MSIAC
Munitions Safety Information Analysis Center

Lithium Battery Fire Compared to IM Fast Heating Threat

PARARI – Canberra, AUS – 24 November 2026

Jean-François (JF) Fournier
TSO Munition Systems
jf.fournier@msiac.nato.int

This document has been prepared for MSIAC member nations. Disclosure of the contents to other nations must be authorised by the MSIAC Steering Committee.

Neither MSIAC nor the participating Nations can guarantee nor warrant the adequacy, accuracy, currency or completeness of the Technical Information contained in this document.

Overview

- IM Standardized FH Threat
- Li-ion Battery Fire Threat
  - Full-Scale Fire Testing – Large Format Li-ion Batteries in EVs
  - Fire Testing – Small Format Li-ion Batteries
- Discussion
  - Munition Engulfed in Li-Ion Battery Fire
  - Li-Ion Battery Fire Within a Munition System
- Conclusion

IM Standardized FH Threat

- Three methods in AOP-4240
  - Method 1 (Standard) – Liquid Pool Fire (LPF)
  - Method 2 (Alternative) – Fuel Burner Fire (FBF)
  - Method 3 (Alternative) – Mini Pool Fire



- Test shall consist of engulfing munition in fire. Key temperature requirements:
  - Flame temperature shall reach 550°C under 30 s after ignition
  - Average flame temperature shall be of at least 800°C



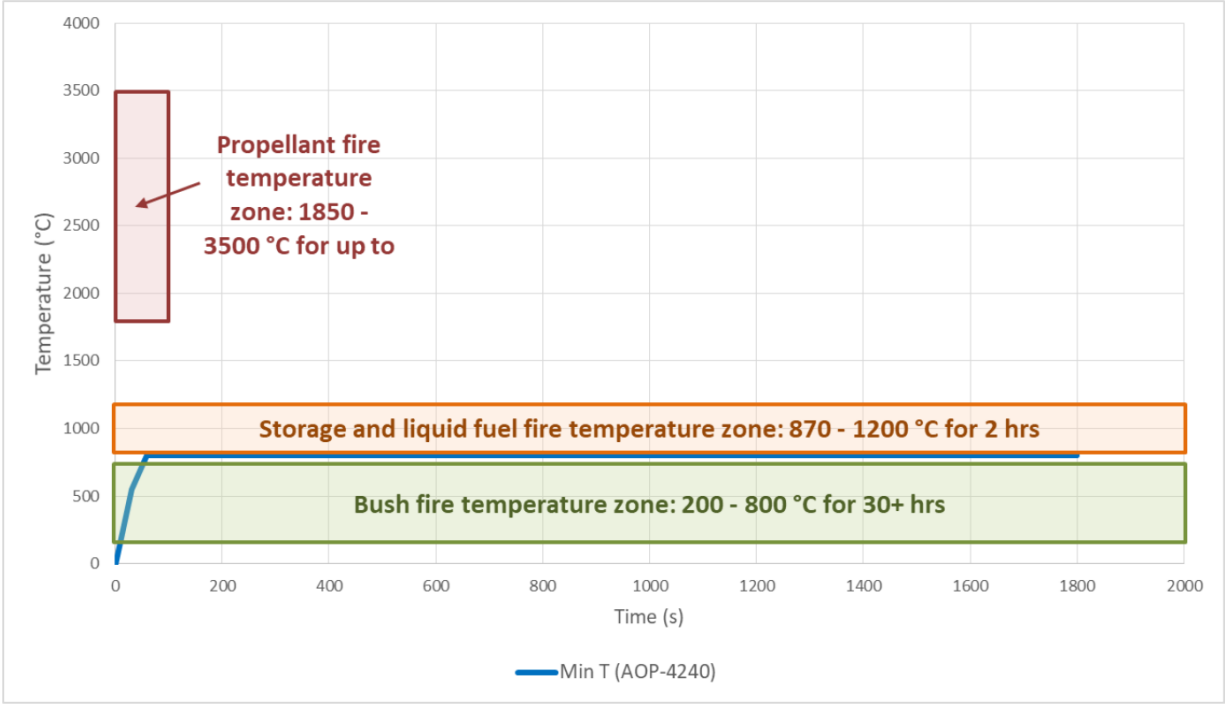
IM Standardized FH Threat

AOP-4240 states:

The Fast Heating Test is designed only to simulate the most intense heating conditions likely to be created in a hydrocarbon fuel pool fire. This test does not, however, simulate a particular in-service or accident scenario.

IM Standardized FH Threat

In MSIAC L-291, AOP-4240 temperature requirements were compared with typical fire temperature zones.



Li-ion Battery Fire Threat

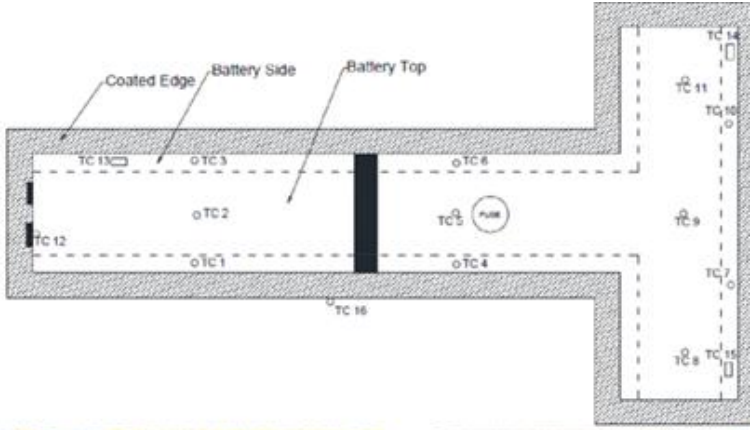
- Real-world scenarios can be expected:
  - Munition engulfed by battery fire while transported in EV
  - Munition engulfed by battery fire from surrounding stockpile of batteries
  - Battery fire within a munition system

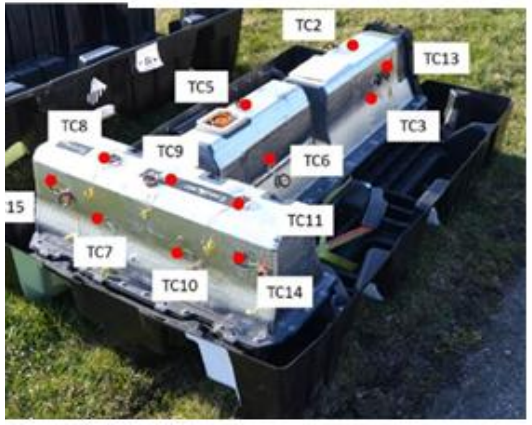
- Test results can be analyzed to determine applicability:
  - Large Format Li-ion Batteries in EVs
  - Small Format Li-ion Batteries

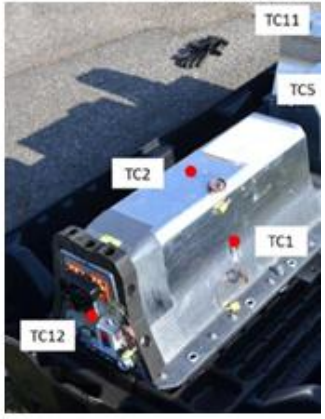
Li-ion Battery Fire Threat – EVs

Fire Protection Research Foundation Tests

- 2 types of batteries from car manufacturers (chemistry not specified)
- Heated by propane burner to cause thermal runaway
- Standalone tests and within mockup vehicle







Li-ion Battery Fire Threat – EVs

Fire Protection Research Foundation Tests











Li-ion Battery Fire Threat – EVs

Fire Protection Research Foundation Tests

Standalone Tests

TC	Maximum Temperature (°F)	Maximum Temperature (°C)	Time	TC	Maximum Temperature (°F)	Maximum Temperature (°C)	Time
1	1600.5	871.4	0:18:19	11	1490.7	810.4	0:17:09
2	1342.4	728.0	0:18:19	12	1264.1	684.5	0:23:26
3	2111.9	1155.5	0:18:19	13	2233.8	1223.2	0:20:54
4	1472.0	800.0	0:17:04	14	1311.4	710.8	0:47:04
5	2040.1	1115.6	0:20:58	15	1262.7	683.7	0:18:13
6	1977.4	1080.8	0:20:54	16	1975.5	1079.7	0:05:20
7	1533.4	834.1	0:19:57	17	201.7	94.3	0:24:09
8	1713.9	934.4	0:16:57	18	127.0	52.8	0:24:27
9	1609.9	321.1	0:06:45	19	230.0	110.0	0:18:14
10	1419.8	771.0	0:05:58	20	106.7	41.5	0:22:35

Suppression Tests in Vehicle Mockups

Test	Maximum Temperature Range (°C)
A1	408-1397
A2	266-647
A3	675-837

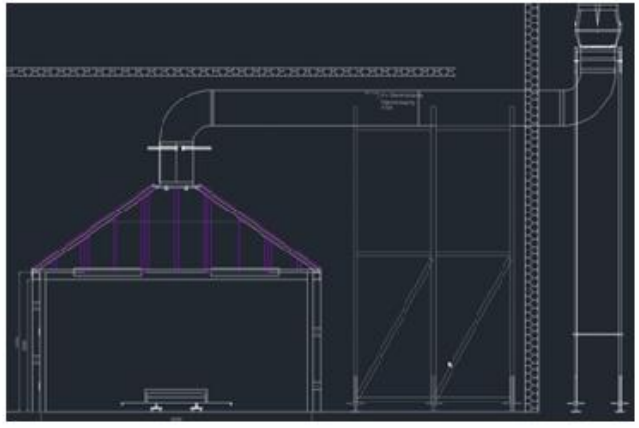
Test	Maximum Exterior Temperature Range (°C)	Maximum Interior Temperature Range (°C)
B1	283-1089	572-1121
B2	782-887	550-793
B3	796-1528	853-1528

Li-ion Battery Fire Threat – EVs

IFAB Institute for Applied Fire Research Tests

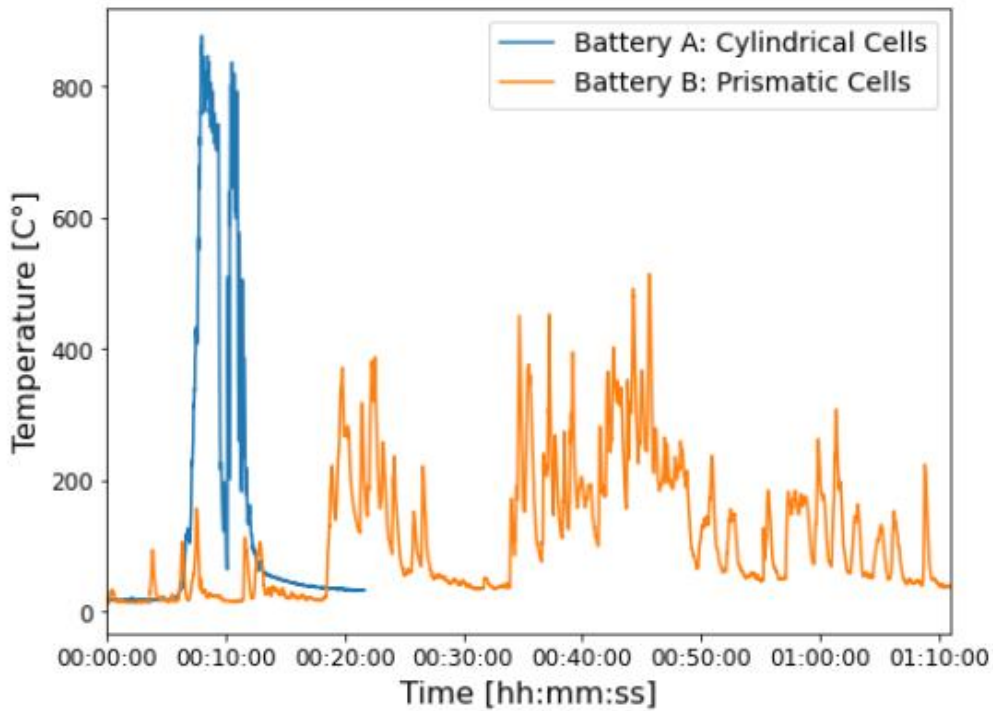
- Series of tests to characterize the fire
- Conducted in purposefully built compartment (4x4x2 m)
- Thermocouples placed at various locations, including exhaust duct





Li-ion Battery Fire Threat – EVs

IFAB Institute for Applied Fire Research Tests

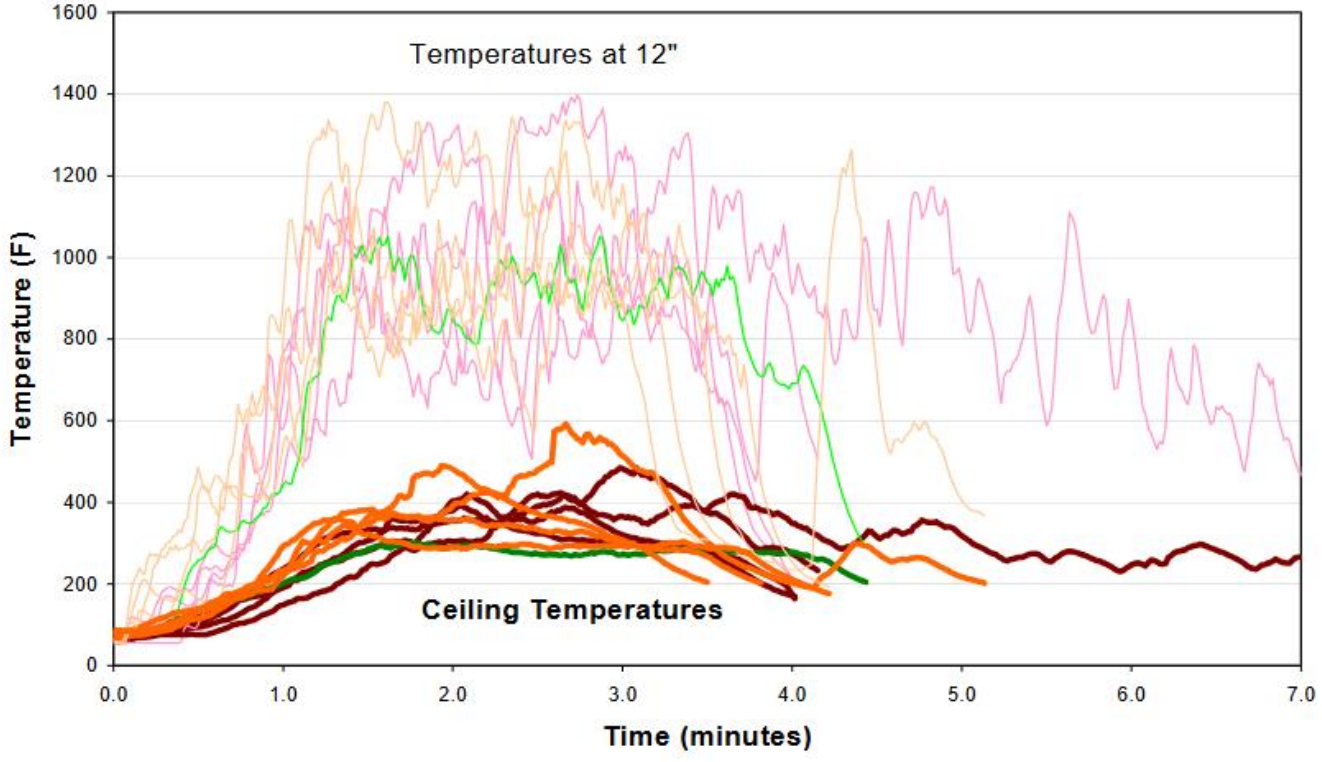


Fire Protection Research Foundation / FAA Tests

- Characterization of fire behaviour li-ion cells and battery packs found in consumer electronics
- Test conditions:
  - Type 18650 cells and packs
  - 50% SOC
  - 3 different manufacturers
  - Number of cells per tests: 1 to 150
- Temperature data recorded at 12” above the floor and at the ceiling

Li-ion Battery Fire Threat – Small Format Batteries

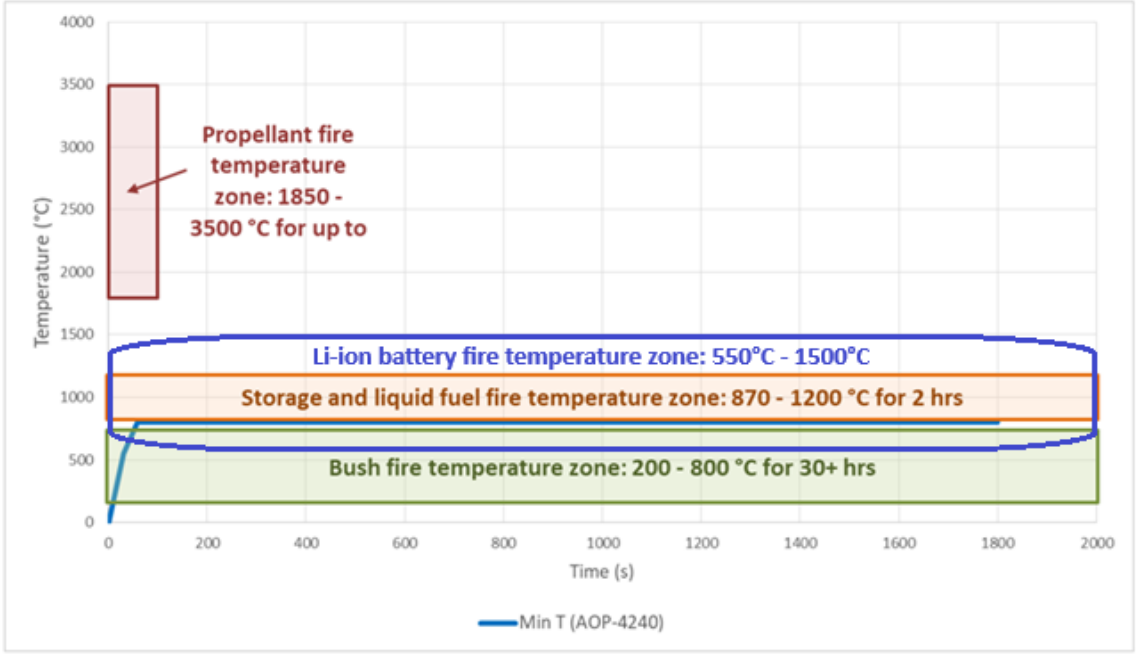
Fire Protection Research Foundation / FAA Tests



Discussion – Munition Engulfed in Li-ion Battery Fire

Observations from analysis of test results:

- For all tests, observed temperatures ranged from 400°C to 1500°C
- Lower temperatures → TC at a distance from flames
- Higher temperatures → TC placed in battery vents
- TC in vents best suited to compare with FH test and TC data
- Therefore, temperature zone → 550°C to 1500°C



Discussion – Munition Engulfed in Li-ion Battery Fire

Additional points to note:

- Similarities in temperature fire zones was expected → combustion of organic electrolyte is a hydrocarbon fire
- Lower temperatures for liquid fuel fires could be explained by limiting diffusion of oxygen and incomplete combustion (black smoke)
- Modes of heat transfer should be considered:
  - ↑ temperatures → ↑ convective/radiative heat transfer?
  - ↑ heating rate ≠ significantly different outcome of test
- Streams of sparks, jetting flames (venting electrolyte) not necessarily replicated by FH test / AOP-4240



Discussion – Li-ion Battery Fire Within Munition System

- Variability of factors must be considered:
  - Battery size / chemistry
  - Munition system configuration
  - Location of battery within munition system
  - Location of EMs within munition system



- Therefore, a THA specific to the munition system should be conducted.

- Other elements to support assessment of munition's vulnerability to the battery fire:
  - Results from battery abuse testing
  - Additional component level battery tests
  - Inclusion of fully charged battery in full-scale IM tests

Conclusion

- Li-ion battery fire temperature zone: 550°C to 1500°C
  - IM standardized FH threat likely comparable to average temperatures, but may not expose munition to higher boundary
- Other consequences of Li-ion battery fires (streams of sparks, jetting flames, explosions?) may not be replicated
- For a Li-ion battery fire within a munition system, a THA specific to the system should be conducted

Conclusion



Questions

