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## Committee of Experts on the Transport of Dangerous Goods and on the Globally Harmonized System of Classification and Labelling of Chemicals

9 December 2019

### Sub-Committee of Experts on the Transport of Dangerous Goods Fifty-sixth session

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Item 4 (c) of the provisional agenda

**Electric storage systems: transport provisions**

### **Information on research on the state of charge (SOC) of lithium ion cells/batteries relating to ST/SG/AC.10/C.3/2019/46**

**Transmitted by the expert from the United States of America**

#### **Background**

1. The United States of America, Federal Aviation Administration (FAA) established the William J. Hughes Technical Center in Atlantic City, New Jersey, USA in 1958 as the world's premier air transportation system laboratory.
2. One of the specific laboratories at the Technical Center is the FAA Fire Safety Branch. The FAA Fire Safety Branch has been involved in almost every major aviation fire accident since the 1960's. They have over 1,000 research and information reports published online relating to aviation fire safety. Following an incident in 1999 at the Los Angeles International Airport relating to lithium batteries, the FAA Fire Safety Branch started conducting research on lithium batteries as it relates to fires and aviation safety. Their research on lithium batteries has continued from that point through to today. Their website has a specific section relating to lithium battery research that currently contains over 130 entries.
3. More information about the FAA Fire Safety Branch may be found at the following website:

<https://www.fire.tc.faa.gov/About>

4. More information about the lithium battery research and information of the FAA Fire Safety Branch and other stakeholders may be found at the following website:

<https://www.fire.tc.faa.gov/Systems/Lithium-Batteries>

#### **Introduction**

5. The expert from the United States of America wanted to make the sub-committee aware of the information and research available from the FAA Fire Safety Branch relating to lithium batteries. Specifically, there are four reports relating to lithium ion cells and state of charge (SOC) which have been highlighted below.

## **FAA lithium battery reports**

### **Report DOT/FAA/TC-15/38: Passive Protection of Lithium Battery Shipments**

6. This report covers testing to evaluate the effectiveness of various types of packaging materials and configurations to prevent or minimize the propagation of thermal runaway in lithium ion cells. The SOC of the cells and divider material between each cell was varied.

7. The reports SOC specific information: The net rate of heat absorbed into the specific 18650 sized lithium ion cells was the factor that determined if thermal runaway would propagate. If the power released by thermal runaway was low enough, then heat was dissipated fast enough to prevent the adjacent cells from reaching the thermal runaway onset temperature.

8. Amongst all the tests that utilized SOC with only one layer of fibreboard separators, the cells at 30% SOC was the only one that did not propagate (the tests were also conducted at 40% SOC, 50% SOC, 60% SOC, 80% SOC and 100% SOC).

<https://www.fire.tc.faa.gov/pdf/TC-15-38.pdf>

### **Report DOT/FAA/TC-15/59: Lithium battery thermal runaway vent gas analysis**

9. This report covers testing to analyze the various gases that were vented from 18650 sized lithium ion cells (lithium cobalt oxide (LCO)) in thermal runaway and evaluate the risk of the buildup and ignition of the gases within an aircraft cargo compartment.

10. The reports SOC specific information: Lithium ion cells in thermal runaway vent a variety of flammable gases (hydrogen, hydrocarbons, carbon monoxide, etc.). For the gases produced in thermal runaway by lithium ion cells, the quantity and the composition of gases vary with SOC. The higher the SOC of the lithium ion cells, the greater the volume of gas produced along with a wider flammability range.

<https://www.fire.tc.faa.gov/pdf/TC-15-59.pdf>

### **Report DOT/FAA/TC-TN16/34: Impact of lithium battery vent gas ignition on cargo compartment fire protection**

11. This report covers testing to determine the impact of the accumulation and ignition of hydrogen gas and hydrocarbons emitted from 18650 sized lithium ion cells in thermal runaway propagation. The testing was conducted utilizing lithium ion cells at both 100% SOC and 50% SOC.

12. The reports SOC specific information: Tests showed that a relatively small volume of ignited battery gases was capable of creating a pressure rise in the B737 cargo compartment that would open the pressure relief panels and negate the capabilities of the fire suppression system on the aircraft. The number of 18650 sized lithium ion cells needed to reach the 7 kPa (0.07 bar) pressure was: for 100% SOC, 2.6 cells and for 50% SOC, 8 cells. There would be an approximate 1/3 fewer cells needed to produce the same 7 kPa (0.07 bar) pressure at cruise altitude. So the reduction in SOC in the cells was helpful, but still would be of concern if propagation of the cells was allowed to occur.

<https://www.fire.tc.faa.gov/pdf/TC-TN-16-34.pdf>

**Report DOT/FAA/TC-16/37: Summary of FAA studies related to the hazards produced by lithium cells in thermal runaway in aircraft cargo compartments**

13. This report is a summary of the FAA Fire Safety Branch work on the fire risk and flammability concerns with lithium batteries. It starts off at the beginning when the FAA Fire Safety Branch first started research on lithium batteries in 2002 and goes through June 2016, when the report was published. This summary incorporates details of the two reports listed above (DOT/FAA/TC-15/38 and DOT/FAA/TC-15/59).

14. Pages 9-18 of the report talk about SOC testing. The tests utilized 18650 lithium ion cells. The lithium ion cells tested at 30% SOC and 20% SOC, did not propagate.

<https://www.fire.tc.faa.gov/pdf/TC-16-37.pdf>

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