



Li-Ion Batteries

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Battery Types



Non-rechargeable Batteries (Alkaline)

Stable, no significant energetic releases.
Consistent energy, long-term power, but loses strength over time.
Long shelf life.



Non-rechargeable Batteries (Lithium Metal)

Stable, large energy density.
Can provide strong energy surges even after a period of low discharge
Lithium metal found inside is extremely water reactive.

Battery Types



Lead Acid Batteries

Stable, low energy density.
Contains Lead and Sulfuric Acid.
Risk of explosion due to Oxygen and Hydrogen generation during charging.



Nickel Cadmium (NiCad)/Nickel Metal Hydride (NiMH) Batteries

Rechargeable and stable
Suffers from "memory effect"
Can be smothered (METAL-X, Sand, etc.)
Water application can cause hydrogen gas release.

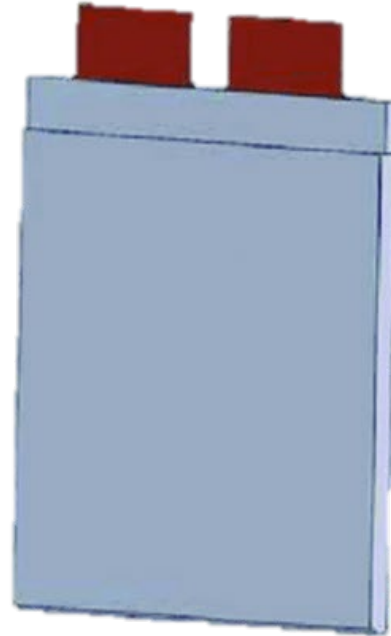
Lithium-Ion Battery Types



Cylindrical Cell



Prismatic Cell



Pouch Cell

Lithium-Ion Batteries

Good memory resistance Very stable High energy density

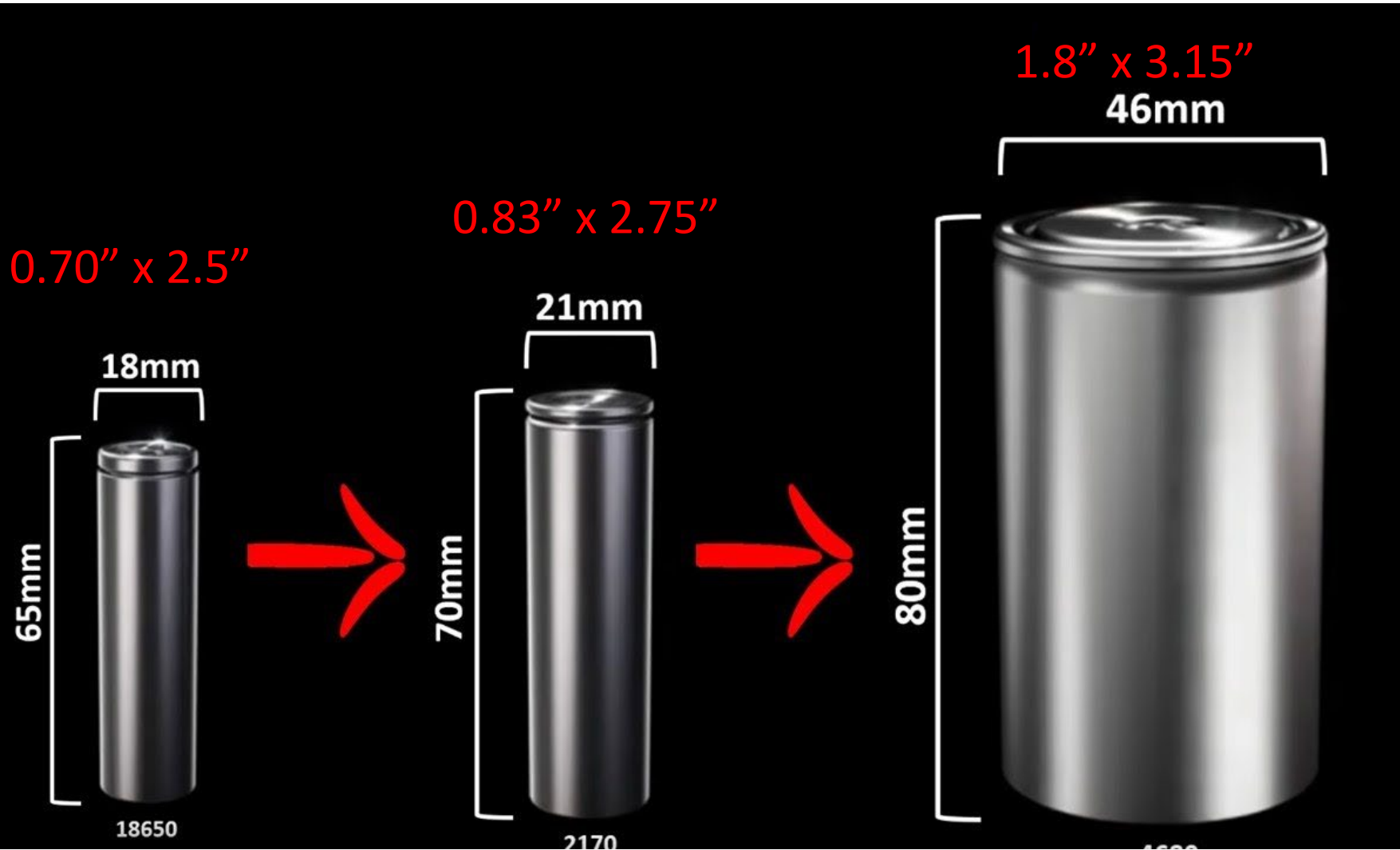
Toxic, corrosive, flammable, and explosive gas generation during thermal runaway

Cylindrical Cells (18650) are the most common battery in most mobile applications (bikes, scooters, etc.)

Cylindrical Cells are also used by electric vehicles, where you can find anywhere from 3K-7K individual cells

Prismatic and Pouch Cells are found in all other electric vehicles

Evolution of the Cylindrical Cell



Here is an example of how the cylindrical cell size has evolved over time.



How do
Lithium-ion
batteries
work?



Voltage in Lithium-Ion Battery Tech

Cell Phones = 3.4 to 4.5V

E-Scooter = 28 to 48V

E-Bike = 48 to 52V

Prius = 200V

Tesla = 350 to 400V

F150 Lightning = 400V

GMC Hummer = 400V

Ford Mach-e = 450V

Trolley = 600V

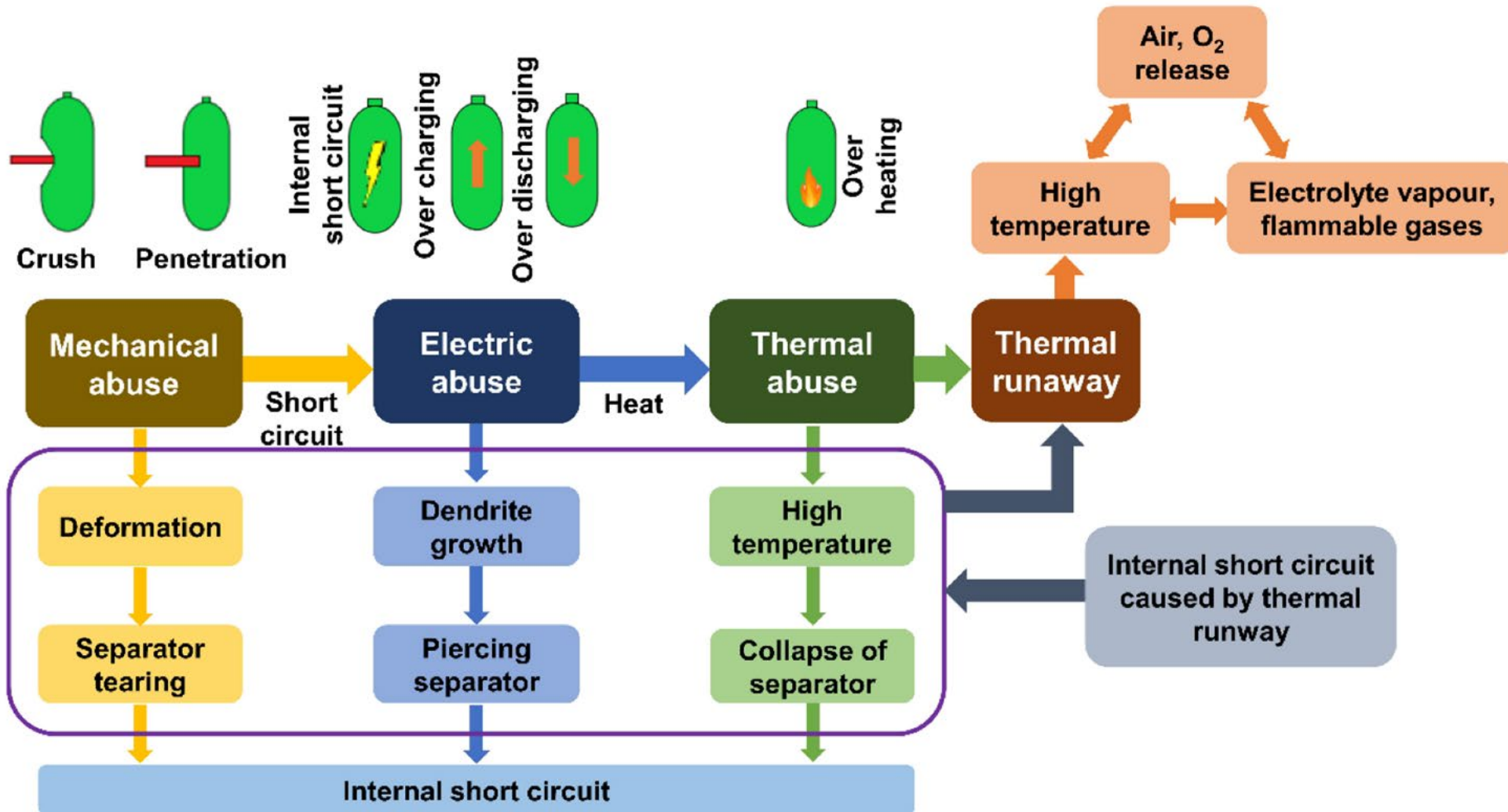
Tesla Truck = 800V (reported)

Tesla Semi = 1000V (reported)

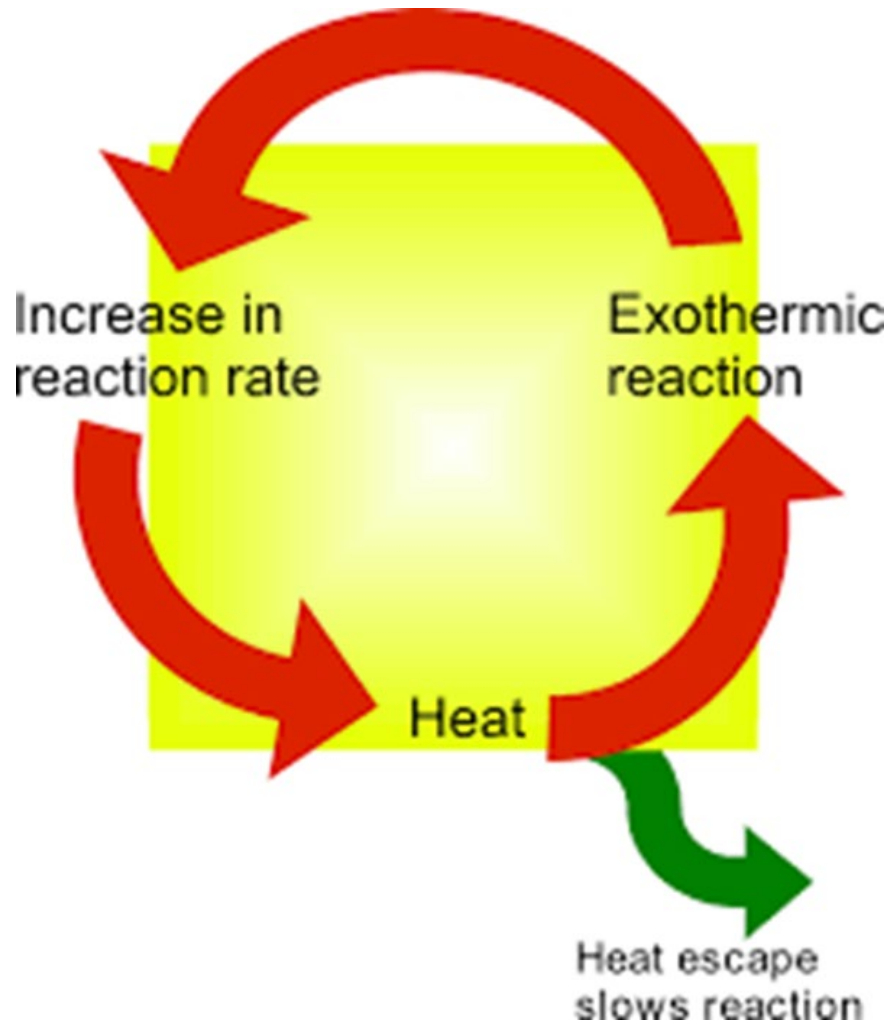




Why do batteries fail?



Differences in Lithium-Ion Battery Fires



- Very toxic atmospheres
- Burn temperatures are higher than normal
- Fires can burn without Oxygen – can't smother!
- Explosive potential – Hydrogen Gas
- Thermal Runaway reaction
 - Chemical reaction – rapid degradation
 - Does not require Oxygen
 - Nearly impossible to stop once it starts
 - Could happen in seconds or days
- Re-ignition is common
 - as much as 30 days or more!

Propagation



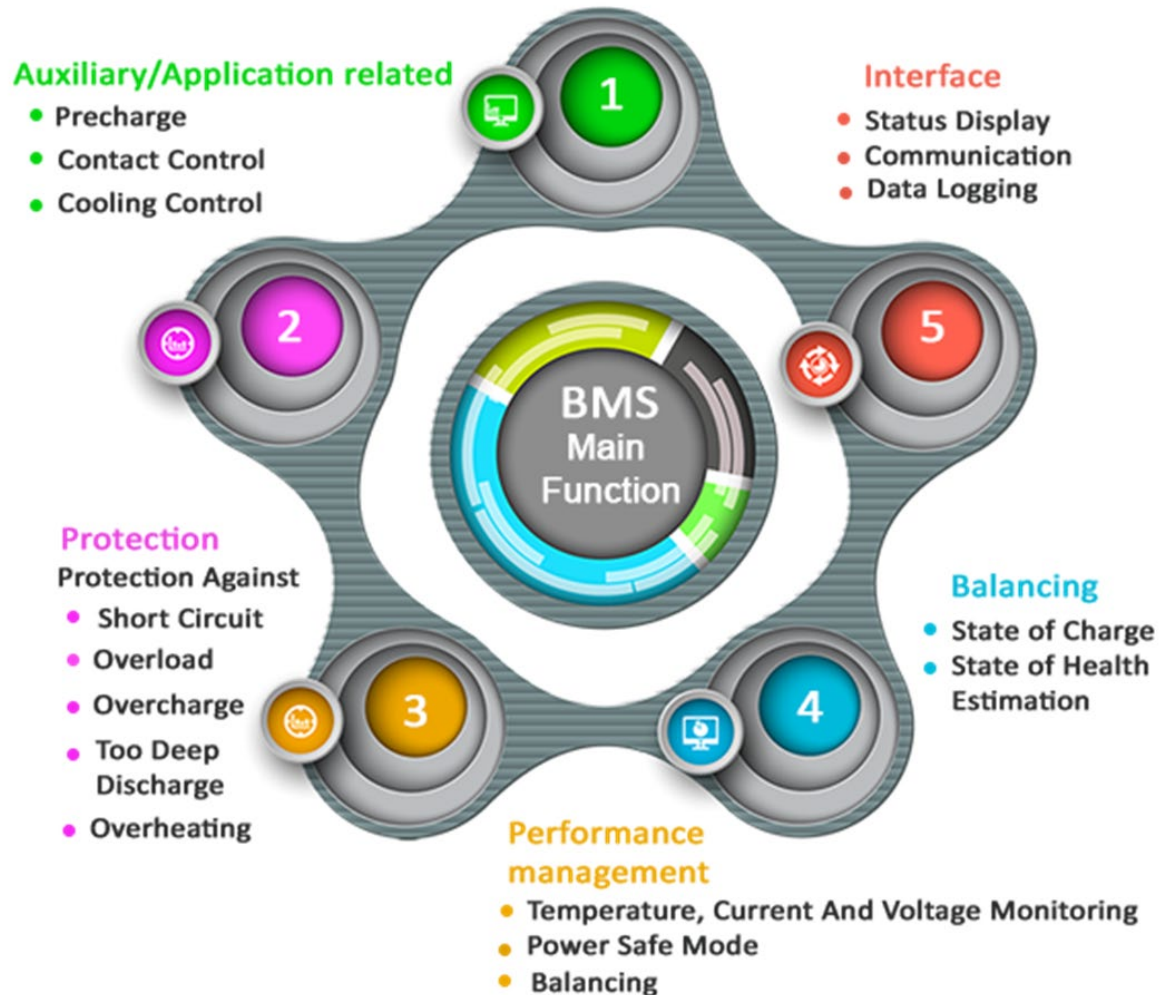
Propagation

- Domino effect
- Thermal Runaway heat in one battery will trigger Thermal Runaway in neighboring cells

Limiting propagation is primary goal

- Cooling neighboring cells may prevent propagation
- Removing exposed cells (i.e., removing other e-bikes, loose cells, etc.)

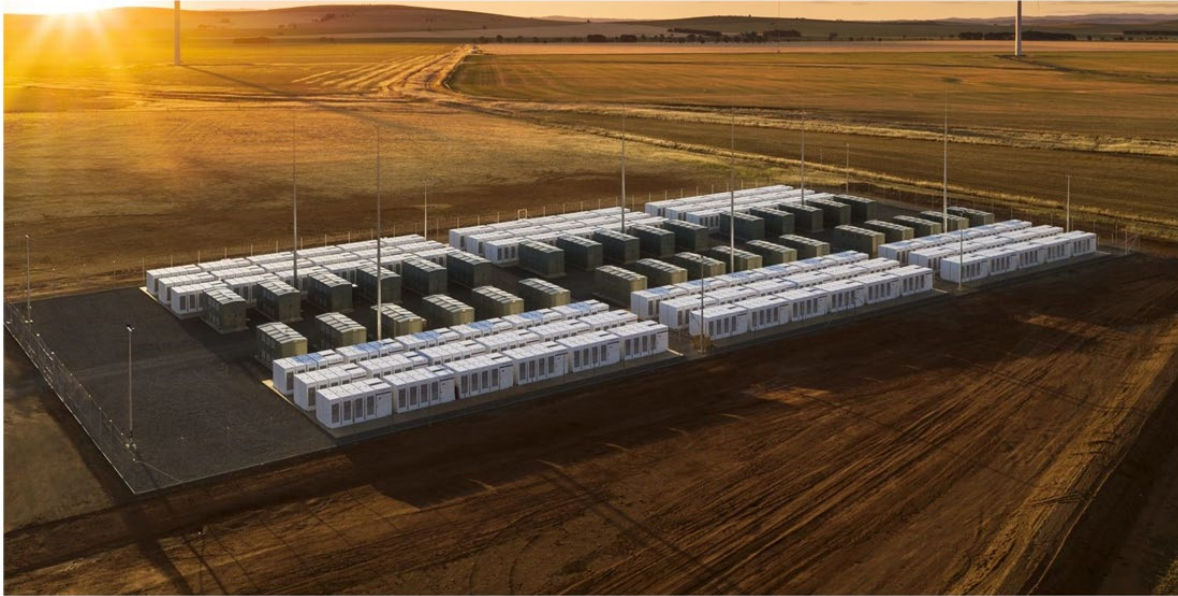
Preventing Battery Failure



A battery pack built together with a battery management system with an external communication data back up system is a smart battery pack.

A smart battery pack must be charged by a smart battery charger.

Three Primary Presentations of LIB



Battery Energy Storage System (BESS)

- Multiple battery packs
- Varies in size
- Regulations
 - NFPA 855
 - Changed after Surprise, AZ
 - No longer walk-in capability
 - Annunciator Panel
 - Ventilation system for gas removal
 - Fire prevention/mitigation tech
 - Varies by manufacturer
 - UL 9540 & 9540A
 - Testing/Burning of system
 - Required to pass standards to receive UL certification



188.8°F



2x

FFC

IR



MA



188.8°F



MAP



Manual operation

24°

240.3 FT



NEXT: N/A

SPEED

0.0 MPH

HEIGHT

244.8 FT

HRZ

AGL



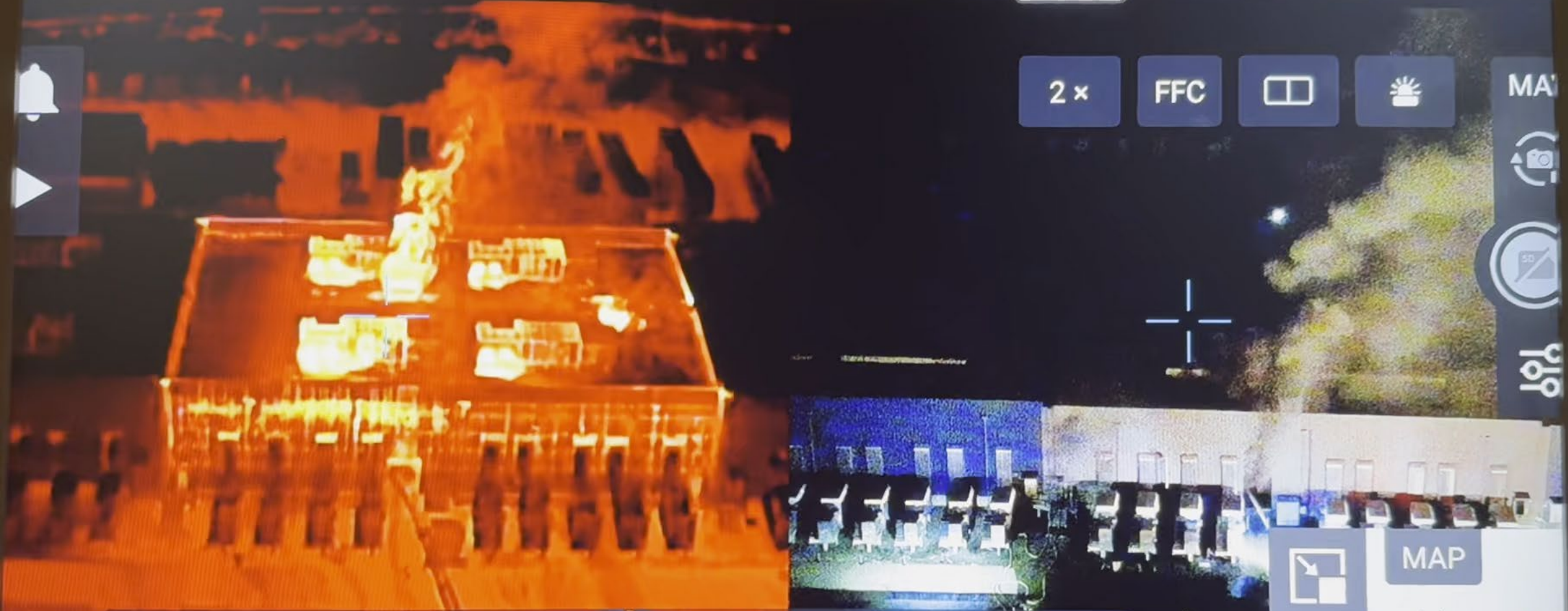
HOME/HOME DIST

0:17:10



2x FFC [Split View Icon] [Flashlight Icon]

MA [Camera Icon] [50% Zoom Icon] [90° Icon]



CURRENT: Manual operation

NEXT: N/A

2° 25° 374.4 FT

CHIMBY ANGLE DRONE/HOME DIST

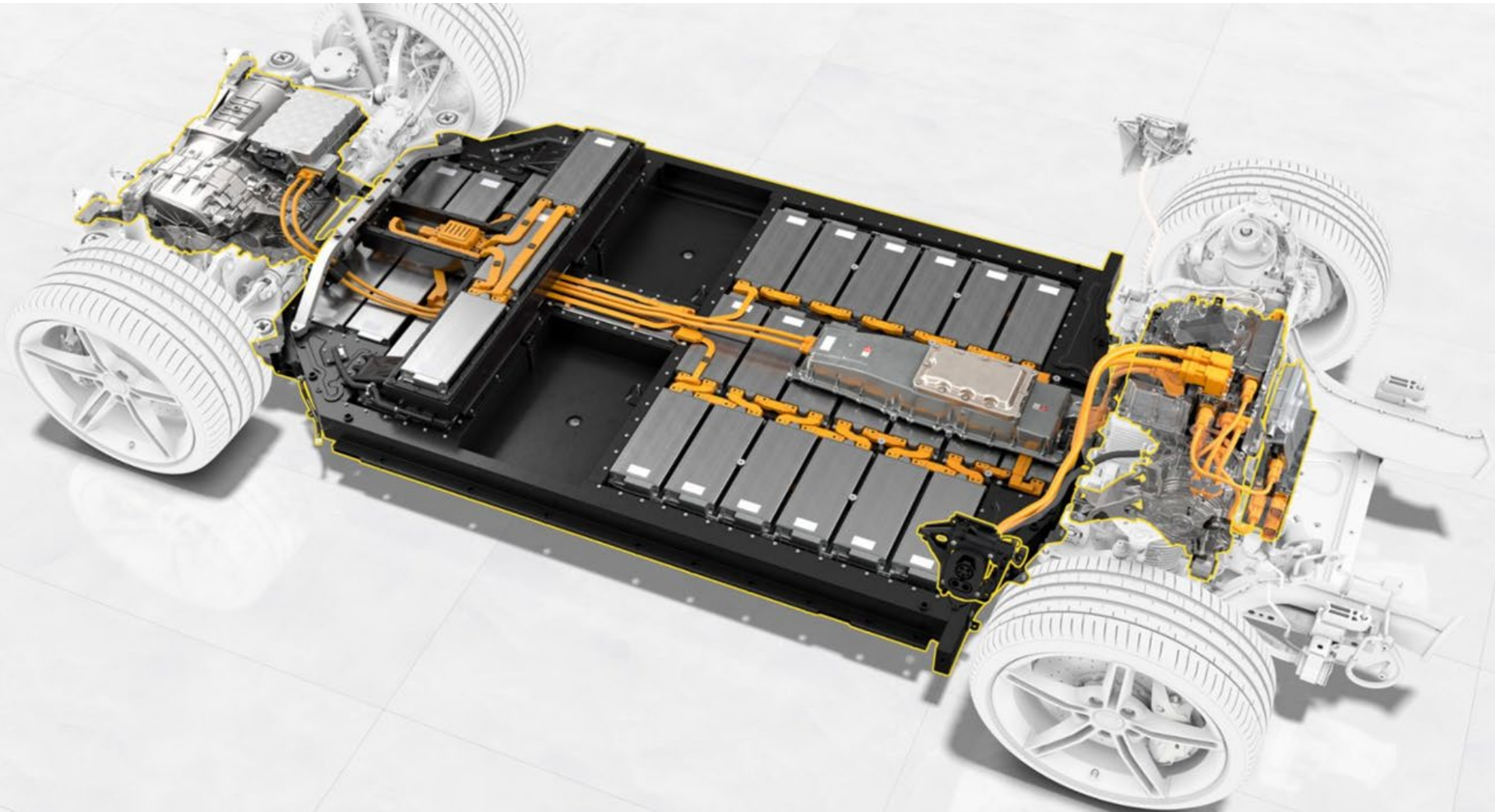


SPEED HEIGHT

HRZ 0.0 MPH AGL 260.2 FT

MAP

Battery Electric Vehicles (BEV)

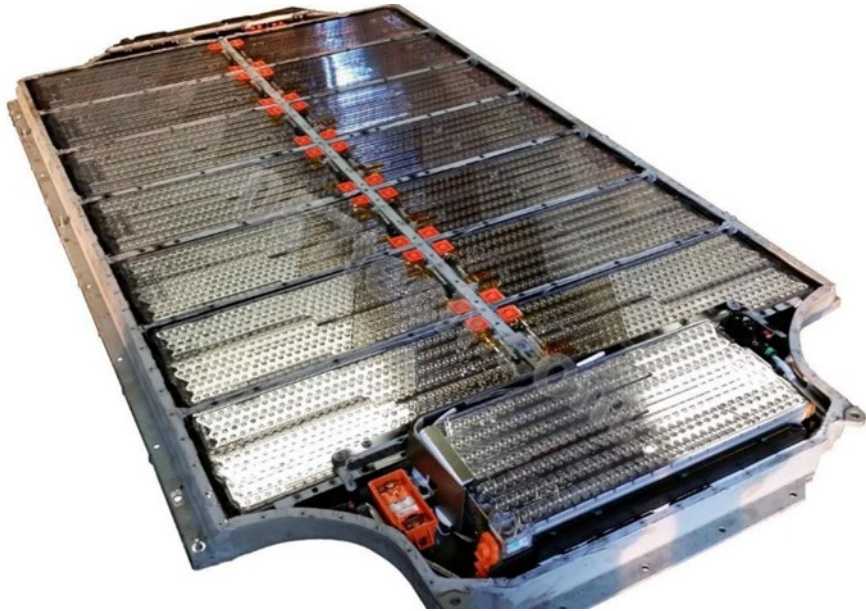




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Battery Electric Vehicle Damage



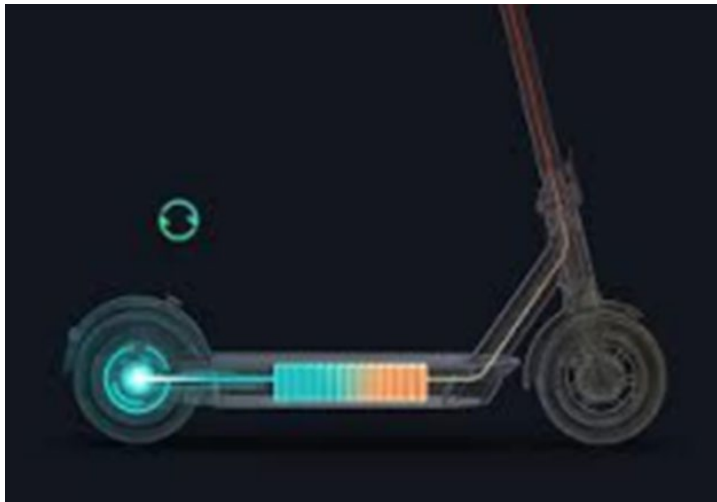
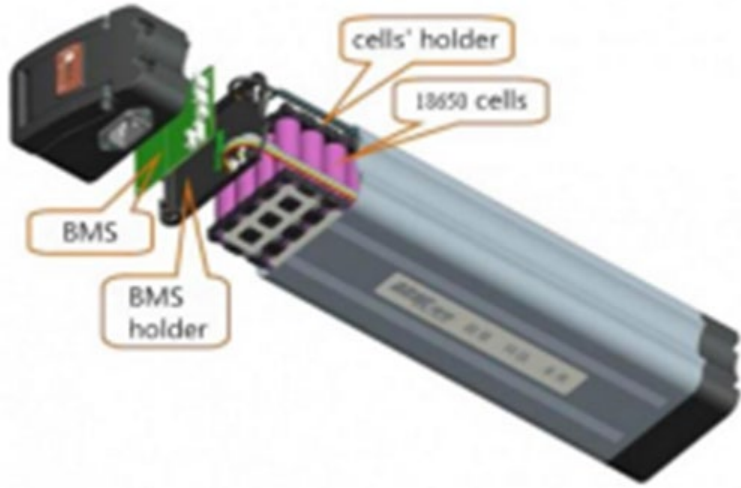
Tesla – Cylindrical Cell Batteries
18650 cell generation

Maui Wildfire Battery Collection- 5,000 cells per Tesla!



Micro-Mobility Devices

E-Bikes, scooters, Hoverboards, etc.



(i) Electric Unicycle



(ii) Egret (kick electric scooter)



(iii) Electric Scooter



(iv) Three-wheeler Electric Scooter



(v) Electric Mobility Cart



(vi) Electric Bike (bicycle)



(vii) Hoverboard



(viii) Segway



(ix) Electric Caster Board

Micro-Mobility Devices



- Largest number of LIB incidents
- FDNY LIB fires:
 - 44 in 2020
 - 220 in 2022
- Public exposure concerns
 - Stored and charged inside occupied residences and businesses
 - Stored near entry and exit ways
 - Can ignite with little-to-no warning
 - **Rekindle is likely.**

Micro Mobility Concerns



Micro Mobility Concerns



Micro Mobility Concerns





VIP Pedicab Downtown SD November 2022

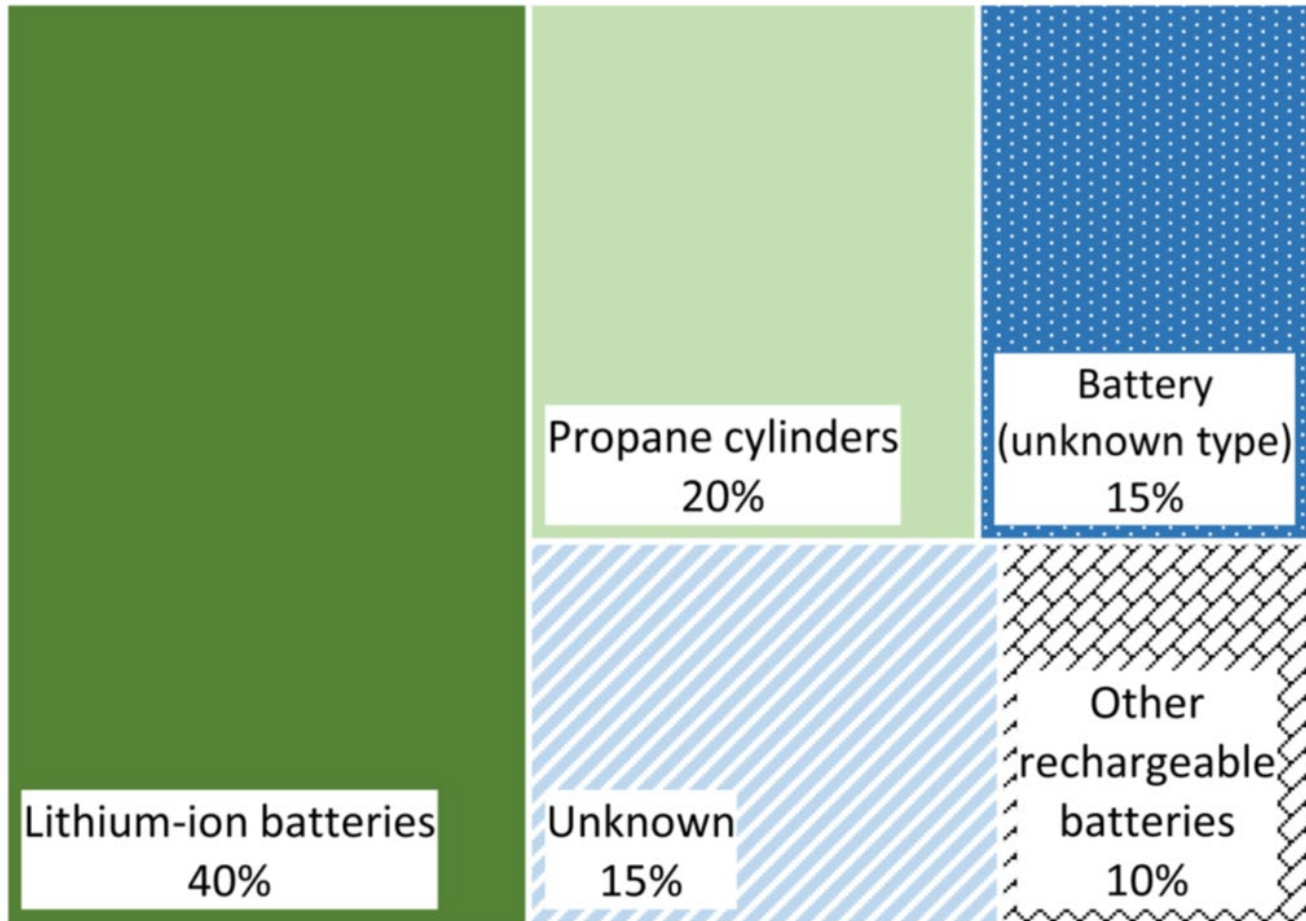


Recognize LIBs as a Hazardous Material



Disposal Challenge

Sources of Fires at Waste Management Facilities



- Trash trucks/recycling facilities
- 60% of trash truck load fires

An Option- DOT Special Permit containers



Battery Safety

- ✓ Store batteries in a secure location away from fire escapes, windows and doors
- ✓ Disconnect chargers when equipment is fully charged
- ✓ Use only compatible chargers designed to charge the specific device
- ✓ Batteries showing signs of damage should be disposed of through an approved facility or recycling center
- ✓ **DO NOT THROW BATTERIES AWAY IN REGULAR TRASH!**
- ✓ Determine if a commercially made battery storage container is appropriate for your facility

Disposal and Recycling Options

Burned or involved in a fire

- Requires disposal through a registered Hazardous Waste Hauler

Damaged or Swollen but NOT reacting

- Household hazardous Waste (Maybe)
- www.Call2Recycle.org/Store DDR Kit (877) 723-1297
- <https://earth911.com> (800) CLEANUP
- <https://www.cirbasolutions.com/> kit sold (800) 852-8127
- <https://Cellblockfcs.com> recycle kit (800) 440-4119
- www.cleanearthinc.com recycle kit (866) 447-5177

In good condition

- www.Call2recycle.org & enter zip code Home Depot, Lowes, etc.
- Household HazWaste (877-713-2784)
- <https://earth911.com> (800) CLEANUP

