

# The Flammable Gasses Produced by Lithium Button Cells in Thermal Runaway



Federal Aviation  
Administration



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# Introduction

- **Ongoing tests have been conducted to study the gasses vented by lithium cells and their effect on an aircraft.**
  - Effect of vent gas combustion (with and without halon 1301)
  - Vent gas composition/volume
  - Minimum quantity of cells capable of producing enough gas to compromise aircraft safety.
  - Hazard of gasses from lithium-metal button cells.



# Li-Metal Button Cell Tests

- **5 tests were conducted to evaluate the vent gasses of button cells in thermal runaway.**
  - Oven Tests (gas analysis)
    - 2032 button cells strapped together
    - 2032 button cells not strapped together
    - 2477 button cells not strapped together
  - Heat Plate Tests (combustion)
    - 2477 button cells on hotplate
    - 2477 button cells on hotplate with enclosure (similar to oven)



Note: 2032: .225mah, 2477: 1000mah

# Procedure (Oven Tests)

- **Cells were placed into the chamber in two configurations (strapped together and not strapped together)**
- **Chamber was sealed and vacuumed to .1psia**
- **The chamber was filled to 10psia N<sub>2</sub>**
- **The entire chamber was then placed in an oven at about 250°C**
- **After sufficient time (a few hours) the chamber cooled and gas was analyzed.**



Cells Strapped



Chamber



Oven

# Results - oven tests



- CR2032 strapped together
  - THC: 19.83% H<sub>2</sub>: 18.53% CO: 2.66% CO<sub>2</sub>: 50.88% Volume: .077 liters/cell
- CR2032 not strapped together
  - THC: 13.84% H<sub>2</sub>: 1.99% CO: 4.27% CO<sub>2</sub>: 79.16% Volume: .108 liters/cell
- CR2477 not strapped
  - THC: 6.18% H<sub>2</sub>: 7.67% CO: 2.41% CO<sub>2</sub>: 85.04% Volume: .526 liters/cell

# Procedure (heat plate tests)

- **Cells were placed on a heat plate in two configurations.**
  - No enclosure around heat plate.
  - Enclosure around heat plate.



# Results - heat plate tests

- 26 CR2477 Without enclosure around hotplate
  - .115 liters/cell
  - 10.2% battery gas → no combustion
- 45 CR2477 With enclosure around hotplate
  - .916 liters/cell
  - 25% battery gas → combustion maximized the pressure transducer at 41psia.



# Additional Test

- **2477 button cell test conducted at .16 psia on hotplate yielded .03 liters/cell**
  - → Cell popped open much sooner because of lower ambient pressure preventing significant reaction.



Fresh Cell

Cathode

Lithium  
Anode



# Summary

- **Volume and composition of button cell vent gasses vary depending on environment.**
  - Oven test (heated surroundings) showed that cells can produce up to 900% more gas volume.
  - Cells that were strapped together produced more flammable gas
  - Cells that were heated with higher pressure produced a greater volume of gas.