



Lithium Battery Webinar Series Recycling & Fire Prevention at Waste Hauler, Storage, & Processing Facilities

**A 30-Year Evolution of Lithium Battery Applications,
Chemistries & Form Factors**

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Lithium ion Battery-Powered Products in Kerchner Household

1. Pole saw
2. Two leaf blowers
3. Notebook
4. E-reader
5. Vacuum
6. Chainsaw
7. Tablet
8. Cellular phone
9. Drill
10. Circular saw (not in photo)



Lithium Metal Batteries v. Lithium ion Batteries



- Lithium metal batteries:
 - Generally non-rechargeable (also referred to as “primary” batteries)*
 - Contain metallic lithium, most contain organic solvent
 - Regulated for transport by U.S. Department of Transportation based on lithium metal content in grams (g)
- Lithium ion batteries:
 - Rechargeable (also referred to as “secondary” batteries)
 - Does not contain metallic lithium
 - Contain organic solvent
 - Regulated for transport by U.S. Department of Transportation based on “Watt-hours” (Wh)

**** There are rechargeable lithium metal battery chemistries on the market!***

Lithium ion Battery Chemistries*



- Lithium Cobalt Oxide (LiCoO_2)
- Lithium Manganese Oxide (LiMn_2O_4)
- Lithium Nickel Manganese Cobalt Oxide (LiNiMnCoO_2)
- Lithium Iron Phosphate (LiFePO_4)
- Lithium Nickel Cobalt Aluminum Oxide (LiNiCoAlO_2)
- Lithium Titanate ($\text{Li}_4\text{Ti}_5\text{O}_{12}$)

** This is not an exhaustive list.*

Lithium Metal Battery Chemistries

(Non-rechargeable)



- Lithium Manganese Dioxide
 - Consumer-type, 3 Volts and most common lithium metal battery
- Lithium Sulphur Dioxide
 - Military and aerospace
- Lithium Iodine
 - Implanted cardiac pacemakers
- Lithium Thionyl Chloride
 - Military and industrial (water meters, oil wells)
- Lithium Iron Disulphide
 - Consumer-type, 1.5 Volts (e.g., Energizer AA and AAA)



Solid State Lithium Batteries



Hybrid Li-Metal Batteries

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BATTERY TECHNOLOGY

POLY
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QuantumScape

Electric vehicles are here.

The future is solid.

Introducing QuantumScape.
Solid-state batteries that work.

today's mobile world has
been limited by yesterday's
battery technology...

Solid Power

Revolutionize the battery.

Safe, energy dense, all solid-state batteries.

Why Lithium?



- Advantages
 - High energy density
 - Rapid charge and high load capabilities
 - Long cycle and extended shelf-life; no maintenance
 - Good energy efficiency
 - Low self-discharge

- Limitations
 - Requires protection circuit to limit voltage and current
 - Possibility of venting and thermal runaway
 - Degrades at high temperature and when stored at high voltage
 - Rapid charging challenges at lower temperatures (< 32°F)
 - Transportation regulations complex and burdensome
 - Higher cost than nickel and lead-based systems

Lithium ion Cell Form Factors



Lithium ion prismatic



Lithium ion polymer/pouch



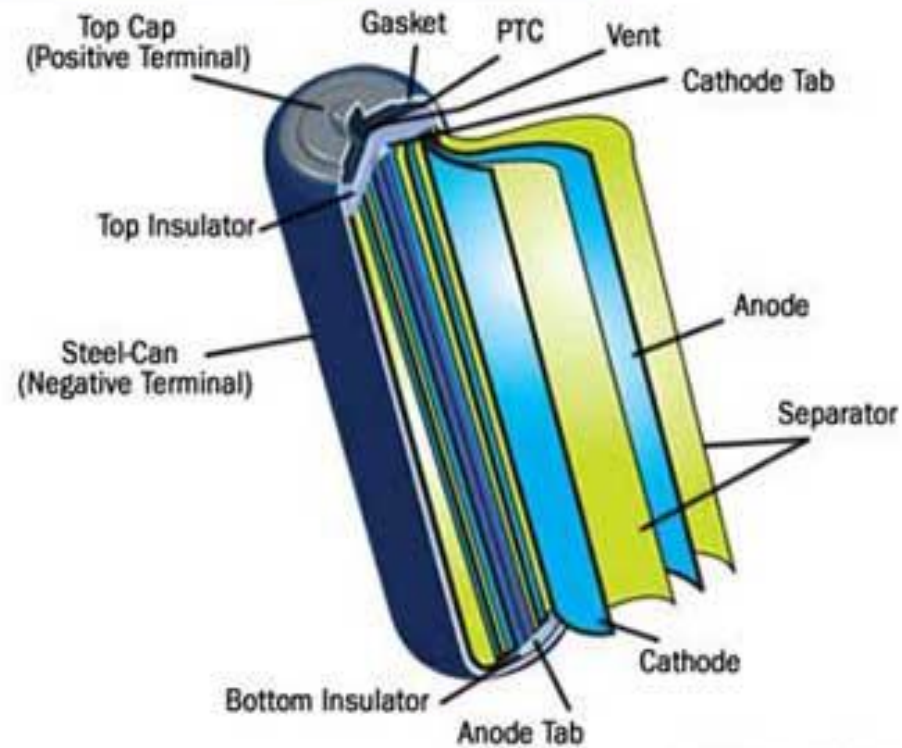
Lithium ion cylindrical



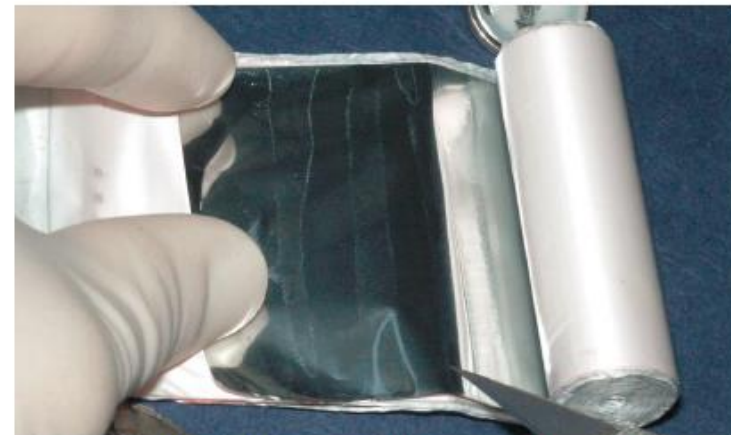
Other Form Factors?



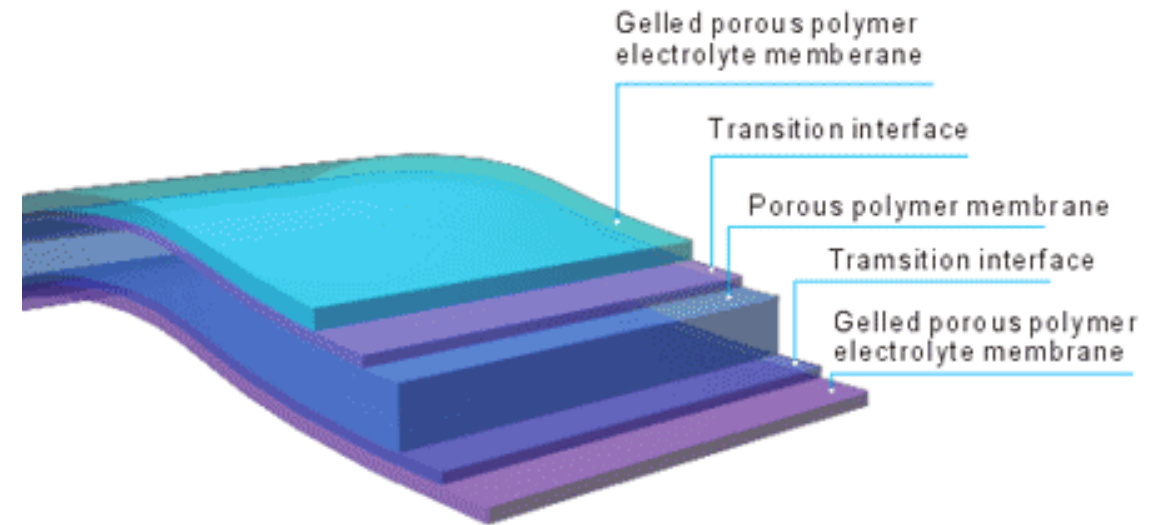
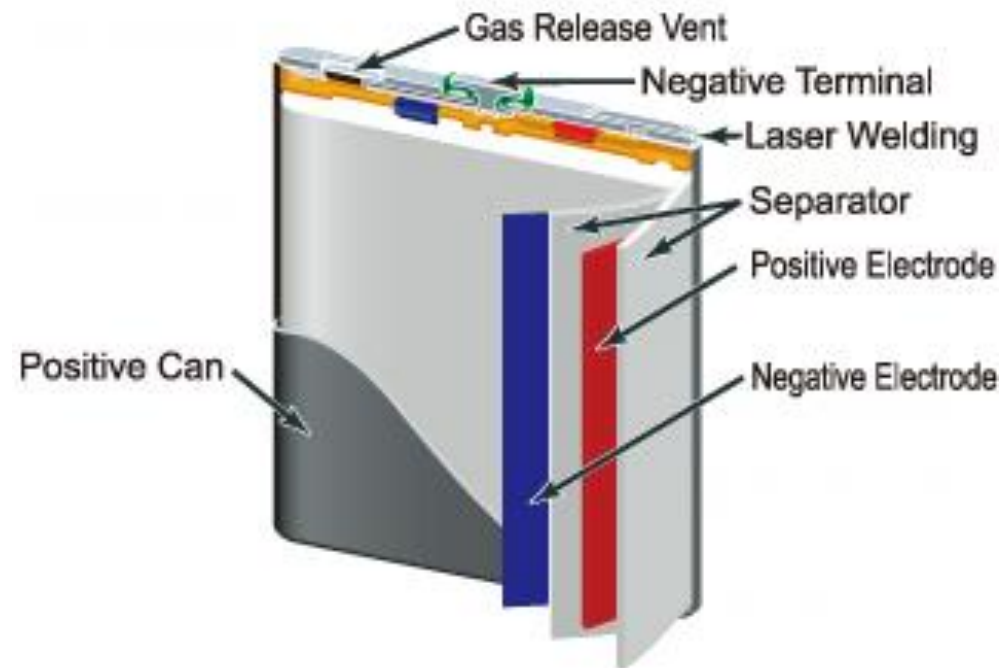
Lithium ion Cylindrical Cell Structure



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Lithium ion Prismatic and Polymer/Pouch Cell Structure



Lithium ion Batteries/Battery Packs



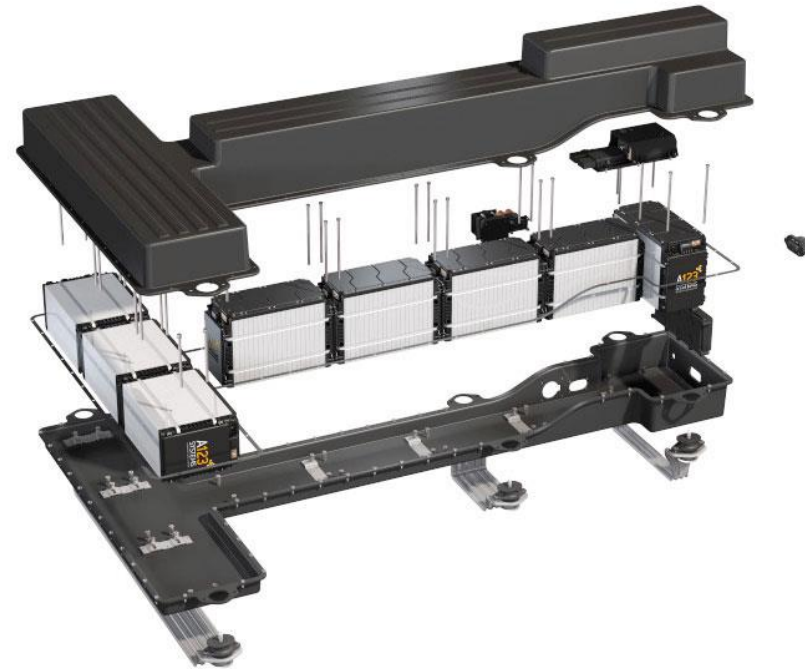
Lithium ion and Lead Batteries



Lithium ion Battery “Modules” and Battery “Assembly”

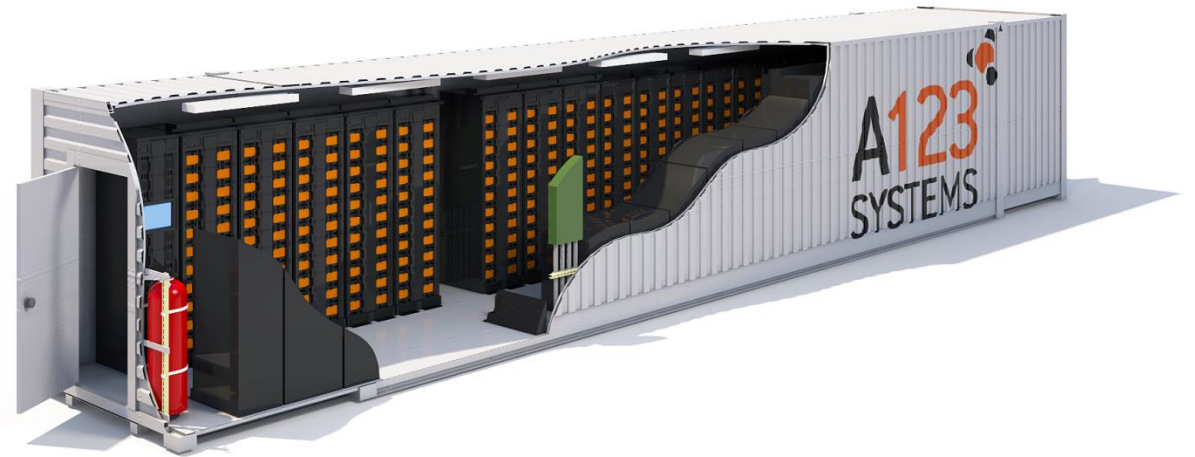


Modules



Assembly

Containerized Lithium ion Batteries



Organizations, Codes, and Standards Impacting Lithium Battery Storage



- National Fire Protection Association
 - Responsible for NFPA 1 Fire Code
- NFPA 855 Standard
 - Standard for the Installation of Stationary Energy Storage Systems
 - Includes Chapter 14 on battery storage
 - Amendments in process to limit scope to lithium batteries
- International Code Council
 - Responsible for International Fire Code

New Chapter in International Fire Code Under Development on Storage Requirements for Lithium Batteries



- Section 321.1 General (include list of exceptions)
 - 321.2 Permits
 - 321.3 Fire Safety Plan
 - 321.4 Storage Requirements
 - 321.4.1 Limited Indoor Storage in Containers
 - 321.4.2 Indoor Storage Areas
 - 321.4.3 Outdoor Storage



Indoor Storage: Sections 321.4

- Applies to indoor storage with more than 15 cubic feet of lithium batteries
 1. Secure permit and have fire safety plan
 2. Technical report to evaluate level of hazard and protection measures
 3. Construction requirements (e.g., 2-hour rated fire barriers)
 4. Fire Protection System
 5. Fire Alarm System
 6. Explosion Control



Thank you!

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