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Li-ion Battery and Electric fires on ships – Is there an answer?

To find an answer we need to know the questions to ask.

To confirm the questions we need to thoroughly investigate the cause.

We are not aware of any confirmed EV fires involving Li-ion batteries on ships.

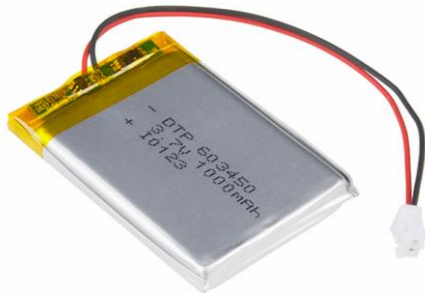
Li-ion Batteries

Different configurations of Li-ion batteries.

How they work.

What can go wrong.

Investigation of fires from Li-ion batteries



Types of Li-ion Cells



Cylindrical cells



Pouch cells

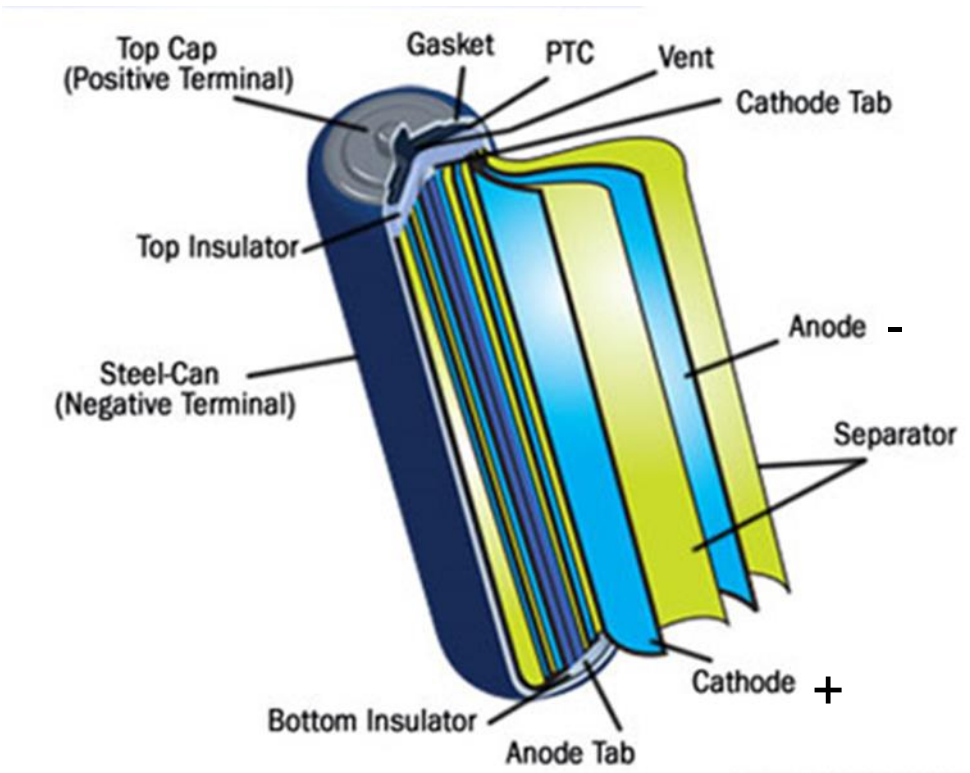


Prismatic cells



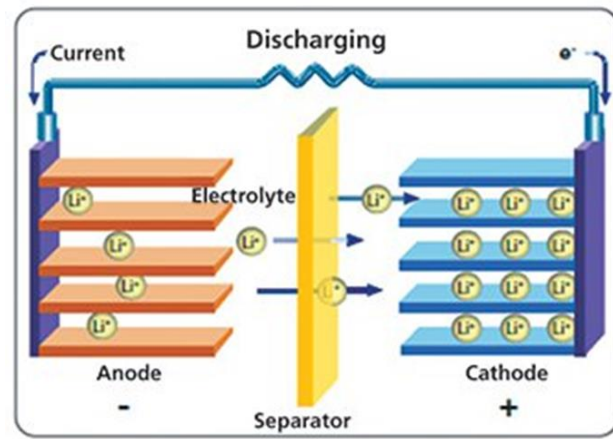
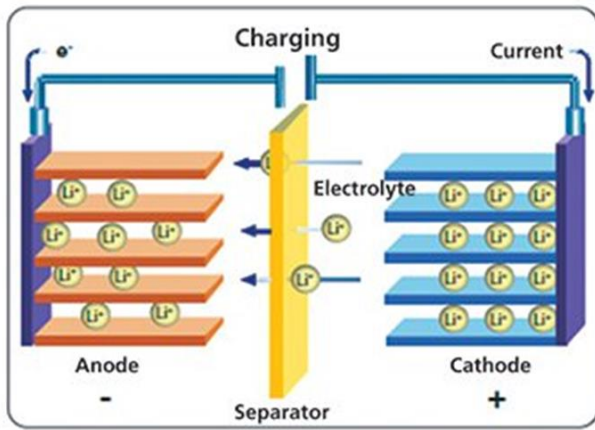
Li-ion Batteries:

A typical 18650 cell construction.



Li-ion Batteries: A typical Li-ion Battery Module Construction.





Li-ion Batteries – Charging and Discharging

When the battery charges, ions of lithium move through the electrolyte and separator from the positive electrode (cathode) to the negative electrode (anode) and attach to the carbon.

During discharge, the lithium ions move back to the cathode from the anode.



Li-ion Battery Faults

Causes of Failure
and hence fires.

Faults in the batteries can result from:

- Poor quality construction.
- Lack of protective circuitry.
- Physical damage.
- Short circuit.
- Overcharging.
- Use of an Incorrect charger.

Li-ion Batteries – Fire in a Container





Li-ion Battery Fire Investigation

- Having seen the last photograph – where do you start?
- Initially Look for the area with the most severe damage.
- Witness evidence
- Fire detector heads
- CCTV
- Other sources of imagery

Li-ion Battery Fire investigation

- Fires involving Li-ion batteries are difficult to extinguish and hence the damage can be extensive, far more than with a conventional fire.
- Hence the source can be difficult to locate.
- If we look at the next picture we can see some of the issues.
- We need to gather as much information as possible regarding the source

PCTC Fire





Li-ion Battery Fire investigation

- As can be seen in the photograph before the cars are very tightly packed and the damage is extensive.
- Locating the source is difficult and often requires the use of secondary evidence as discussed.
- It is also the case that the most severe damage may be close to an air vent from deck, where more oxygen is available to support the fire.



EVs Fire investigation

- There may therefore be two areas of high heat, the source and the location of oxygen
- We need to eliminate other sources
 - Electrical cables and circuits examined for evidence of short circuits and failure before the incident
 - Overheating / falling light fittings
 - Fuel leakages from hybrid vehicles
 - Evidence of hot work



Extinguishing Fire involving Li-ion Batteries.

- Fire fighting
 - What evidence is available to show what was used:
 - Crew statements
 - CCTV
 - Fire equipment lying around e.g. Fire hoses and nozzles/ Breathing apparatus
 - Fixed fire fighting systems – have they been used?
 - Peeling paint on pipes of CO2 may show that this was used
 - The lower level in the storage tank will show this was used
 - High expansion foam concentrate levels in tank and test certs (was it still in date)
 - Vent flap position and effectiveness – i.e. do they actually close
 - Fire zones – where they isolated/closed as required (both vertical and horizontal)

Extinguishing Fire involving Li-ion Batteries.





Extinguishing Fire involving Li-ion Batteries.

- Water - can cool down the battery pack and may prevent re-ignition, however, water and electricity don't mix.
- Water - can react with Li to produce hydrogen gas.
($2 \text{Li(s)} + 2 \text{H}_2\text{O} \rightarrow 2 \text{LiOH (aq)} + \text{H}_2\text{(g)}$)
- Carbon dioxide (CO_2) - limited time benefit and has no cooling capacity.
- Foam - a can exclude oxygen but has a limited cooling capacity, may evaporate at high heat levels.
- Cooling the batteries or inhibiting heat transfer between the cells, appears to be mostly widely accepted firefighting tactic, if they are accessible.
- Aqueous Vermiculite Dispersion (AVD) extinguishers.

Reignition



- But
 - Packs in cars cannot be accessed
 - Because they are installed
 - Because of close packing of the cars on the decks
 - Effectively the only way to is to use lots of water from a drencher system to contain fire to a small area
 - There is always a risk of reignition
 - Fire fighting will take a lot longer than just to extinguish the fire, as it will be necessary to cool the battery.
 - It will be essential to monitor the area until discharge



THANK YOU FOR LISTENING

DISCUSSIONS

AND

QUESTIONS