accurate on all the boxes. The effectiveness of this dog in detecting lithium batteries shows that this could potentially be a reasonably accurate and practical method for future detection of non-compliant lithium battery shipments on passenger and cargo aircraft.

17. Key Words Lithium, battery, lithium-ion, lithium metal, canine, dog	18. Distribution Statement This document is available to the U.S. public through the National Technical Information Service (NTIS), Springfield, Virginia 22161. This document is also available from the Federal Aviation Administration William J. Hughes Technical Center at www.faa.gov/data_research/library		
19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	19. Security Classif. (of this report)

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Acronyms

Acronym	Definition
FAA	Federal Aviation Administration
UN	United Nations
g	grams
kg	kilograms
Wh	Watt-hour

Executive summary

In order to protect air passengers and crew, all bulk shipments of lithium batteries are forbidden from being shipped on passenger aircraft, and must follow very strict regulations to be shipped on cargo aircraft. Undeclared lithium battery cargo can potentially create a significant fire hazard when these regulations are not followed. Trained canines are being explored as a practical method to detect illegal lithium battery shipments. This report summarizes a short test conducted by the Federal Aviation Administration (FAA) to determine the effectiveness of an extensively and uniquely trained dog by Canine Solutions, SOC LLC to detect lithium batteries hidden inside of boxes.

Fifteen identical cardboard boxes containing different types of lithium batteries, or remaining empty, were distributed around a large area of the FAA hanger floor for the canine to inspect. On the initial quick scan, the dog was correct on 11 out of the 15 boxes, with more accurate results on lithium-ion batteries than lithium metal. On a second more thorough inspection, the canine was 100% accurate on all the boxes. The effectiveness of this dog in detecting lithium batteries shows this could potentially be a very accurate and practical way to detect illegal lithium battery shipments.

1 Introduction

Since 2006, there have been 109 incidents reported to the Federal Aviation Administration (FAA) involving smoke, fire, or extreme heat from lithium batteries in aircraft cargo shipments (Federal Aviation Administration, 2023). This incident list does not include three major accidents where lithium battery cargo shipments were implicated but not proven to be the source of the fire:

- an Asiana Airlines 747 near South Korea on July 28, 2011,
- a United Parcel Service (UPS) 747 in Dubai on September 3, 2010, and
- a UPS DC-8 in Philadelphia, PA on February 7, 2006 (Federal Aviation Administration, 2022).

In order to protect the air passengers and crew, bulk shipments of lithium batteries are forbidden from being shipped on passenger aircraft, and must follow very strict regulations to be shipped on cargo aircraft. Bulk shipments of lithium-ion batteries are classified by the United Nations (UN) as UN 3480, which limits individual batteries to 30% state of charge or less. Packages containing cells less than 20 Watt-hours (Wh) or batteries less than 100 Wh cannot exceed 10 kg. Packages containing cells or batteries over this capacity cannot weigh more than 35 kg. Lithium metal cells are classified as UN 3090 which limits cells with less than 1 g of lithium and batteries with less than 2 g of lithium to packages of 2.5 kg or less. Larger lithium metal cells and batteries are limited to a maximum package weight of 35 kg (International Air Transport Association, 2023).

If a shipper of lithium batteries does not declare the contents of the shipment or does not adhere to the regulations, the risk of dangerous cargo fires increases. Large quantities of lithium batteries placed on a passenger aircraft could be catastrophic. Early detection and removal of these undeclared shipments is very important in preventing major incidents, but machinery used to detect lithium batteries is expensive and rarely used. Trained canines potentially offer a much less expensive and more versatile solution to detecting lithium battery shipments that are not following UN regulations. Additionally, dogs have been used by prisons very effectively since at least 2007 in finding cell phones smuggled in by prisoners by sniffing out the lithium battery (KOLD News 13, 2012).

2 Test Setup

In the FAA Technical Center aircraft hangar, fifteen identical cardboard boxes were spread out around the building for the trained canine to inspect. The boxes either contained different types of lithium batteries or were empty. The lithium-ion batteries were at varying states of charge as well. The contents of each box are shown in Table 1. None of the employees of Canine Solutions, SOC LLC were told what contents were contained in each box. A picture of the boxes arranged in the hangar is shown in Figure 1. As an example, the batteries inside of Box B is shown in Figure 2. The goal of the test was to determine if the canine could correctly determine which boxes contained lithium batteries and which did not.

Table 1. Contents of each box placed around hangar

Box A	Over-discharged lithium-ion power tool batteries
Box B	100 Lithium ion LiCoO2 18650s at 50% state-of-charge
Box C	Lithium metal LiMnO2 D-cells
Box D	Lithium ion LiFePO4 32 Wh pouch cells at unknown state-of-charge
Box E	Empty
Box F	100 Lithium ion LiNiCoMnO2 18650s at unknown state-of-charge
Box G	100 Lithium ion LiCoO2 18650s at 100% state-of-charge
Box H	Empty
Box I	60 Lithium metal Li-SOCl2 D-cells
Box J	Empty
Box K	Lithium metal LiMnO2 CR2320 button cells
Box L	Various previously burnt batteries
Box M	15 each Lithium ion LiSO2 G36/2, LiSOCl2 17500, and LiMnO2 17500
Box N	Empty
Box O	4 Packaged Lithium metal multi-cell LiSO2 batteries

Figure 1. Boxes spread around aircraft hangar

Figure 2. Internal contents of Box B

3 Results

The canine went down the rows of boxes and sniffed each one individually. If lithium batteries were detected, the canine was trained to lay down, as shown in Figure 3. On the initial quick scan of about 3 seconds per box, the canine correctly identified 11 out of 15 boxes (73%) as shown in Table 2. The dog was correct on all of the empty boxes and all of the rechargeable lithium-ion batteries, except for the over-discharged power tool batteries. These batteries were not just at 0% state-of-charge, they could not be charged at all because they had no voltage. For the boxes containing lithium metal batteries, the dog was correct on just 2 out of 5 boxes (40%). The two correct boxes contained batteries of the chemistry $LiMnO_2$, while the three incorrect boxes were (a) $LiSOCl_2$, (b) $LiSO_2$, and (c) a combination of $LiSO_2$, $LiSOCl_2$, and $LiMnO_2$.

Figure 3. Canine when lithium batteries were detected

A second attempt was provided for the canine to detect the batteries that were undetected on the first scan. The canine spent about 5 to 10 seconds on each box during the second time around and was able to detect all the batteries missed on the first scan. The dog also correctly inspected an empty box on the second scan to make sure he was not laying down for every box sample on the second attempt.

Table 2. Canine detection test results

	First Scan	**Second Scan**
Box A (Li-ion power tool batteries)	Wrong	Correct
Box B (Li-ion 18650s)	Correct	
Box C (Li metal D-cells)	Correct	
Box D (Li-ion pouch cells)	Correct	
Box E (Empty)	Correct	
Box F (Li-ion 18650s)	Correct	
Box G (Li-ion 18650s 100% SOC)	Correct	
Box H (Empty)	Correct	Correct
Box I (Li metal D-cells)	Wrong	Correct
Box J (Empty)	Correct	
Box K (Li metal button cells)	Correct	
Box L (Burnt batteries)	Correct	
Box M (Li metal 17500s)	Wrong	Correct
Box N (Empty)	Correct	
Box O (Li metal multi-cell batteries)	Wrong	Correct

There are a few factors that may have caused some batteries to be more difficult to detect than others. Some small amount of off-gassing must occur from the batteries in order for it to be possible to detect them by scent. The box containing the dead power tool batteries likely off-gassed very little because of their excessive age and minimal voltage. The other batteries that were not detected initially were all lithium metal batteries, which may release less gas than lithium-ions. Additionally, Box O contained multi-cell batteries with a case made of metal, then wrapped in plastic, then placed in a cardboard box, then wrapped in plastic again, then placed in the outer big box identical to the others. There were several layers that could contain the off-gassing and the dog was still able to detect the battery when given more time to sniff.

4 Conclusion

Fifteen boxes with various contents were placed around a large space to determine the effectiveness of a trained canine to detect lithium batteries. The dog used for this testing was reasonably accurate in detecting lithium-ion batteries when doing a quick scan by correctly selecting 11 out of the 15 boxes with no false positives. The canine was correct on all lithium-ion

batteries except the batteries with no charge, which are much less of a fire hazard to aircraft. The three remaining boxes concealed all lithium metal batteries, which are less frequently used in electronic devices. When given additional time on each box, the canine was 100% accurate in discerning which boxes contained lithium batteries and which did not. This brief testing shows the potential that canines have in being a practical solution to identify undeclared lithium battery shipments.

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