Preventing and Responding to Lithium-ion Battery Fires At Sea

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http://www.uscg.mil/

https://i1.wp.com/wpicpc.org/wp-content/uploads/2017/09/cropped-WPI-LOGO.png?resize=476%2C476&ssl=1

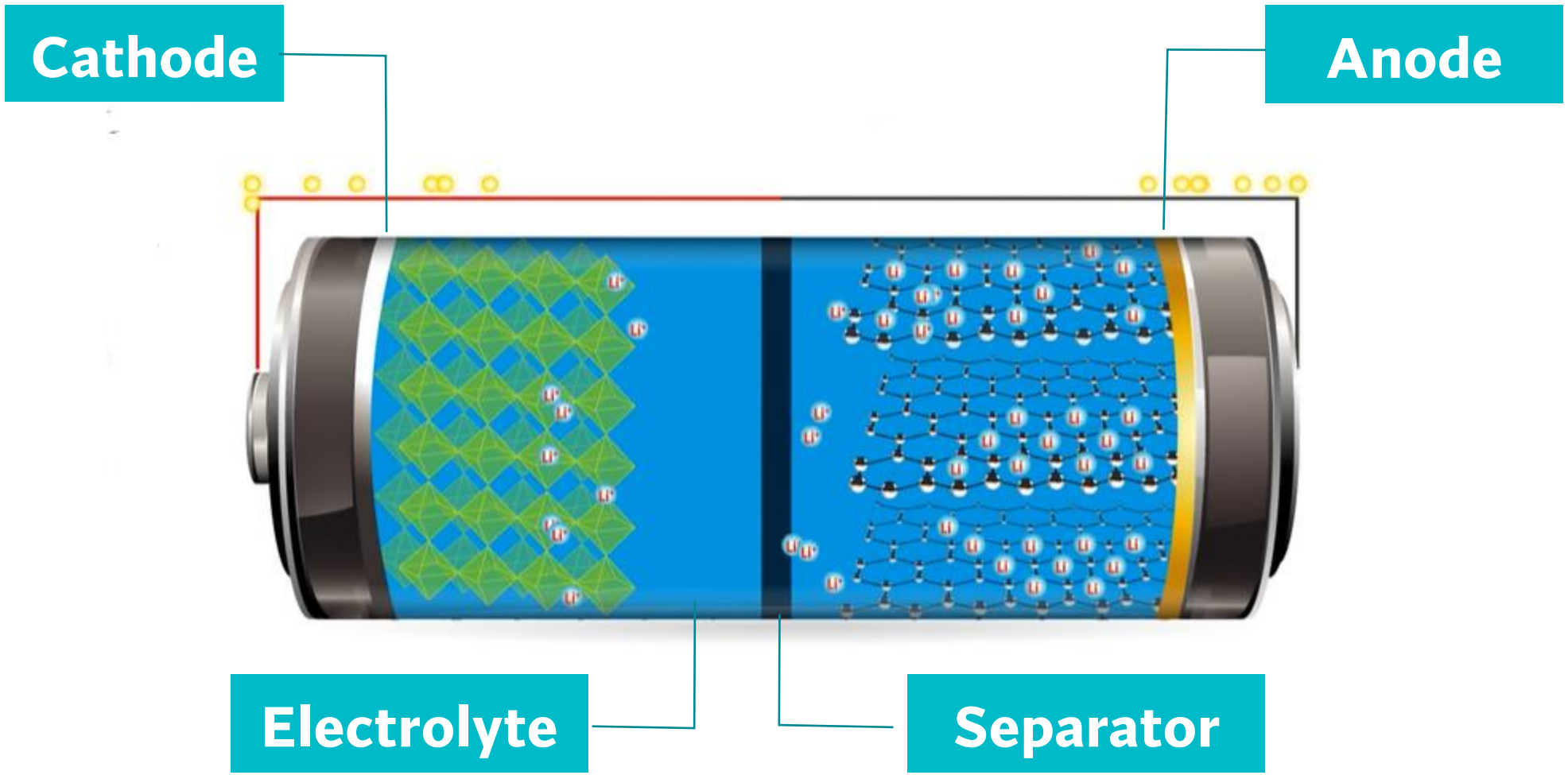
Project Goal

To develop an executive-level report to advise the United States Coast Guard in drafting standards and best practices for preventing and responding to lithium-ion battery fires onboard passenger vessels and roll-on-roll-off carriers.

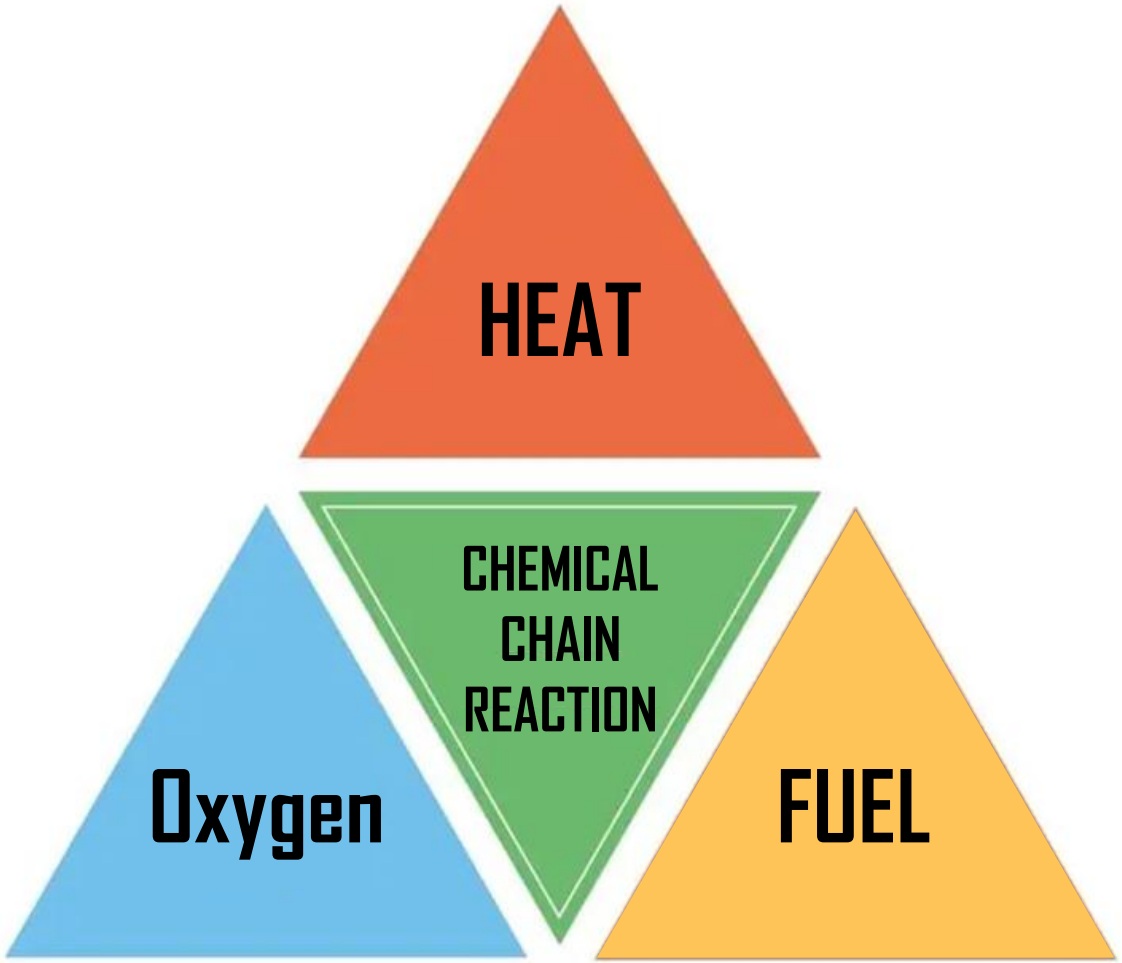
https://capecodlobstercruise.com/new/wp-content/uploads/2014/01/Lobster-Roll-Cruises-22.jpg

Project Objectives

1	Document emerging technologies and the current state of the LIB industry.
2	Review and document safety regulations regarding LIBs in various industries.
3	Document current practices for preventing, responding to and mitigating lithium-ion battery fires.
4	Propose policy changes and evaluate proposals through SME feedback.

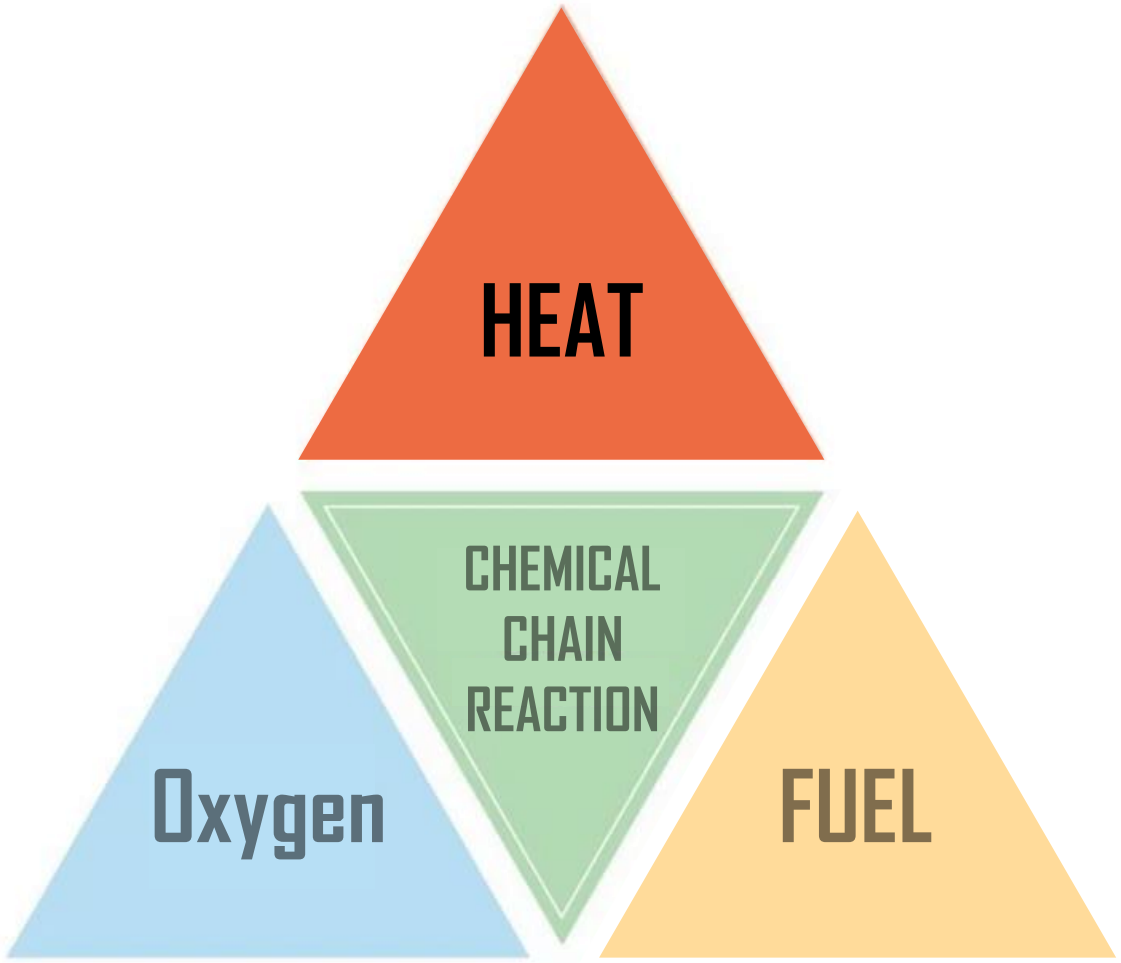


https://www.energy.gov/eere/articles/how-does-lithium-ion-battery-work



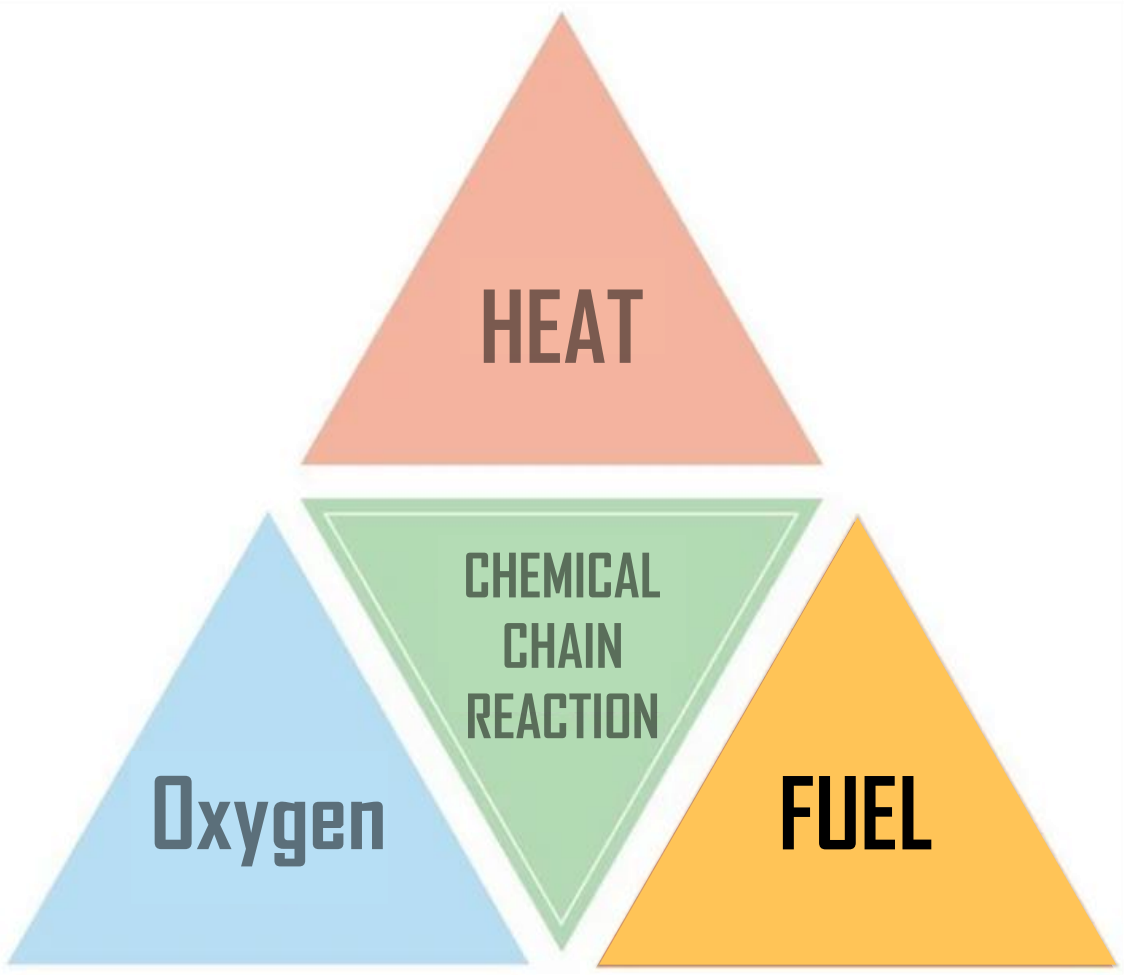
LIBs are a unique danger.

https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/



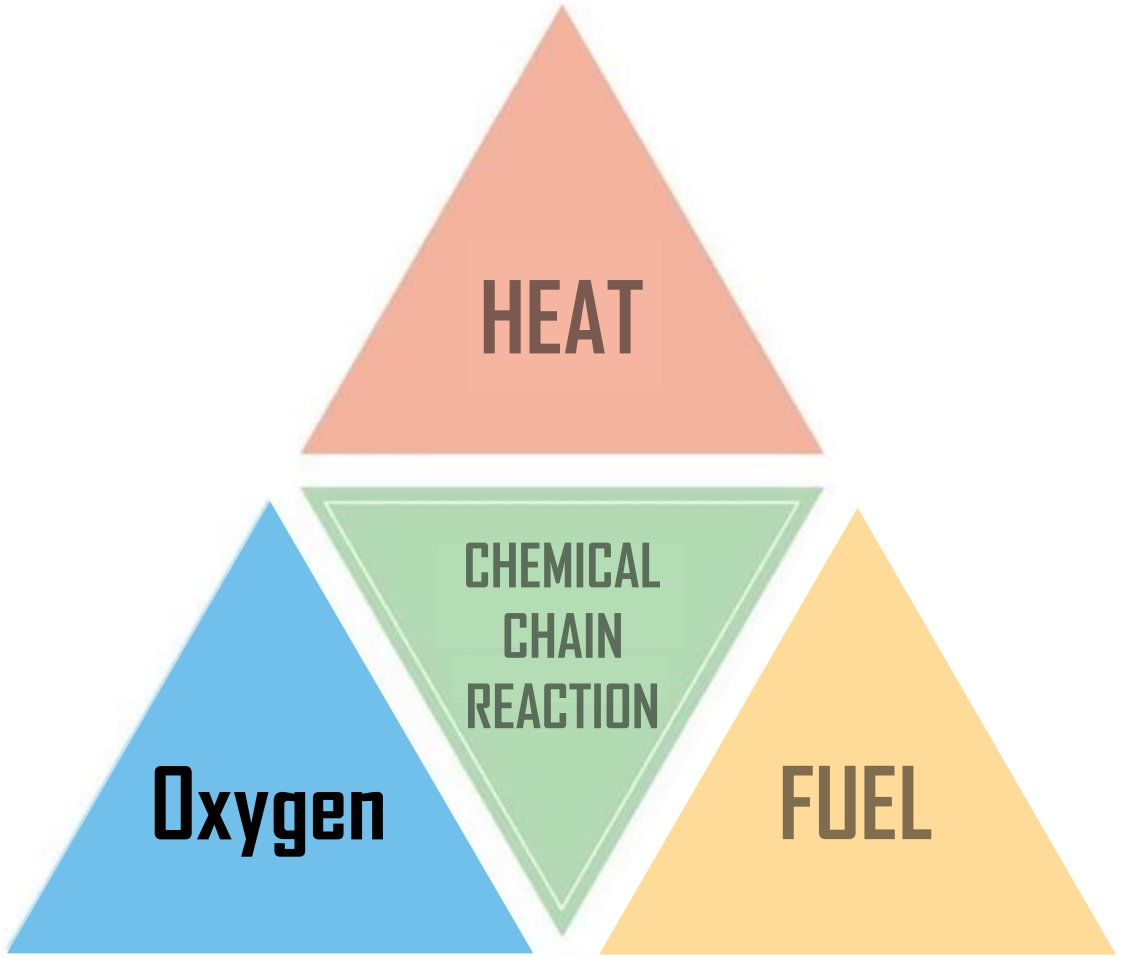
LIBs produce heat through thermal runaway.

https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/



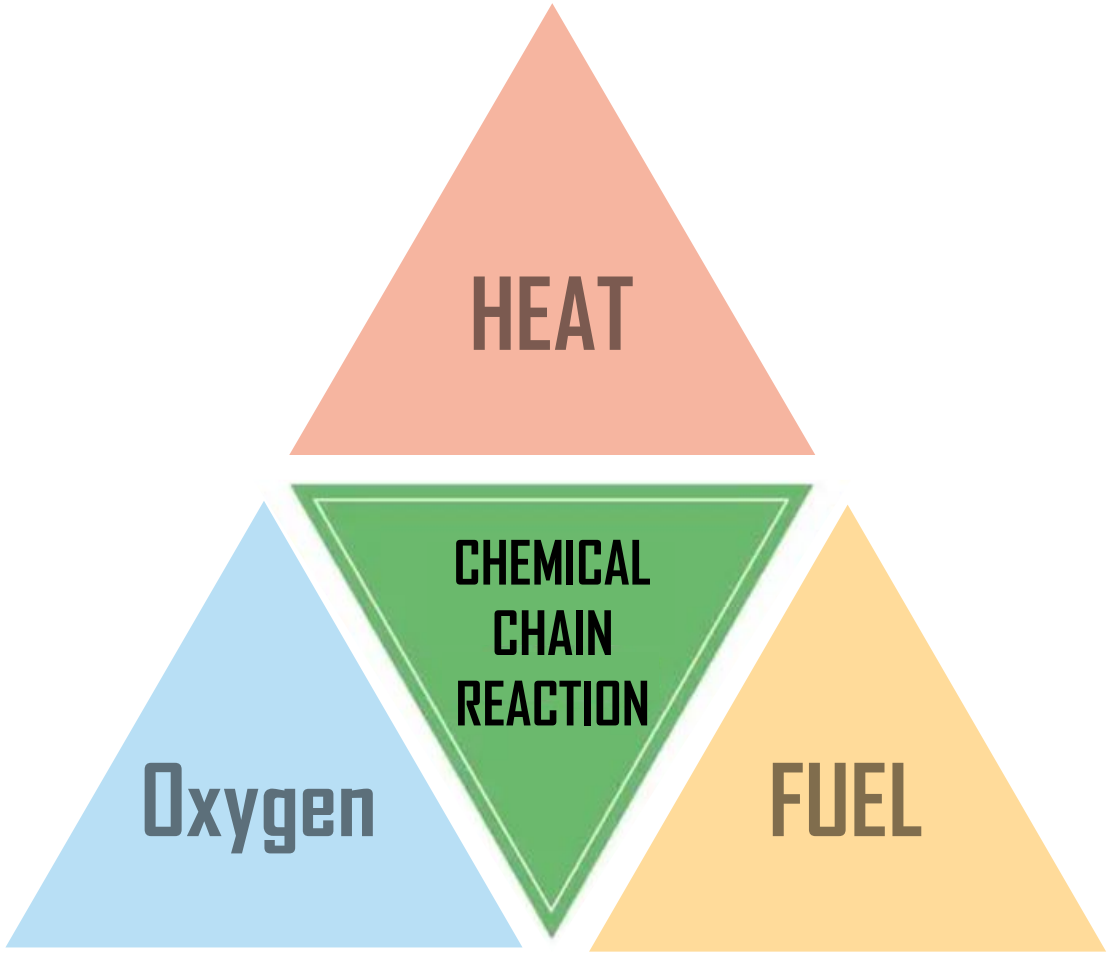
LIBs contain highly flammable components.

https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/



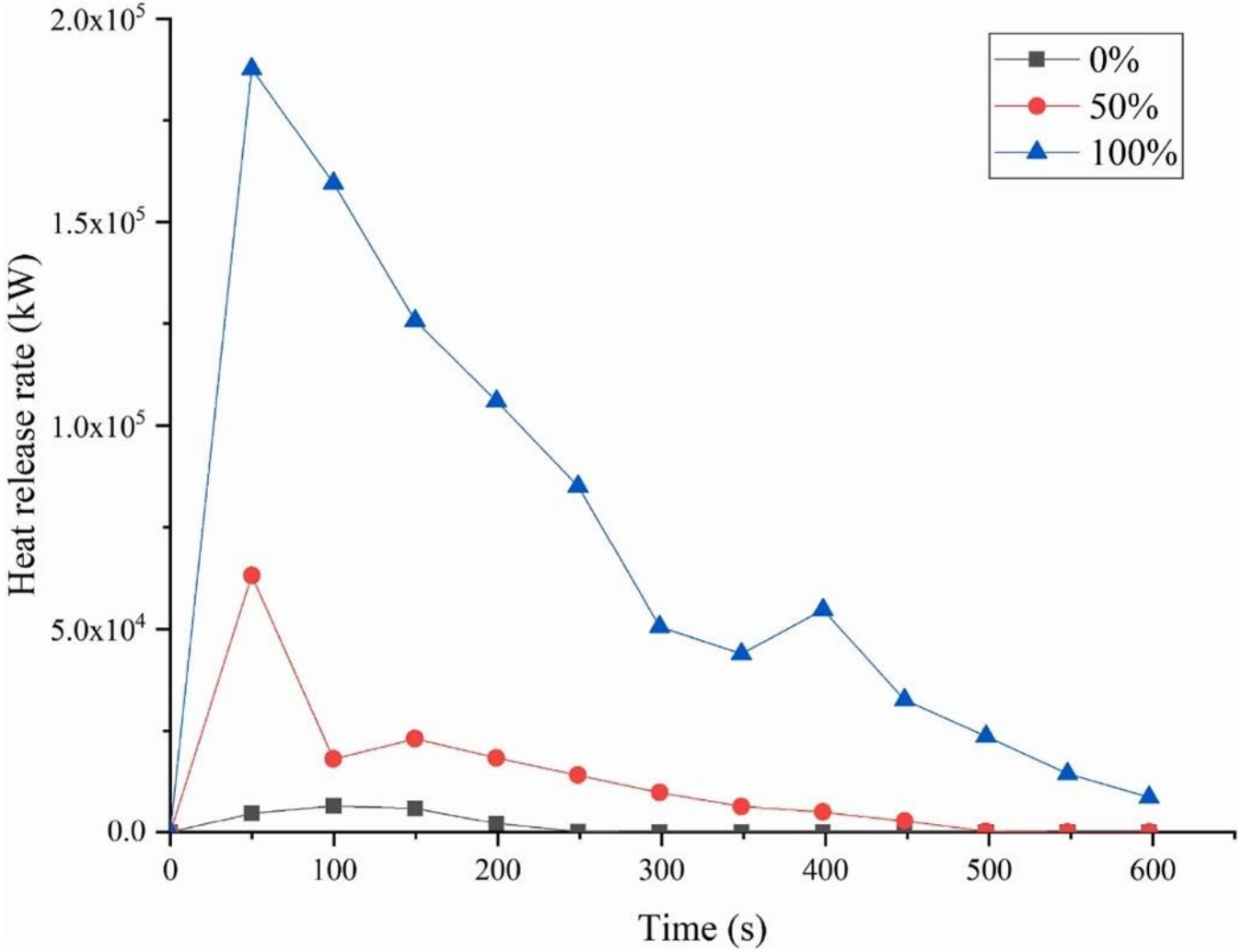
Cathodes produce oxygen when they decompose.

https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/



Combustion is a chemical chain reaction

https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/

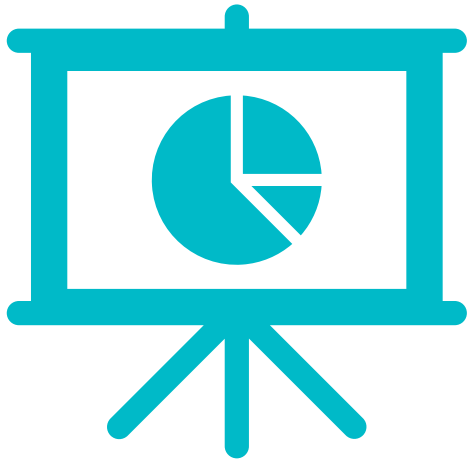


Higher State of Charge results in:

- Higher HRR
- Lower ignition temp
- Longer duration of heat release

https://www.highspeedtraining.co.uk/hub/fire-triangle-tetrahedron-combustion/

Results



It is difficult to enforce existing safety policies during cargo and vessel inspections.

https://media.defense.gov/2017/Oct/26/2001833798/990/382/0/171026-G-IT257-290.JPG

Clearer definitions for used and damaged batteries would help shippers properly identify them.

https://www.ecfr.gov/current/title-49/subtitle-B/chapter-I/subchapter-C/part-172/subpart-E/section-172.447

There are inconsistent regulations across different transportation modes.

Tightly packing vehicles on Ro-Ros facilitates the spread of fire.

https://www.nytimes.com/slideshow/2012/07/15/automobiles/15ship-slides.html?smid=url-share

Early detection is critical for preventing a fire.

https://www.robotroom.com/IRTest/Flir/Automobile-infrared.jpg

Mist systems have greater cooling capabilities than other sprinkler systems.

https://www.cannonfiresprinklers.co.uk/wp-content/uploads/2020/03/watermist-hp.jpg

Clean agents and water additives assist in extinguishing LIB fires.

- Carbon Dioxide
- Novec 1230
- HFC-227ea
- F-500 EA

https://i1.wp.com/quattroventures.com.au/wp-content/uploads/2021/02/chrome_ZEvEbcq4cu.png?w=970&ssl=1

Small Passenger Vessel Recommendations

Require markings and cautionary signage for appropriate charging areas.

https://www.discountsafetysigns.co.nz/wp-content/uploads/2017/02/warning_DO_NOT_LEAVE_BATTERY_CHARGING_OPERATION_UNATTENDED.jpg

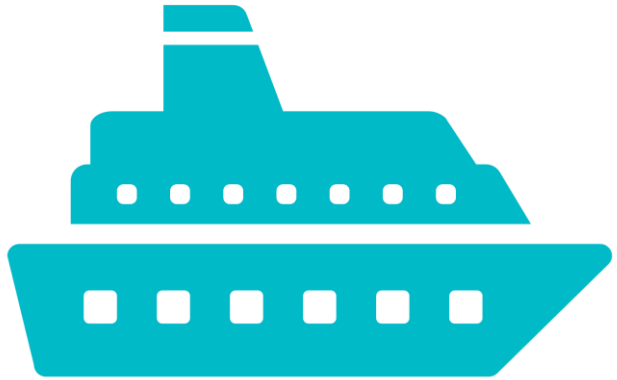
Educate crews on the dangers of LIBs.

https://www.uniteammarine.com/wp-content/uploads/2016/12/pic-1-Uniteam-Marine_Crew-Management.jpg

Require vessels to have a DOT-approved LIB container to store at-risk batteries.

https://www.westlondonmodels.com/wp-content/uploads/2018/08/Extover-Extinguishing-Granules-Plastic-Pail-33l-27022000_b_0.jpg

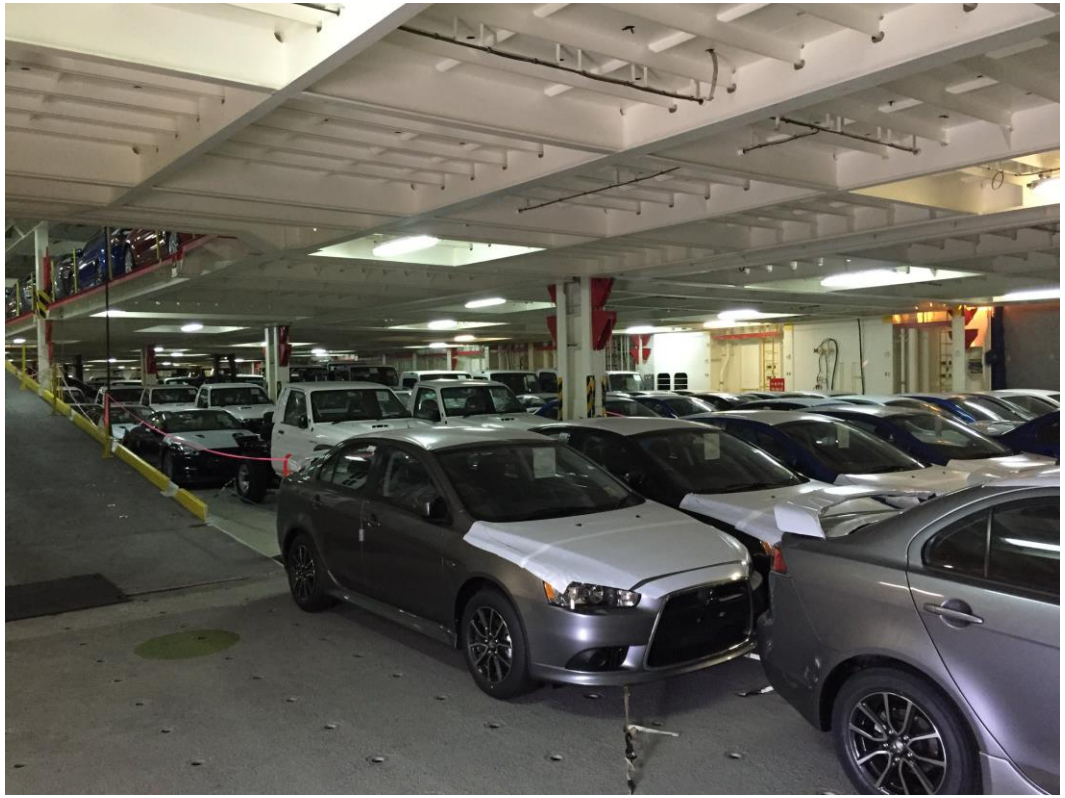
Roll-on-Roll-off Recommendations



Require a state of charge of no greater than 50% when transporting EVs.

https://rmi.org/wp-content/uploads/2020/04/EV-charging.jpg

Require a distance of 6 feet between vehicles during transportation.

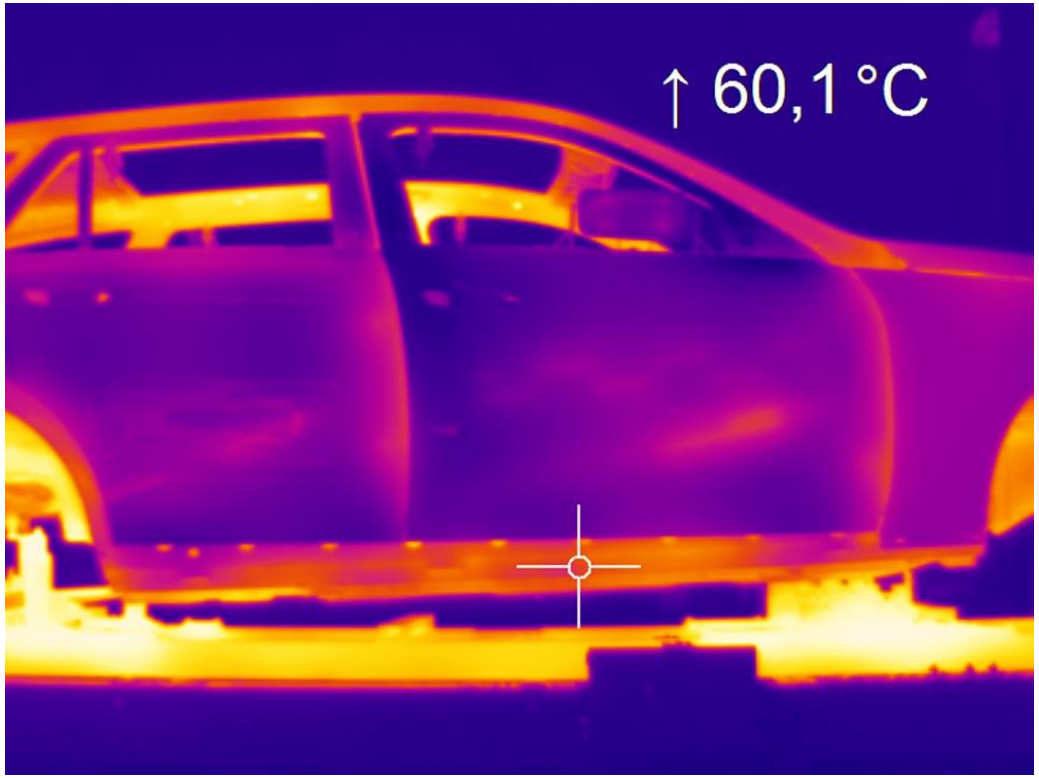


https://pbs.twimg.com/media/Cdz11fvUsAA94sT.jpg:large

Increase the frequency of safety patrols in EV cargo areas.

https://brentwoodmarine.co.uk/img/containers/main/img/vessel-watch-image.jpg/7cb20ce35590103d04d0bc8021ca98cc.jpg

Use thermal imaging devices in EV cargo areas, either passively or actively.



http://www.optris.com/tl_files/bilder/products/infrarotkamera/pi-640/ir-camera-optris-pi-640-thermal-image-car.jpg

Train crews to be prepared to fight a LIB fire.

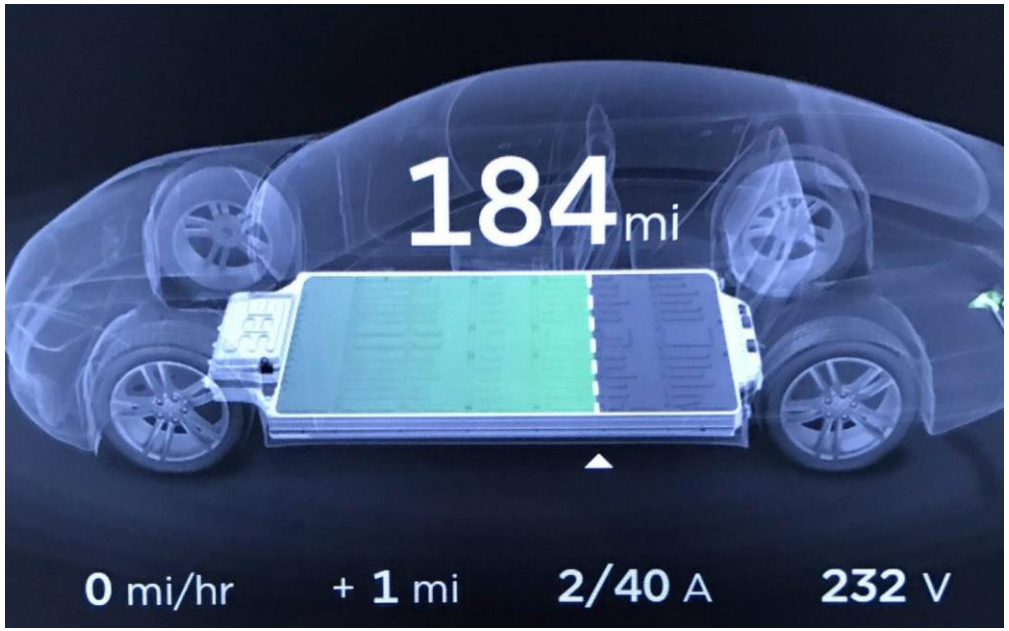
https://www.carriermanagement.com/assets/bigstock-Fire-Fighter-In-Car-Blaze-2029998-768x510.jpg

Require water mist systems and encourage water additives in cargo areas transporting EVs.

https://aito.com.my/wp-content/uploads/2019/12/WATERMISTPROTECTIONSYSTEM.png

Future Technology

Internal thermal management systems can monitor the vitals of individual batteries.



https://i1.wp.com/electrek.co/wp-content/uploads/sites/3/2016/12/tesla-battery-charging-e1481730205937.jpg?resize=1600%2C1000&quality=82&strip=all&ssl=1

Different battery chemistries and structures lower their combustibility.

https://www.airsoftworld.net/media/catalog/product/cache/357fb9658ab79bb191145ef48d4285b4/t/o/topbattery.jpg

Acknowledgements

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Professor Linda C. Looft	Worcester Polytechnic Institute
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Thank You!

Questions?