

LITHIUM-ION BATTERY CHALLENGES FOR BALTIMORE REGION TRAFFIC INCIDENT MANAGEMENT CONFERENCE

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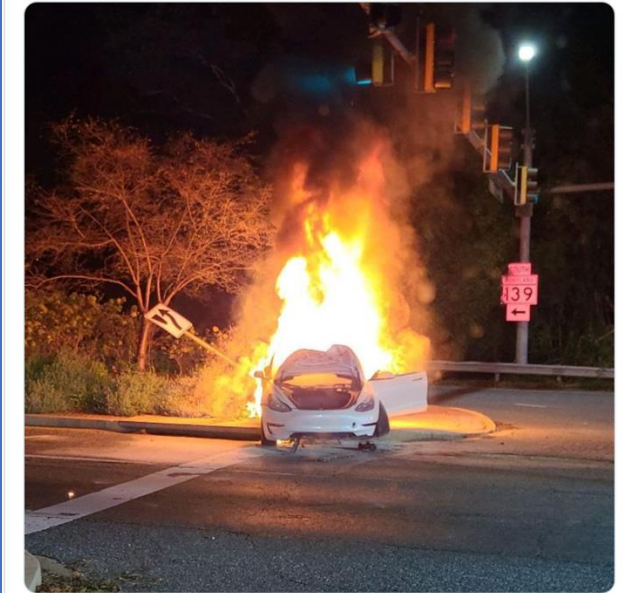
240-444-5730

April 23, 2025



Baltimore Co. Volunteer Firefighter's Association
@BaltCoVolFire · Follow

TOWSON 1-2 N CHARLES ST & W TOWSONTOWN BL -
VEHICLE FIRE. TESLA ON FIRE. REQUEST LARGE
CAPACITY WATER TANKER, HAZMAT UNIT, AND FOAM
UNIT DUE TO ELECTRIC VEHICLE ON FIRE. ROAD IS
BLOCKED #BCOTRAFFIC @LVFC30 @ProvidenceVFC29
@BaltCoFire



8:32 PM · Sep 30, 2021



Bob Swaim

NTSB Aviation Major Accident Investigator since 1987

Working with firefighters and other responders around the world for 37+ years

2013 Launch investigator for JAL 787 fire investigation

Lithium-Ion battery work at UL labs, vehicle, and battery manufacturers

Electric vehicle investigator since 2017

SAE Instructor and J2990 First Responder Safety Committee

NFPA Instructor



People Buy EVs Sell Due To Personal Finances

Actual examples:



	2023 Hyundai Tucson	2020 Chevrolet Bolt	2016 Ford Transit
Cost	\$27,000 (new)	\$27,000 (new)	\$16,000 (used)
MPG	28 mpg	136 e-mpg	16 mpg
Cost to fill/charge 12,000 mi/year	\$ 45	\$ 6.85 (home)	\$ 80
Yearly Cost \$3.50 gas \$.146 kWh	\$ 1,500	\$ 316	\$ 2,625

How Fast Can Things Go Bad?

Clues to move away fast:

Watch for flash of van tail lights,
venting **sound**,
Sight of smoke,
Smell

Watch for truck fuel shift from
plastic to battery venting



vent

smoke

flame

truck

third

Police – Unwitting Smoke Victims

Typically first on scene

Smoke initially does not smell hazardous

Contents:

- Reduced oxygen (judgement impact)

- Contain toxins

 - Acids affect lungs and eyes

 - Heavy metals remain in body

- Flammable gas & explosive hydrogen

**MOVE AWAY AT FIRST
SIGHT - SOUND - SMELL**



Current Actual Hazards

REAL EV HAZARD AT DAILY ROUTINE TRAFFIC ACCIDENTS

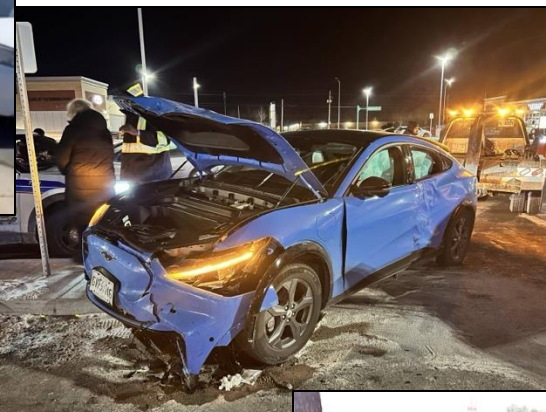
Daily Hazard: The drivers foot near the accelerator pedal



Extensive injury to legs of FDNY Firefighter
July 2022

Electric Car Drivers More Likely To Cause Accidents, Research Shows

BY LERO OCTOBER 2, 2024



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REAL HAZARD AT DAILY ROUTINE TRAFFIC ACCIDENTS

EVERYBODY REPEAT:

"The daily hybrid/EV threat to ME are crush injuries

From silent movement due to

The drivers foot near the accelerator pedal"

EVERY TIME

CHOCK

PARKing brake

PARK shifter

OFF key/power

Spoofing Automated Vehicles

Chosen Pattern Injection

Makes vehicles detect items which do not exist

Example: Signs printed on T-shirts



Driving Aggressively

Makes vehicle yield

Altered speed signs

Temporary Physical Items

People surround vehicle

Cover sensor with aluminum foil

Cones



Current Leading Lithium Battery Issues

1. E-Bikes



Current Leading Lithium Battery Issues

1. E-Bikes

Cover with fire blanket if available.

Can move if in full gear with SCBA

Using a pole hook

or

Pick up front wheel and drag



Current Leading Lithium Battery Issues

2. Vapes

66% of burn injuries start in a pocket and create third degree burns

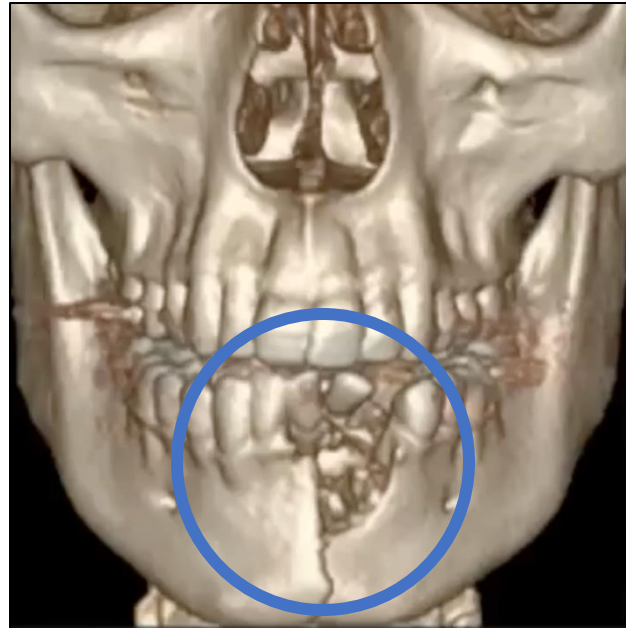


Current Leading Lithium Battery Issues

2. Vapes

Facial injuries create choke hazard

Bursting case
becomes shrapnel



Finger sweep mouth for debris



3. Trash Trucks and Landfills

Consumers dispose of Lithium-Ion cells or devices in trash
Crushing or short circuits with other metal items create fires



Ventura, Cal. 9/9/23



Staten Island, NJ. 3/17/22

Battery Fires – Recycling Facilities

Fires

at facilities that
dismantle/recycle



4. Box trailers or rail cars containing drums of spent cells. (DDR-Damaged Defective Recalled)

Vapor cloud exploded in parked box trailer



(Photo by Birmingham Fire and Rescue Service)

Basics Of EVs & Hybrids For Responders

Goal: Prepare first responders to operate safely at incidents

EVs and Hybrids have two things in common



Each has a
large HV
battery

and

12V battery

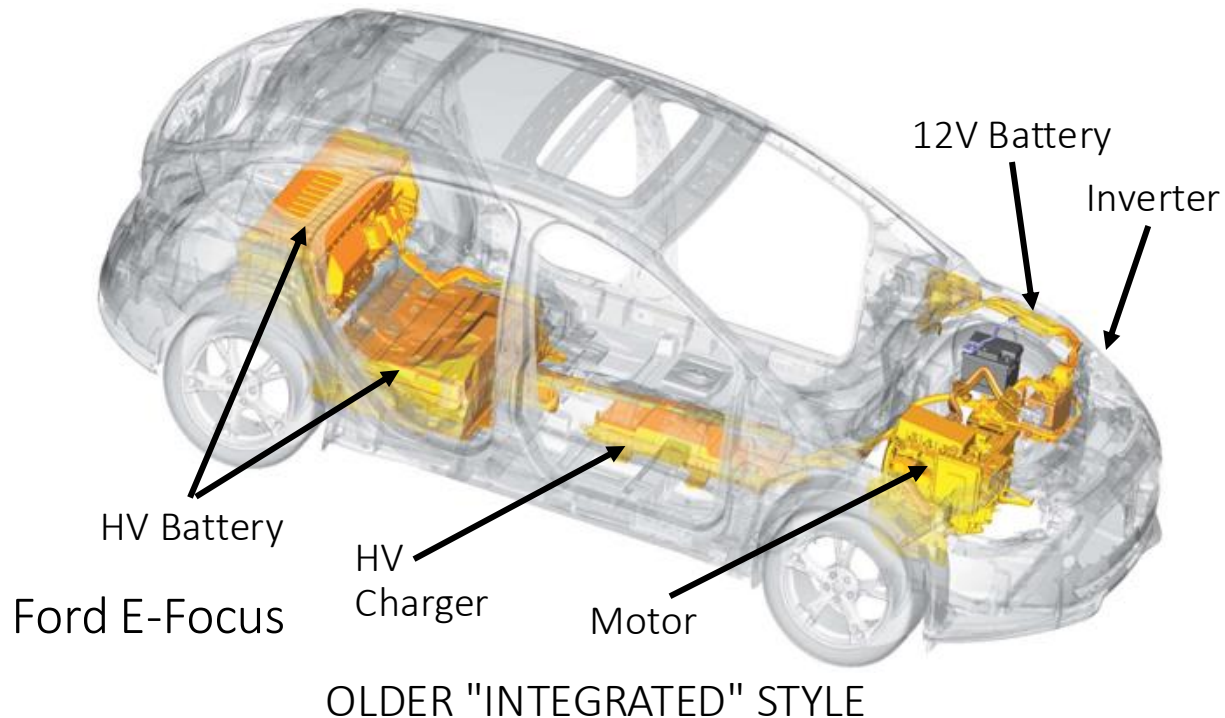
Yellow Low Voltage – Orange High Voltage

High voltage traction battery moves vehicle (350-800 VDC)

12 VDC Battery for "house" functions.

Radio, windows, airbags, etc

Orange denotes high voltage >30 VAC or 60 VDC



BATTERY/MOTOR "ROLLER SKATE"
VW ID.3

A Hybrid or EV May Have Three Fuels

Tesla Model 3 Electric Vehicle



Interior fire
Plastics and electronics

Toyota Prius Hybrid



ICE (gas) engine fire

Tesla Model S Electric Vehicle



Battery fire

Vehicle Fires- Suppression

Emergency Operations

How and Where of Water
is key

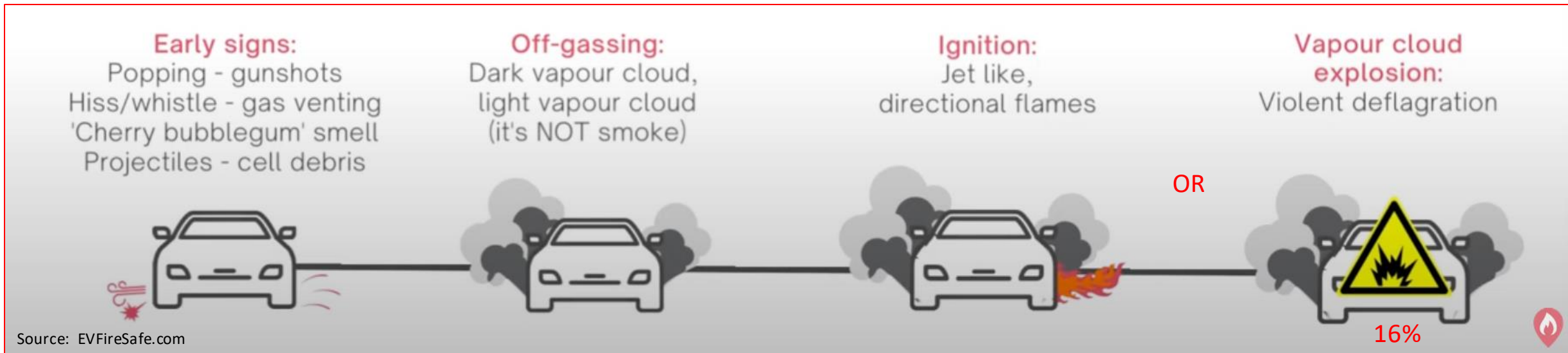


If Battery access is limited, most of
the water will likely be wasted



EV Fire Progression

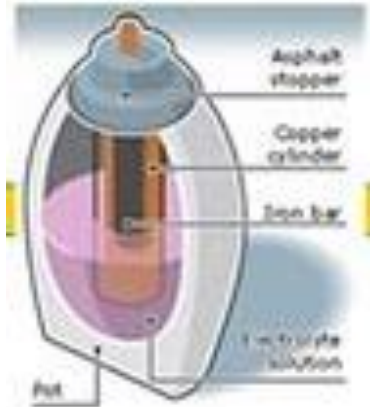
Watch for battery involvement with
SIGHT - SOUND - SMELL



Battery Basics

Batteries Are Not New

<https://www.helios-h2020project.eu/news/batteries-long-history-powerful-future>



Cu/Fe
vinegar/wine



Zn/MnO₂/C
NH₄Cl or ZnCl₂



Zn/MnO₂/C
Zn in KOH



Li/Ni/Co/Mn/Fe
Li in carbonate



Na-ion
Metal-Air
Al-S
....

Three Most Common Chemistries Of Lithium-ion Batteries

Source: <https://nordkyndesign.com/lithium-battery-banks-fundamentals/>

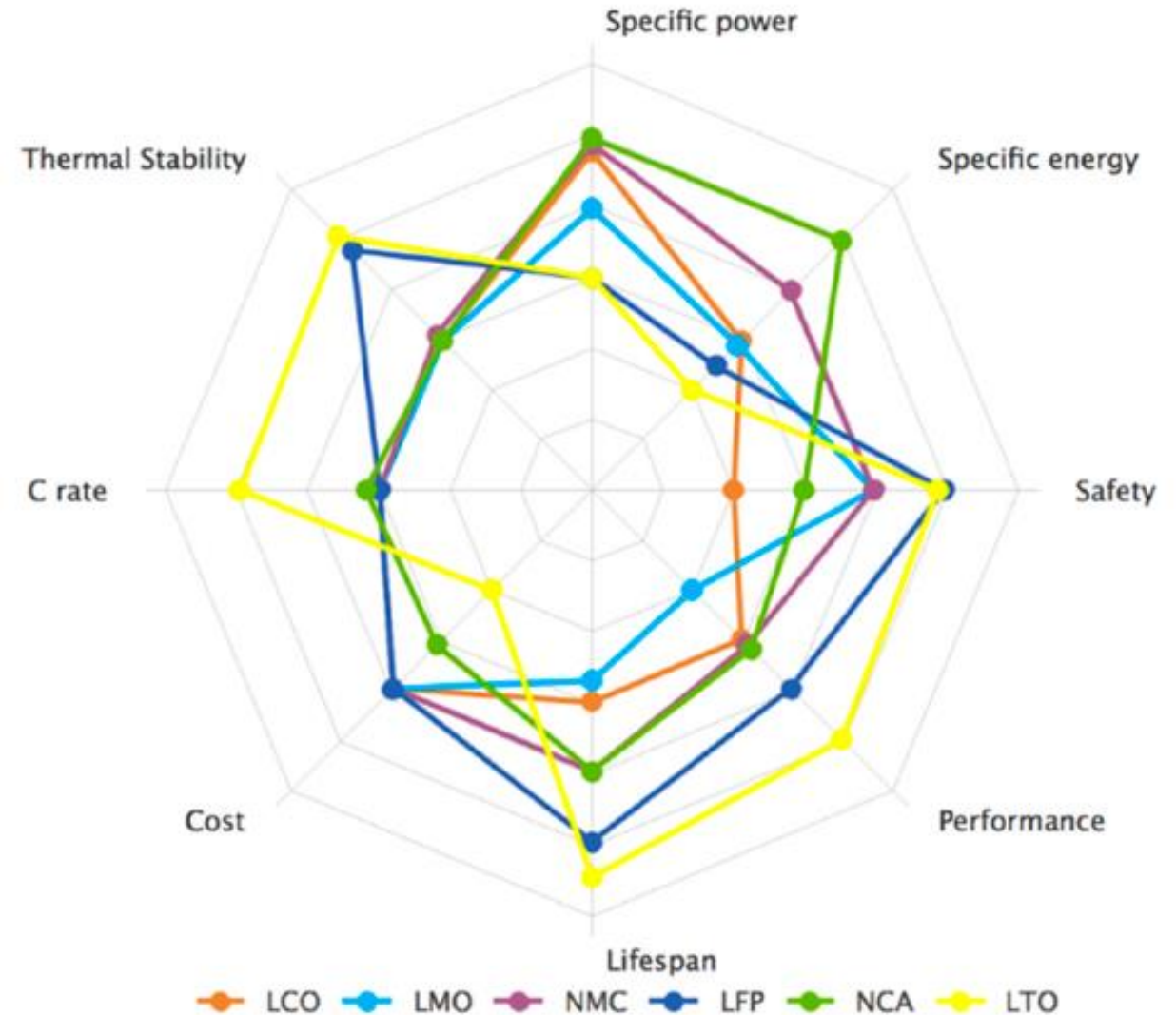
Other non-lithium chemistries exist, such as NiMH in Toyota C-HR and Nissan Leaf

*NCA – lithium nickel cobalt aluminium oxide (1999),
NMC – lithium nickel manganese oxide (2008),
LFP – lithium iron phosphate (1993) (aka LiFePO_4),
LCO – lithium cobalt oxide (1991),
LMO – lithium manganese oxide (1996),
LTO – lithium titanate oxide (2008).*

NCA - Highest energy. Low mfg cost. TR history.
Source issues [Russia Nickel, Congo Cobalt]
Early Tesla models

NMC - High energy. TR history.
Source issues [Russia Nickel, Congo Cobalt]
Rivian
Jeep 4xe
BMW iX3
Hyundai Ioniq 5

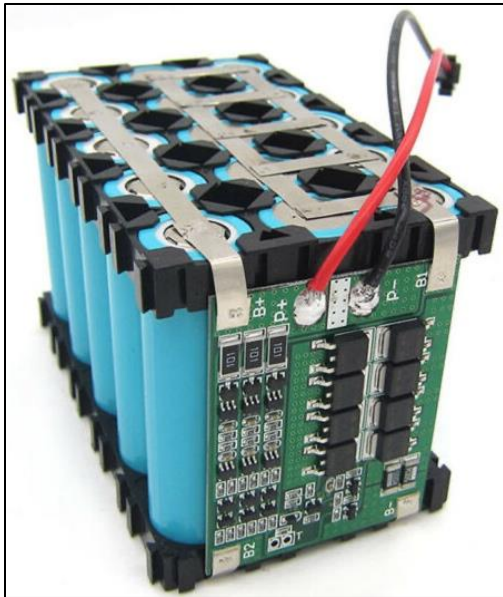
LFP - Longer life. Thermal stability. Lower energy density
Rivian (new)
Tesla 3 (new CATL)
Hyundai Ioniq 5



Three cell shapes/formats

Hazard typically is based in chemistry and not format

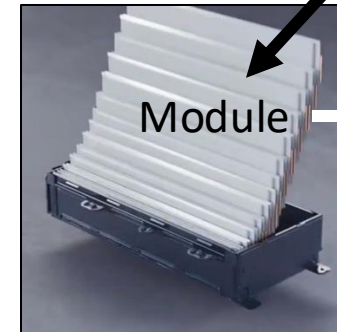
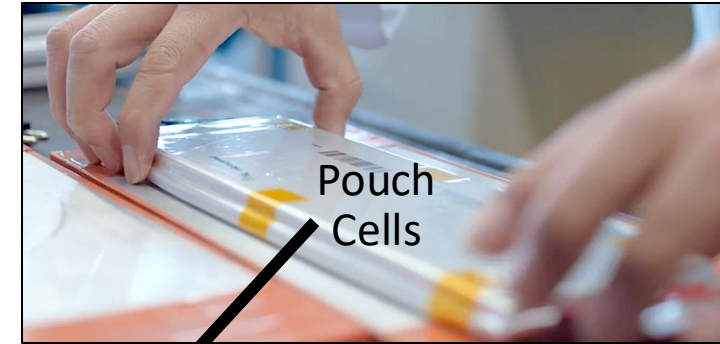
Cylindrical cells



Prismatic cells

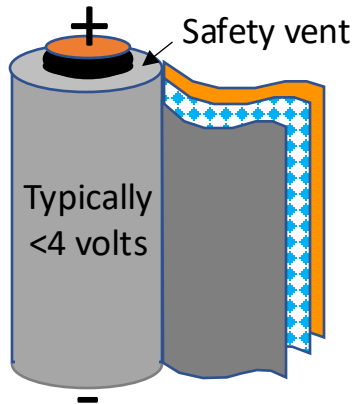


Pouch cells



How A Lithium-ion Battery Functions

Four Components



Anode (-)

Copper foil with porous carbon coating

Separator

Porous polypropylene membrane

Cathode (+)

Aluminum foil with porous oxide coating



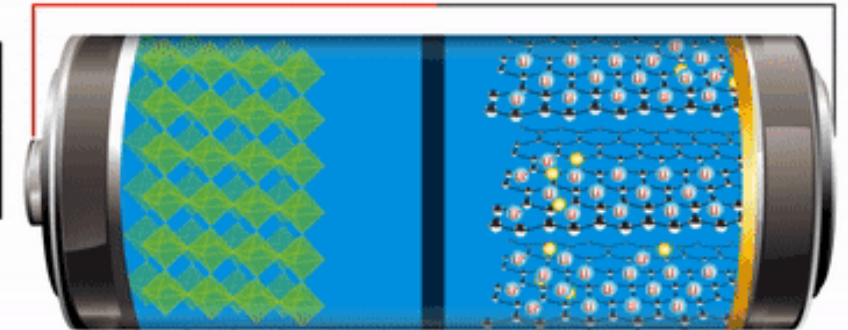
Electrolyte (typically oil) contains lithium ions (salt)

Lithium salt ions move in electrolyte

Discharge



Charge
Meter



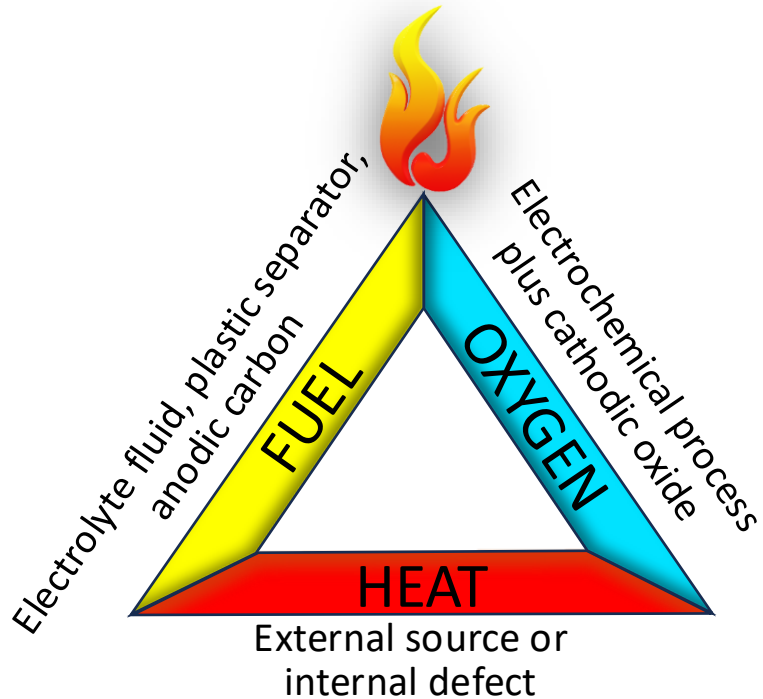
U.S. DEPARTMENT OF
ENERGY

Office of ENERGY EFFICIENCY
& RENEWABLE ENERGY

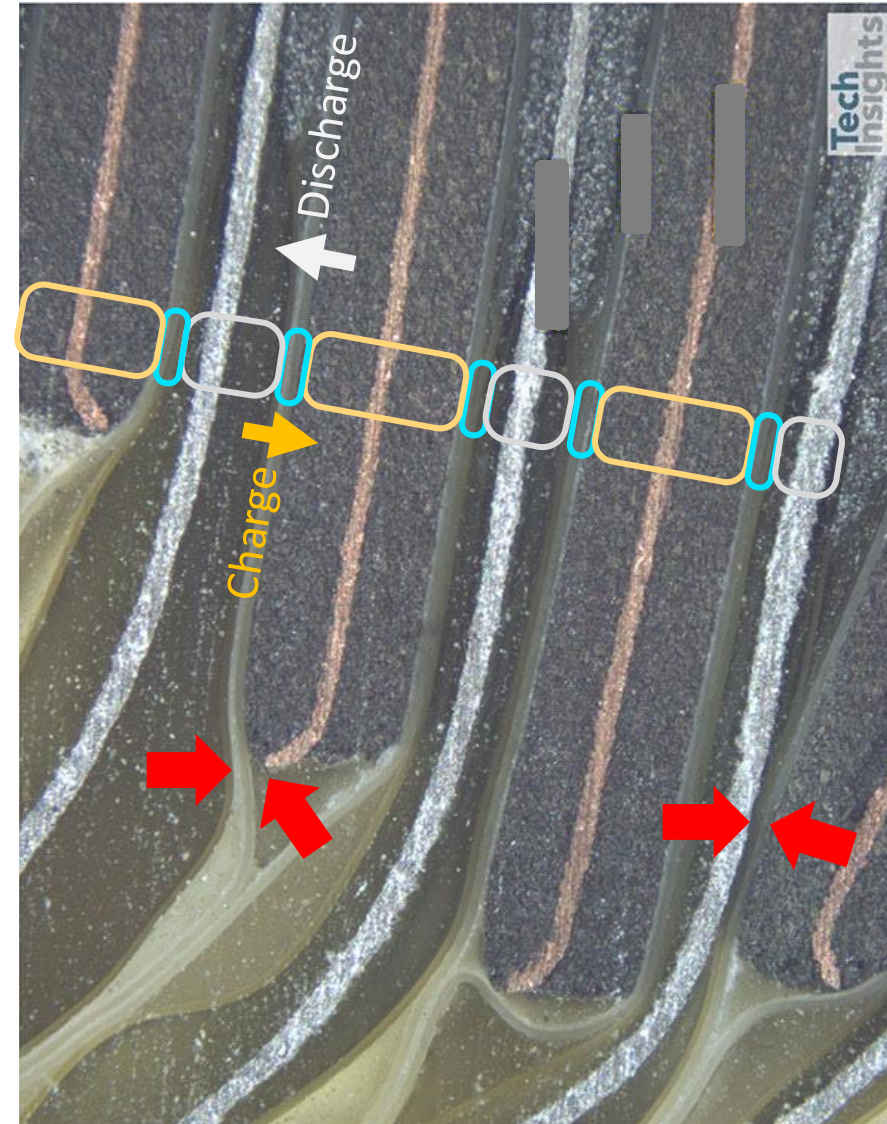


Potentially vulnerable points

Each cell has BOTH electrical (30%)
AND chemical energy (%70)



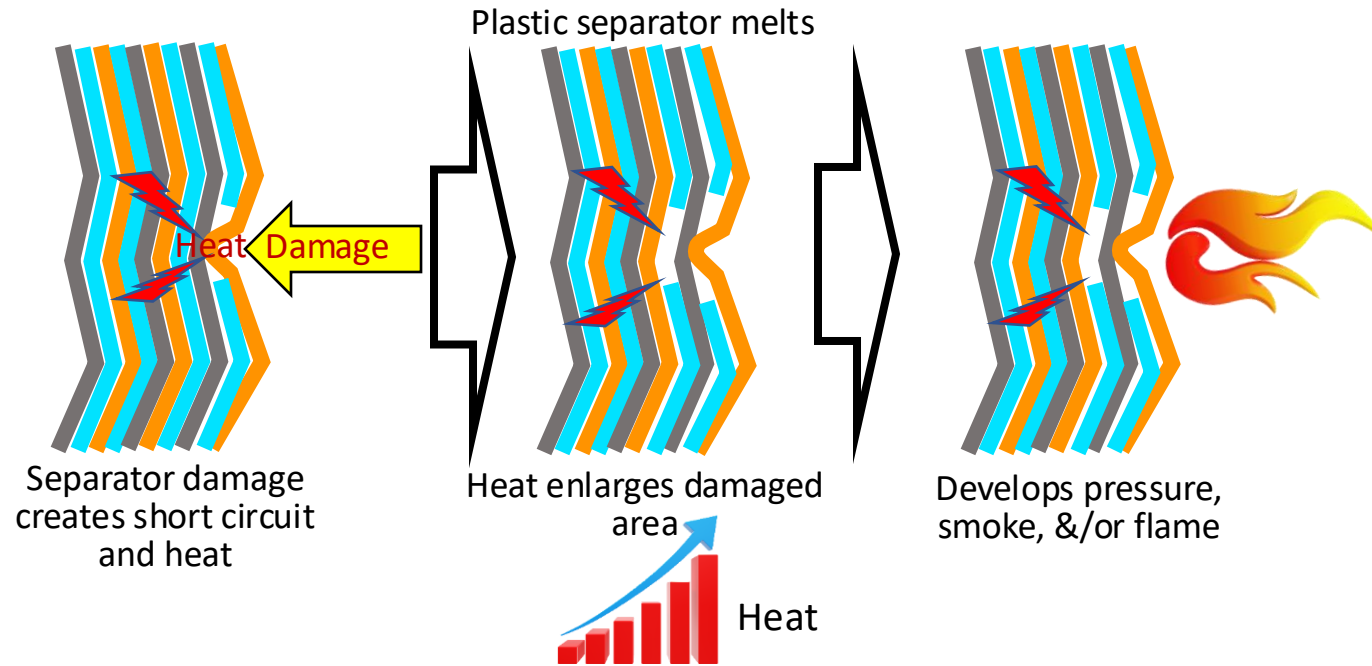
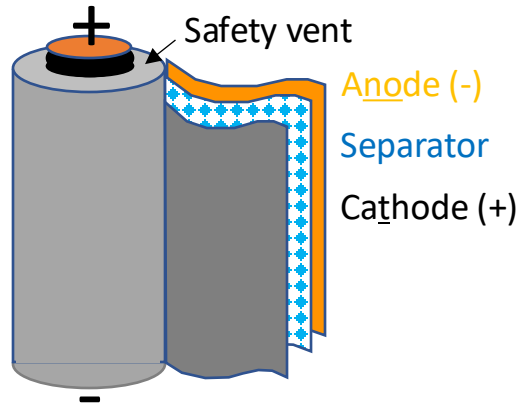
Each cell contains a complete fire triangle



Potential to damage separator

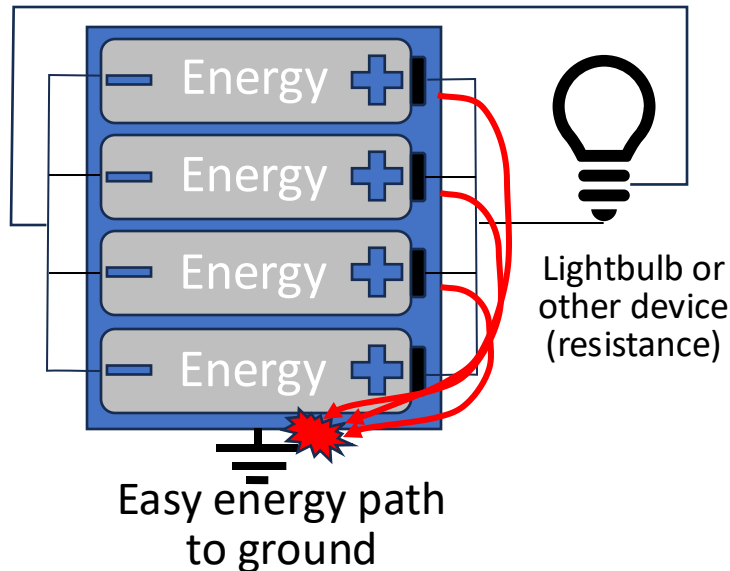
LG Electronics SB035Z6 Ion Battery SEM Cell Cross Section from a Chevrolet Bolt

Thermal runaway process

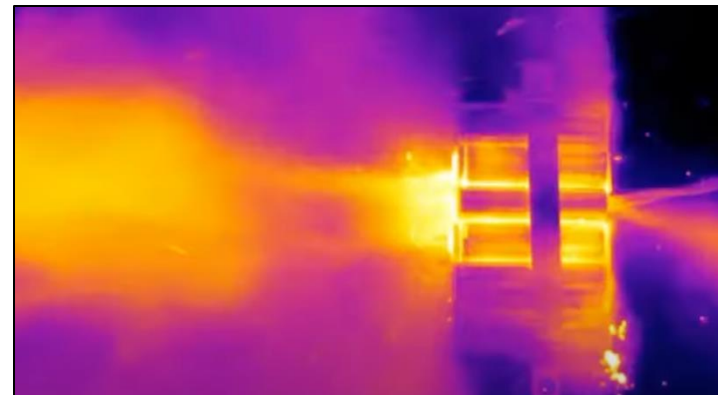


Temp <100C
can stop
thermal
runaway
process

5800 mAh
+
5800 mAh
+
5800 mAh
+
5800 mAh



Cell venting



"Thermal runaway" in small cells

Lithium Ion cells contain both electrical and chemical energy

Internal short circuit (ISC) heat may ignite electrolyte. Heat ignites adjacent cells

Venting of electrolyte may smoke with or without ignition

Demonstration of lithium ion battery ignition in laptop computer



Source: FAA

Watch and listen for individual cells to ignite



Four Types Of Battery Fire Or Explosion Hazard

1. Free burning fire. Flammable gas finds ignition source
2. Jet fire. An example would be electric vehicle vents
3. Flash fire. Sub-sonic flame front through flammable gas cloud
4. Vapour cloud explosion. Vented gas in flammable range ignites and develops pressure. May be supersonic flame front or may be pressure build-up in an enclosed space.



Free burning cell phone on hot dashboard



Jetting 787 Battery in NTSB test

Vapor cloud exploded in parked box trailer



Rates and Recognition

Rates of ICE vs EV Events

Where do Most Vehicle Fires Start?

ICE



Engine drivetrain



ICE fires typically 8.5+ years old, driving, with occupants

EV

Frequently cited rate of 60.9 ICE fires per EV fire

By actual response rates:

Sweden 17.9:1

London 35-38:1

Typically initial 18 months

44% Parked or charging, generally unoccupied



Identification Can Be Hard!

Gasoline



Electric



Hybrids With Minimal Or No Badging May Surprise Responders

BMW 530i



Ford Hybrid Explorer Interceptor



Jeep Grand Cherokee



Volvo XC60 PHEV



Exploded while doing 360

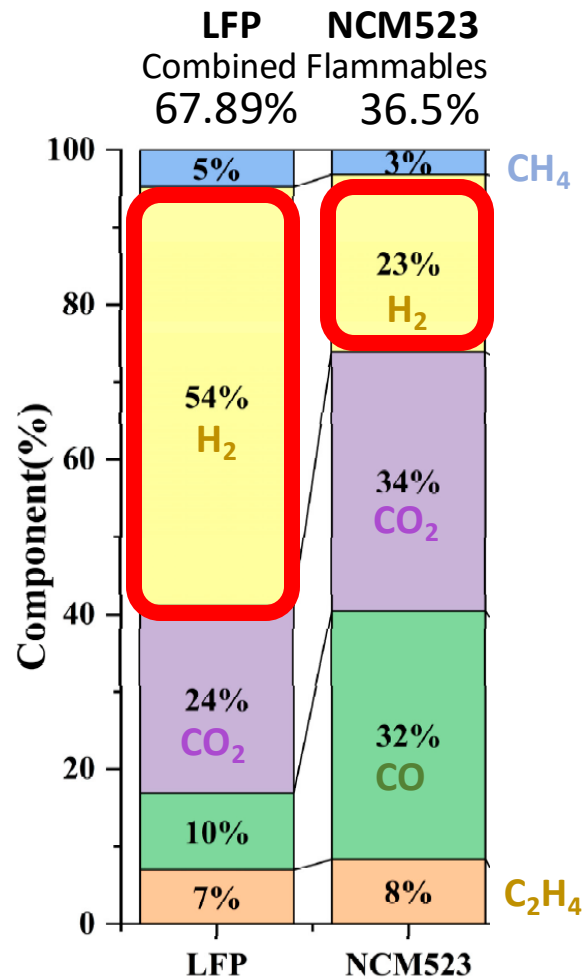


March 30, 2024, Boulder, CO, 6:38 am

One Threat is Flammable/Explosive Hydrogen Gas

Flammable Range = 4% - 74%

Combined LiB gas/smoke by cell type and volume
(100% SOC)

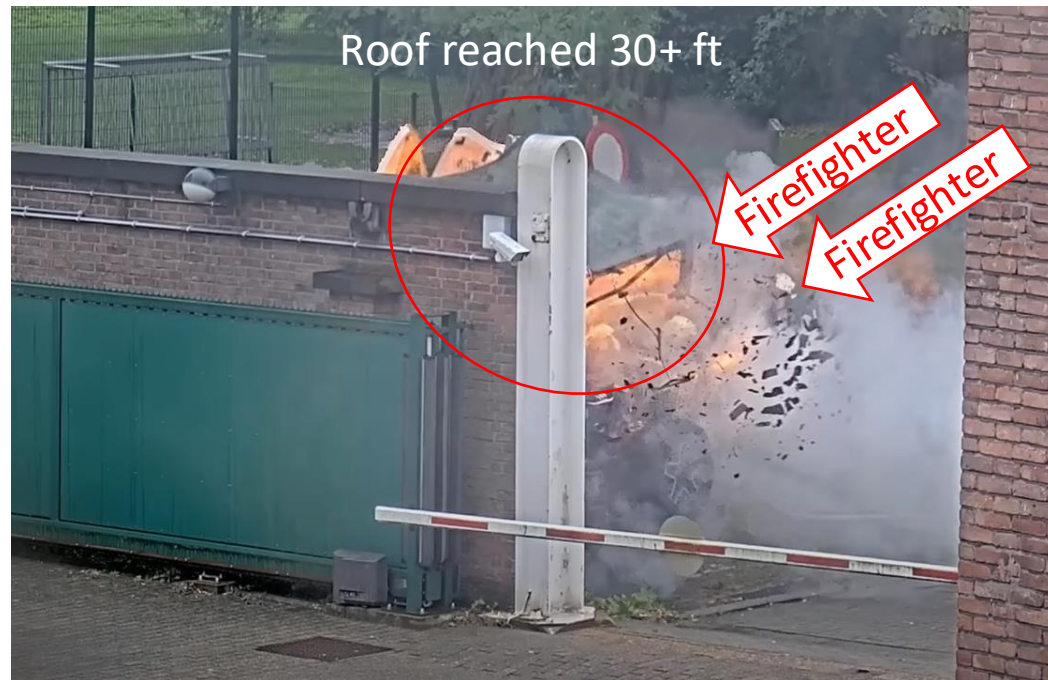


Multi Gas Meters Do Not Detect Hydrogen

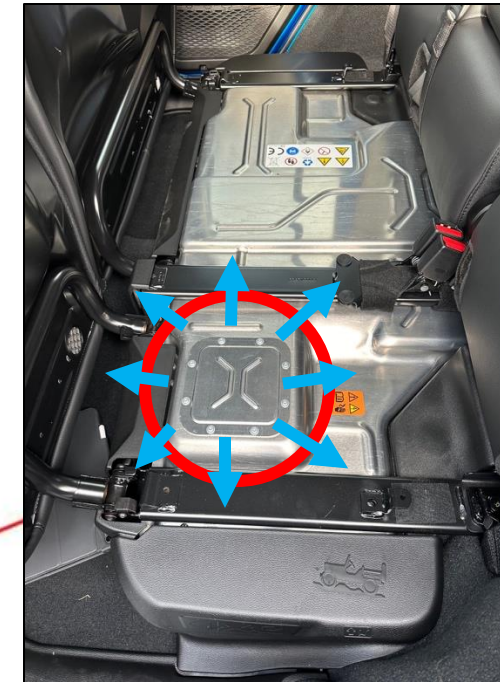
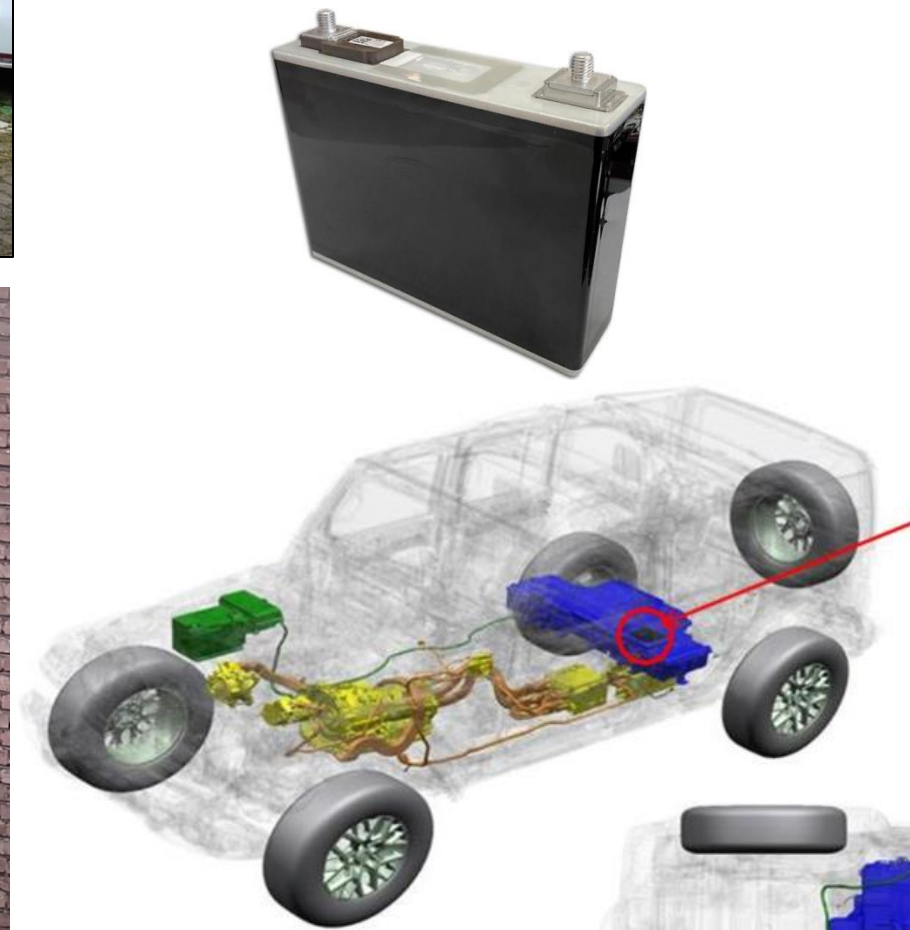


Lack of Identification Can Be Hazardous

Jeep 4xe Hybrid, Belgium



Samsung SDI cell lot found defective
96 prismatic cells, Samsung SDI 2700,
94 Ah nickel manganese cobalt NMC cells, 3.7v cell,
Each can generate 109 liters of gas/smoke



Electric Vehicle Firefighting Has Differences



Call Center
Location,
general details,
ask for vehicle

Need to adapt existing formal written risk management plans

While driving:
Find Rescue Sheet

Assess scene
ID vehicle

(Assume Li-Ion)

Evaluate hazards
Fire/chem/elect

Command decision
Active or Passive

(If possible with Li-Ion)
Passive (Let it burn):

No occupants
Isolated
No smoke threat
Water unavailable

Procedures are changing fast

Previously called for universally cutting cut-loops
Tesla & GM now – Only cut firefighter loops if necessary

Tesla was silent on submerging – Now recommend against

GM – Flooding cabin can cool some batteries (Ultium)

Active:

Stabilize vehicle
Chock-Park-Park-Off

Occupant Rescue

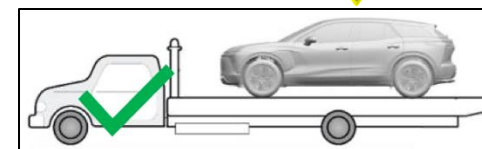


Oversight
Person

Firefighting

Cool
(Monitor)

Tow (Do not turn wheels)



Prepare and equip driver. Use remote controls ONLY
13% of Li-Ion fires re-ignite
Follow to salvage location

TOWING AND RECOVERY OF ELECTRIC VEHICLES

By Robert Swaim, www.HowItBroke.com

Tow operators have a saying about electric vehicles (EVs): there are those who have had one catch fire and those who will. EVs, with their distinct mechanical and electrical systems, require specialized knowledge and handling techniques.

Tow truck operators should undergo specialized training on EV systems. Certification programs provide essential knowledge on safe handling, isolation procedures and emergency response. This article is intended to address only some of the mystery and myths and to avoid unintentionally creating problems.

First, we need to recognize what an EV is, because manufacturers are reducing the badging on these vehicles. For example, the photo below is of a Volvo XC60 Plug-In Hybrid (PHEV) which has only a small generic badge on the tailgate.



The Volvo XC60 Hybrid is an example of an EV with the current trend to minimize badging.

Source: Volvo Emergency Response Guide

For our purposes, an EV includes any car, light truck, bus, or even heavy truck which can be powered by a large high-voltage "traction battery," whether hybrid or pure electric. Light vehicle traction batteries are commonly 400 to 800 volts or more, weigh 1,200 to 5,000 lbs., and usually take up the entire bottom of the vehicle between the four wheels. While a surprisingly large number of electric buses and heavy trucks are now on the road, this article is about fully electric and hybrid light passenger cars and pickups that are more popular.

CHOCK - PARK - PARK - OFF

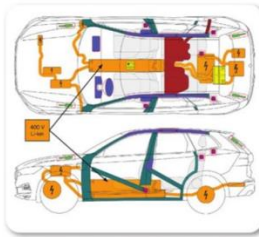
The one thing to remember about any EV or hybrid is chock - park - park - off.

- Chock the wheels before any other steps because EVs can move silently. This has led to numerous injuries and deaths.
- Park. Pull the physical or electric parking brake control and do not release it until the EV is ready to be pulled onto the flatbed/rollback.

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- Park. Put the shifter into park.
- Off. Push the power button or turn the key to off. Then move the key fob away from the EV, possibly to the cab of the tow truck.

Avoid contact with anything orange, the standard color for high-voltage components, according to National Highway Traffic Safety Administration (NHTSA) Regulation FMVSS 305. Never cut or damage an orange component.



This illustration shows the Volvo XC60 battery in orange between/beneath the front seats, as well as other high-voltage components. The gasoline tank is the brown shape beneath the rear seat. Source: Volvo Emergency Response Guide

BREAKDOWNS OR ACCIDENTS

Next, we need to separate the types of towing to be undertaken into two groups: one for simple breakdowns and service calls and the other for vehicles involved in accidents.

Undamaged EVs being moved for repair or general transport typically are not a problem and can be treated like most any modern vehicle. If the EV's battery is completely depleted, the vehicle may not engage in neutral mode, making it difficult to tow. In such cases, refer to the owner's manual for instructions on manually disengaging the parking brake and shifting into neutral.

A key thing to know is that the drive wheels generate electricity whenever they rotate because the rotating tires are used to recharge the traction battery when coasting. The

faster the tires turn the higher the power being generated. An issue is not knowing whether the individual car has motors driving one axle or both, and the tow operator will not have time to do research.

The answer is to use a flatbed to keep the wheels stationary during the tow. Most manufacturers do not permit the use of wheel dollies. Load the EV slowly to minimize how fast the tires turn.



The Volvo Emergency Response Guide is typical in only permitting use of a flatbed/rollback to move vehicles. Source: Volvo Emergency Response Guide

In the extremely rare case where a tow operator arrives and the EV looks normal but is full of smoke, immediately call the fire department and stay away from it. The smoke can contain a large amount of explosive hydrogen and detonations have occurred, including in the Volvo model shown above.

EVs involved in accidents generally are transported without incident, but precautions can be taken to minimize risks. Again, we can separate the accident vehicles into two groups: those having what only appears to be relatively minor collision damage versus those that have had smoke, fire, or with exposed orange components.

EVs with apparent minor collision damage can be moved much the same as those being moved for service. Again, the key is to minimize rotating the tires and load slowly so electricity is not generated. Note that it is essential when loading to watch for any indication of smoke, and be prepared to unload quickly at the first sign.

THERMAL RUNAWAY

Batteries are assembled from groups of cells installed into separate modules. Manufacturers use extensive plastic throughout the modules to keep the high-voltage connections separated from metal parts. Any internal damage to the plastic insulating materials can result in short circuits explosively releasing thousands of amps of energy causing injuries. More commonly, lower power short circuits involving a single cell can lead to heating the cells around it, releasing smoke or even flames from the case. This is called a thermal runaway.

If an EV starts to smoke, the smell may not be bad enough to initially cause concern and it is easy to underestimate

the risk of breathing it. Be aware that the smoke typically contains acids which will lead to shortness of breath the following day and pneumonia-like symptoms as fluids accumulate in the lungs. Further, the ash has metals such as cobalt and lead that cause cancer and can cripple. Therefore, try to load with the EV downwind.

Smoke or venting flames typically come from beneath the EV and especially the rocker areas located between the front and rear wheels. EVs have ignited once loaded, and operators using controls beneath the bed have been burned. To stay away from an EV as it starts to move onto the bed, use trucks with a bed that can be operated remotely.



Brian Jones of Morton's Towing and Recovery demonstrates use of a wireless remote to load an EV. The car is downwind from where he is standing. It can be dangerous to use the controls located beneath the bed.



Brian Jones of Morton's Towing and Recovery demonstrates use of a wireless remote to load an EV. The car is downwind from where he is standing. It can be dangerous to use the controls located beneath the bed.

Pause when a collision-damaged EV is first coming off the ground and the bottom becomes accessible as shown below. EVs do not have a transmission like gasoline-powered cars do, so check the rear wheels to prevent the vehicle from rolling backward.

See Towing and Recovery of EVs on page 56

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Towing and Recovery of EVs on page 55



Stopping at this point allows the tow operator to examine the bottom of the battery for road damage and hot areas. Check the rear wheels so the EV cannot inadvertently roll backward.

Get down to look for road damage such as punctures or dents in the bottom of the battery. Few tow operators carry a thermal camera, but even an inexpensive (\$30) infrared non-contact thermometer from any hardware store can be used to scan the bottom and look for hot spots. If nothing else, feel around the bottom of the battery by hand for a conspicuously hotter area. If a hot area is found, the EV should be kept off the truck. Be aware that some models have a cooling plate beneath the cells, so this may not be effective.

EVs use coolants for battery cooling, cooling the drive components, and heating the cabin. If coolant is leaking from the vehicle, look for the source. While a leaking cabin heat system could be dismissed, leaking battery coolant may be a sign of significant internal damage.

If a collision-damaged EV has any visible traction battery damage, treat it as if it has had a thermal event described below. Otherwise, the loading procedure can be completed once satisfied that the battery is not damaged.

Once an EV or hybrid is loaded for any reason, watch closely in the tow truck's rearview mirrors for any sign of smoke during transport when stopped at lights or for traffic, and be prepared to unload it.

FIRE-DAMAGED VEHICLES

Having now covered transport of undamaged EVs and those with collision damage, we are left with the very few which have had a thermal incident that produced smoke or fire. While few catch fire even after a major accident, about 12% of those which have been involved in a fire have re-ignited - many more than once.

Instead of simply breaking the insulating plastic in the case like in a crash-damaged battery, the heat of a thermal runaway will have melted it, potentially leaving hidden but high-voltage components in near contact. The EV may have been sitting for hours to weeks, appearing to be unremarkable and safe to move. However, the bouncing and distortions involved with loading can result in those internal components developing short circuits which bring a thermal runaway to life. That is why it is even more essential to pause when the EV is at the bottom of the ramp, check the tires, and slowly check the bottom for hot sections. Then closely watch it during transport.

When unloading a fire-damaged EV, keep it away from any other vehicles due to further reignitions from bouncing and distortion of the battery case.

Tow operators should be equipped with appropriate personal protective equipment (PPE), especially if the transport is more than just moving a car for service, which is low-risk. Firefighter-style bunker gear, complete with a face shield and insulated fire-safe gloves should be worn when loading and unloading collision and fire damaged EVs.

EMERGENCY RESPONSE GUIDES

Emergency response guides are available for nearly all EVs and hybrids. These are short documents intended for first responders and include towing instructions. They also cover water recovery. While the emergency response guides can be found on the manufacturers' websites, they are collected in one archive and can be downloaded for free from <https://autorecureapp.com>.

Some emergency response guides call for disconnection of the 12-volt battery while others do not. All will show how to disconnect the high-voltage battery. Be aware that this is different in nearly every EV and may not be effective if collision damage has resulted in internal damage to the high-voltage connectors. Therefore, never trust the orange components to be disconnected even if the procedure is followed.

Disables direct hazards / Safety regulations

The propulsion system is disabled when the "Safety mode See Manual" indicator in the instrument cluster is illuminated.

Deactivation of propulsion system, if "Safety mode See Manual" indicator is not illuminated:



The Volvo XC60 PHEV emergency response guide shows how to disconnect the high-voltage battery by locating a plug in the floor between the rear seats.

Finally, be prepared for customer questions because towing an EV will likely be new to them too. Explain the steps you will take and be prepared to answer questions about the safety of their EV as well as how you will prevent damage to the battery and drivetrain. Transparency builds trust and ensures a positive experience.

Bob Swaim began working on cars when he was old enough to pass tolls to his father. After becoming a licensed aircraft mechanic and engineer he investigated major aircraft accidents around the world for the National Transportation Safety Board (NTSB) for 32 years. He was the board's investigator in January 2013 when a Boeing 787 lithium-ion battery caught fire. He began investigating electric vehicle fires with the NTSB Highway Division in early 2017 and joined the SAE J2990 Responder Safety Group, which he is still part of. Swaim continues to work extensively on lithium battery issues. His website is www.HowItBroke.com.

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EDITOR'S NOTES

By Tim Jackson, Editor
tjackson@towtimesmag.com



Shock Hazard from Submerged Electric Vehicles?

This issue's article, "Towing and Recovery of Electric Vehicles" by lithium battery expert Robert Swaim, offers insight on the safe handling of electric vehicles (EVs) involved in breakdowns, collisions and fires.

He noted that EV and hybrid emergency response guides are available from vehicle manufacturer websites, and the EV rescue app autorecureapp.com. Sources also offer towing instructions - including water recovery.

Submerged and flooded vehicles can be a common call for tow operators, especially after flooding events from heavy rains and hurricane/tropical storm surges. These vehicles may likely include EVs, and while an EV may not be totally submerged, its lower portion, which houses the EV's traction battery, will often be underwater.

Approaching and hooking up to a submerged EV can certainly pose questions of risk to tow operators, mainly a potential shock hazard.

The National Fire Protection Association (NFPA) produced a safety bulletin titled, "Submerged Hybrid/Electric Vehicles," that provides safe response practices for responders.

Does a submerged EV pose a shock hazard? The following information is contained in the bulletin. Hybrid, electric, and fuel cell vehicles are designed to be safe in water, even when fully submerged. The high-voltage (HV) system is isolated from the chassis and is designed to NOT pose a shock and NOT energize the surrounding water.

Warnings:

- Never remove a submerged service disconnect.
- Submersion in water (especially salt water) can damage low- and high-voltage components. Although not a common occurrence, this could result in an electrical short and potential fire once the vehicle is no longer submerged.
- Damaged HV batteries can produce flammable gas. Venting the passenger compartment is recommended once the vehicle is out of the water. Do not store vehicle indoors.

Tips for Safe Response Practices

Submerged Vehicles

- Avoid contact with the EV components, cabling, or service disconnects on a submerged vehicle.
- If possible, turn the ignition off in a submerged vehicle, but do not attempt any other disabling activities.
- If ignition cannot be turned off, wait until the vehicle is no longer submerged and is drained of water before attempting to disable it.

• In some instances, small bubbles may be seen coming from an immersed HV battery. This is referred to as micro-bubbling. This DOES NOT indicate a shock hazard and DOES NOT energize the surrounding water.

The Energy Security Agency (ESA, energysecurityagency.com) advises the following in a safety checklist for EVs that are submerged or exposed to high volumes of water:

- "If the vehicle is found totally or partially submerged, fire department should conduct a surface water assessment. If the water is bubbling, fire is bubbling/popping/hissing or gas meter sampling reveals CO (carbon monoxide) presence, DO NOT attempt recovery for a minimum 14 days. Contact local EPA for water hazard assessment or conduct pH evaluation of water."

• "If the water assessment is negative for hazards, attempt appropriate recovery. Use only synthetic connections and avoid nonstructural anchors including control arms. Doors most likely will be inaccessible due to low voltage loss of power - roof sling capturing A or B posts is recommended. DO NOT make contact with high-voltage components or battery pack. The body of water will not present a direct electrical hazard to operators."

Robert Swaim adds that there is virtually no direct shock hazard, at least 21 EVs caught fire following recovery in Florida's Hurricane Ian aftermath and the batteries were drained. National Highway Transportation Safety Administration (NHTSA) bought and disassembled the batteries of 10 of those saltwater flooded EVs to find that despite manufacturer's best efforts, water penetrated nearly all of them. Further, the salt aggressively attacked seals and electrical connections. Off gassing may be silent so heed the NFPA guidance to keep the vehicle open and vented which prevents explosive gases from accumulating inside.

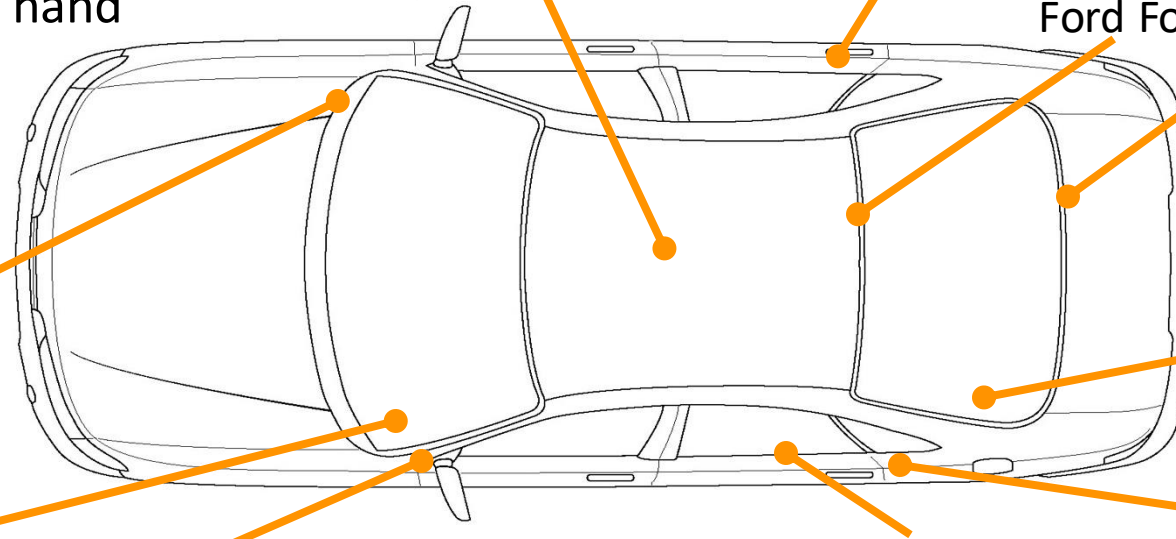
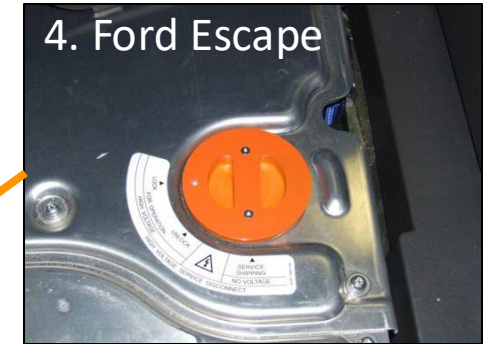
Swaim notes that the Florida floodwater experience with post recovery fires reinforces the need to keep flooded EVs away from other vehicles in a tow yard. Some yards now have concrete block enclosures to minimize loss of space and others simply keep salvage EVs in steel containers, such as 20-foot roll-off dumpsters.

Fortunately, there is a wealth of information available by online sources as well as EV training programs like the one being held at this year's Tennessee State Fair. See the ad on page 20 for details. Learning as much as possible before responding to the call can help eliminate guesswork and enhance tow operator safety.

6 towtimes.com • SEPTEMBER 2024

HV Disconnects Are Not Standardized

1. Pull plugs by hand (typically hidden)
2. Cut loops requiring cable cutter
3. Cut loops requiring circular saw
4. Twist knob by hand (typically hidden)
5. Fuse - hard for gloved hand



International Standard ISO 17840 Provides Standardized Info

Standardized Info For Procedures

CONTENTS

0. Rescue Sheet	Page
1. Identification / recognition	Page
2. Immobilization / stabilization / lifting	Page
3. Disable direct hazards / safety regulations	Page
4. Access to the occupants	Page
5. Stored energy / liquids / gases / solids	Page
6. In case of fire	Page
7. In case of submersion	Page
8. Towing / transportation / storage	Page
9. Important additional information	Page
10. Explanation of pictograms used	Page

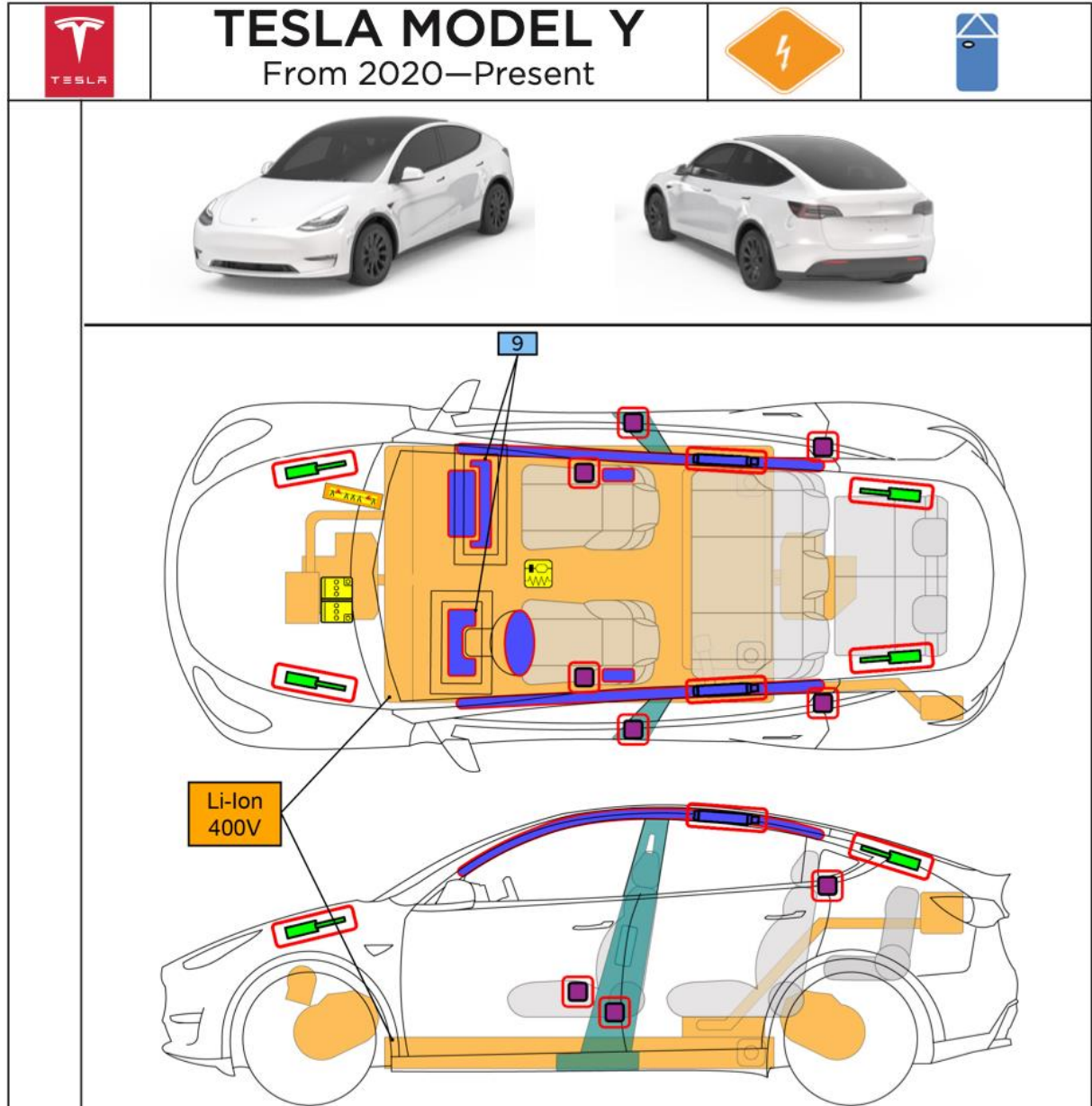
Standardized Colors & Symbols For Fuels




















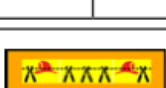
GREY	DIESEL
RED	GASOLINE
GREEN	GAS
WHITE	CRYOGEN LNG
BLUE	HYDROGEN
ORANGE	HIGH VOLTAGE



FREE DOWNLOADS FROM
www.autorescueapp.com

ISO-17840 Standardized Graphics, Pictograms, And Colors



	Airbag		Stored gas inflator		Seatbelt pretensioner		SRS Control Unit		Pedestrian protection active system
	Automatic rollover protection system		Gas strut/pre-loaded spring		High strength zone		Zone requiring special attention		
	Battery low voltage		Ultra capacitor, low voltage		Fuel tank		Gas tank		Safety valve
	High voltage battery pack		High voltage power cable/component		High voltage disconnect		Fuse box disabling high voltage system		Ultra capacitor, high voltage
	Cable cut								

FREE DOWNLOADS FROM
www.autorescueapp.com

New York First State With Legislation To Mark Vehicles Per SAE

SAE Recommended Practice J3108/1 of December 2024



Examples:

Battery Electric



Hybrid



Natural Gas



Dual fuel
LPG / Gasoline



Hydrogen fuel cell



Less Recognized Battery Fire & Explosion Threats Tactical Considerations

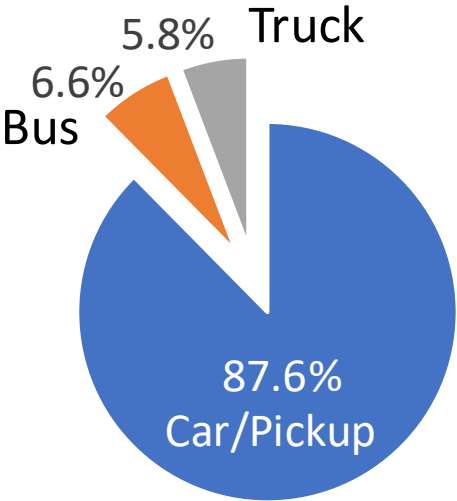
1 in 8 EV Fires Are Commercial Vehicles – Fleet Is Increasing

Trucks and busses

Bigger batteries operating with or near greater numbers of people



Diesel electric hybrid



Volvo modular chassis for tractors, box, refuse
Built in Dublin, VA



BIG
batteries



Kenworth

= Up to 6
Model 3 Tesla



= Up to 8 Model 3 Tesla



Explosive Force Is Created In Contained Spaces

14 Ga Steel (0.75")

20 lb Barbecue propane container has explosive force of about 100 kg (220 lbs) of TNT

BBQ Propane Tank, Vancouver, BC



Batteries underway to recycle may fill space with hydrogen gas

Lithium batteries, Houston, TX



External Markings Frequently Not Applied To Inform Firefighters

Required Hazard Communication - § 172.102, Special Provision 389 (see Guide 10 diagram for additional details):

- The batteries inside the cargo transport unit are not subject any marking or labeling requirements.
- The cargo transport unit must display the UN ID number (3536) on an orange panel, white square on point, or a Class 9 placard. The three options for displaying the UN ID number are displayed in the diagram below.
- The cargo transport unit must be placarded on two opposing sides with the Class 9 placard.
- Transportation by aircraft is forbidden, unless approved by the Associate Administrator.

PACKAGING AND HAZARD COMMUNICATION DIAGRAM

3536

3536 orange panel



3536 in a class 9 placard



3536 in white square on point (dimensions of placard)



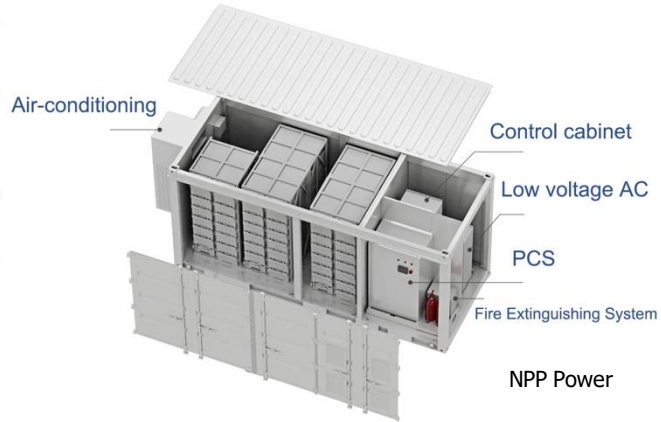
Individual packaging

<https://www.phmsa.dot.gov/sites/phmsa.dot.gov/files/2021-09/Lithium-Battery-Guide.pdf> Guide 10

Improper Transport of Battery Energy Storage System (BESS)

Tip-overs occur due to high CG when not carried on low trailers

1 MW Unit can weight 48,500 lbs



Proper carriage is on low trailers



I-15 Shut for one full day then kept to one side



Los Angeles Port of San Pedro was closed for two days
Tip-over



Explosion followed by fire



Use of typical height flatbed



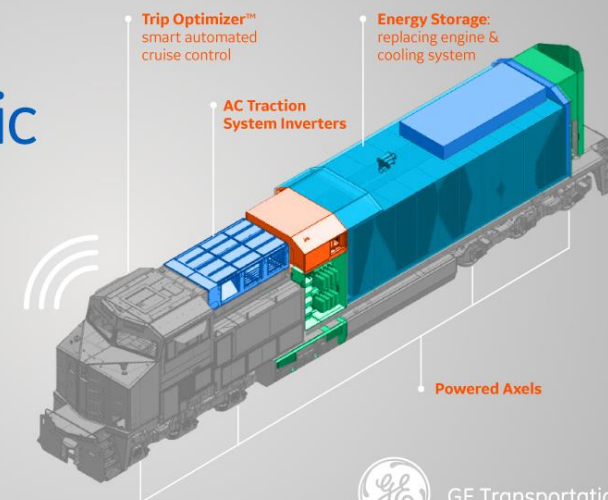
Rail Could Interrupt I-95



30 Tesla Model 3

GE Transportation's Battery-Electric Locomotive

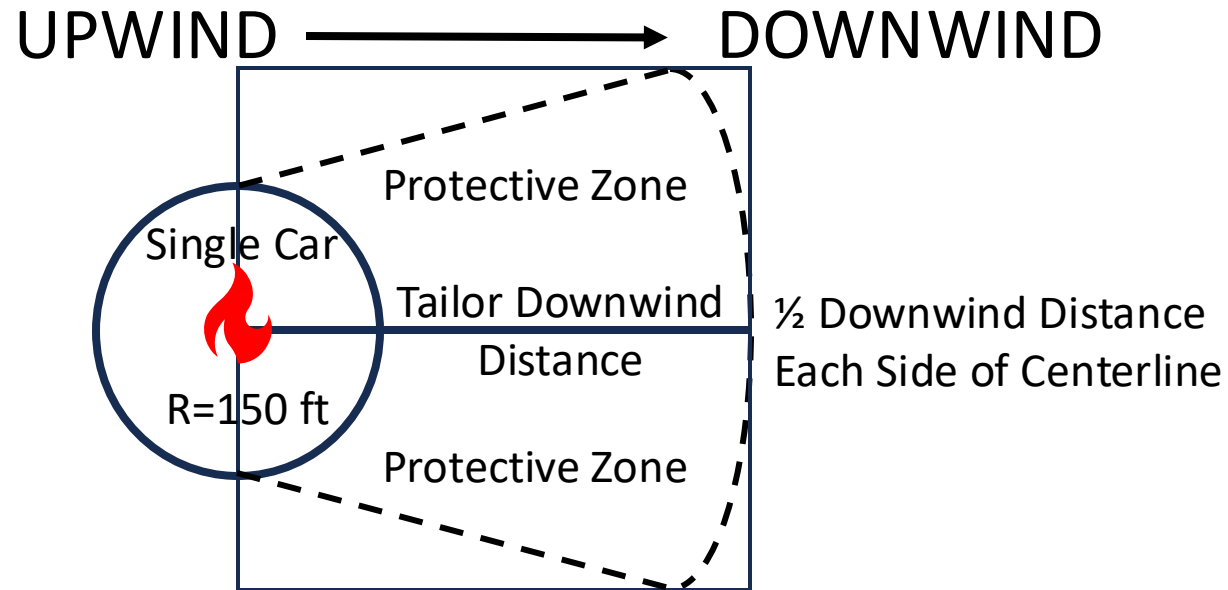
Massive power
generation
capabilities up to **2400 kWhrs**
Huge
fuel savings
of at least **10-15 %**



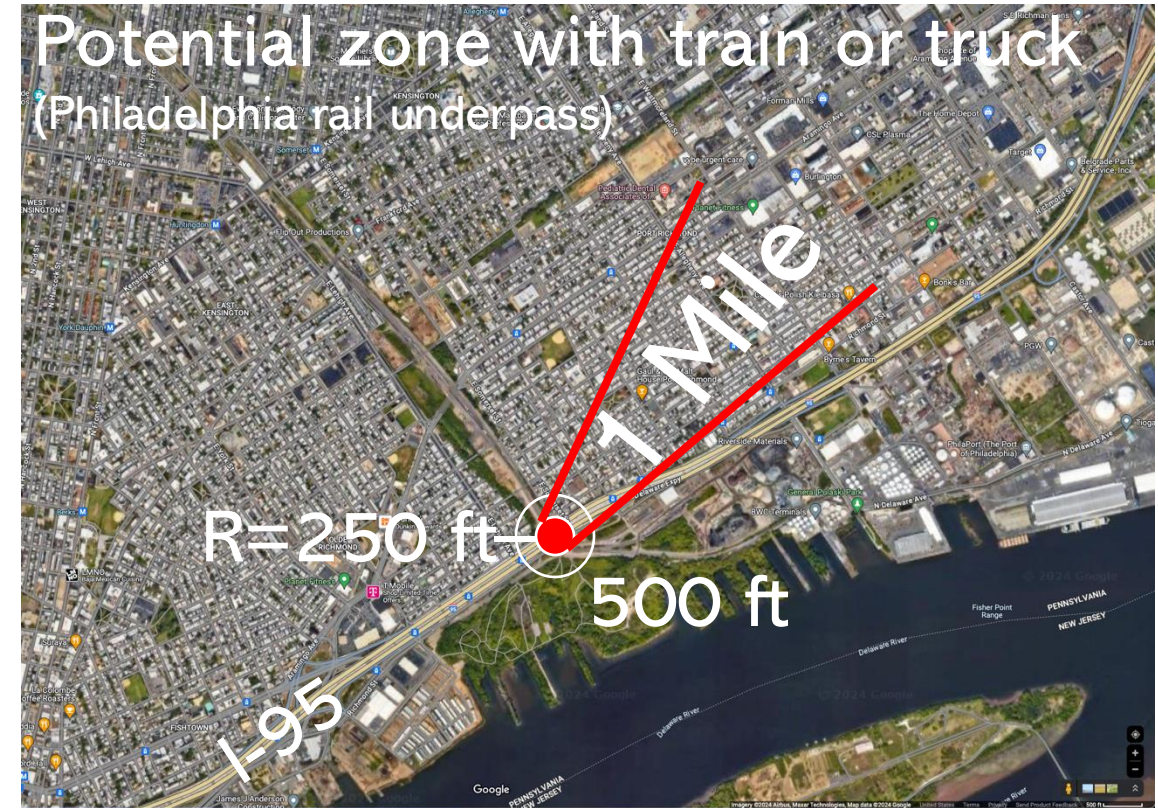
GE Transportation

Isolation Zones Must Increase For Rail and Commercial Vehicles

For single car establish 150 ft radius
Alter for wind and other conditions



Increase for commercial and rail vehicles
to the smoke affected area



Li-Ion Battery Transport Fires/Explosions Now Occur Monthly

Trailers filled with hydrogen gas then detonated

(PHMSA Database)



Source: Birmingham Fire and Rescue Service

Birmingham, AL, 3/31/23



Livermore, CA, 12/23



Norfolk, VA, July 19, 2023

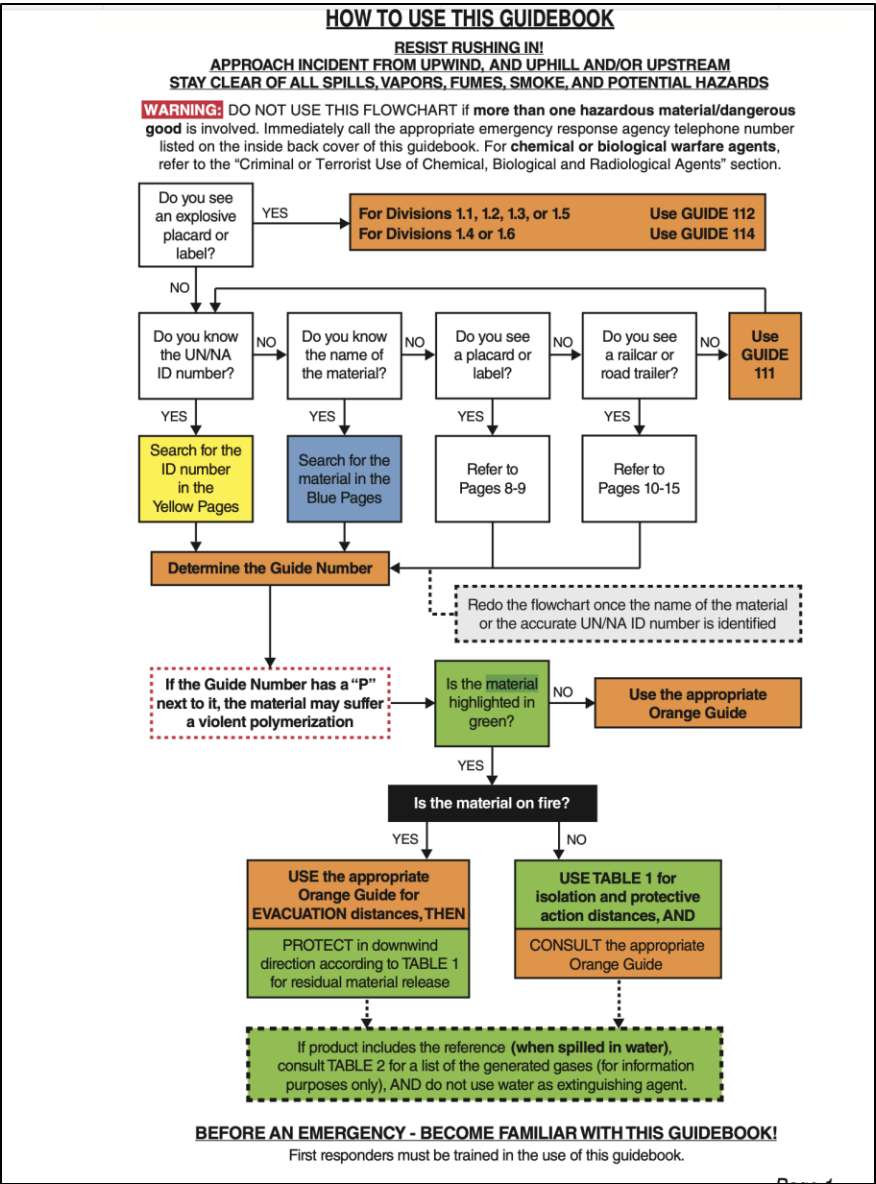
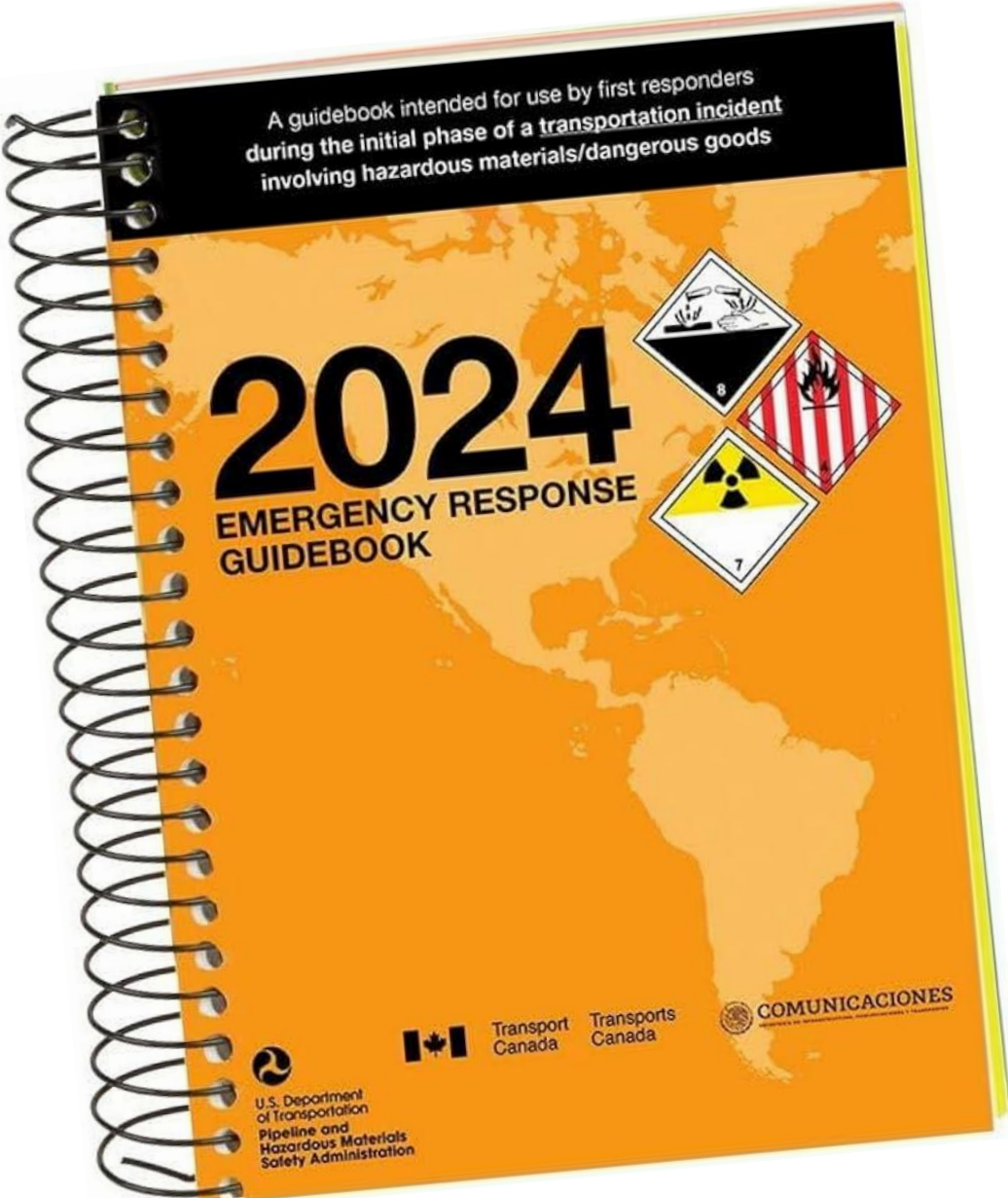


Columbus, OH, 4/18/24

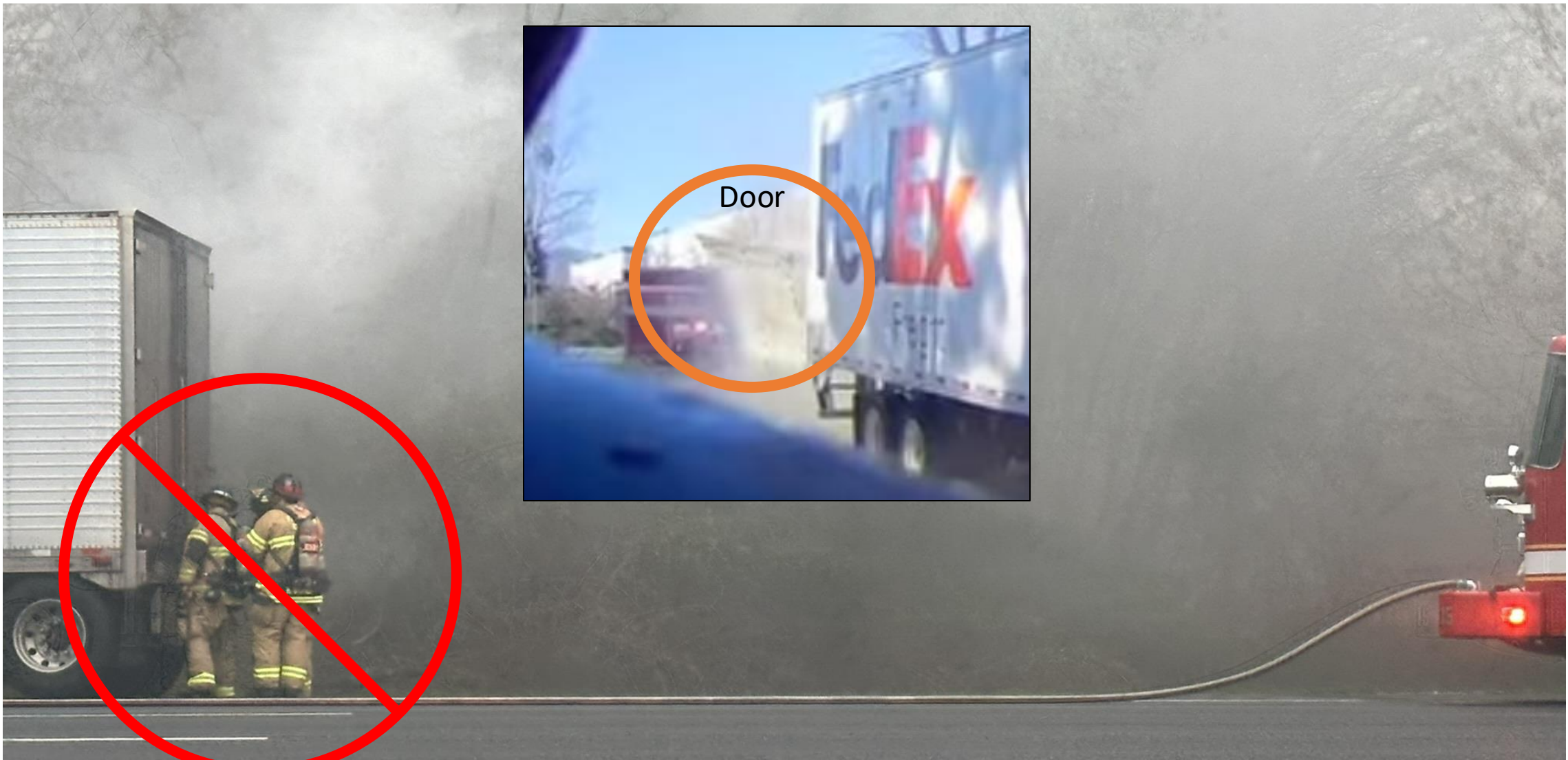
HowItBroke.com



Start Trailer Operations With Emergency Response Guidebook



Behind The Doors Is A BLAST ZONE



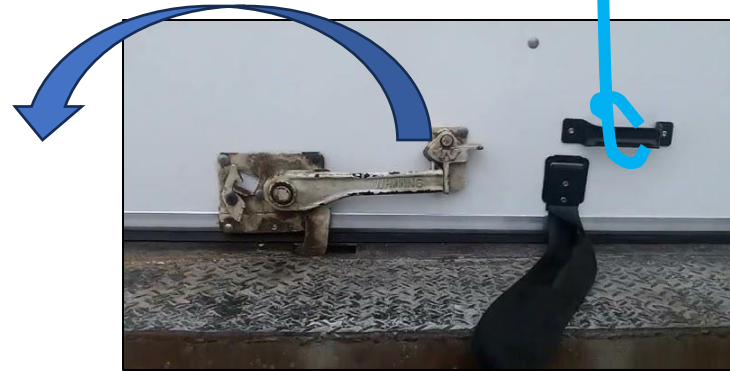
Indirectly Open Trailers and Car Doors To Vent Potential Hydrogen Gas

IF the doors need to be opened

- Flip lock or handle while keeping DOOR SHUT
- Attach rope
- Move away and stand on diagonal
- **Do NOT stand behind door**
- Pull door open
- WAIT FOR SMOKE TO DISSIPATE



50+ feet on diagonal



50+ feet on diagonal

To Ladder



Recycling Transport Lithium-Ion Fire Losses Occur Daily

Fires Vastly Outnumber Explosions but the unknown mandates use of SCBA

Trash trucks and collection point fires experience fires daily
California found 65% waste facility fires started by lithium-ion batteries.
Seattle FD responded to 79 lithium-ion fires in the last two years.

Result: In January 2024 Seattle joined others banning all batteries in trash.



Ventura, Cal. 9/9/23



Staten Island, NJ. 3/17/22



Fires, Smoke, Flammable Gas

Tools: Do NOT Puncture Or Damage Battery Case

No vehicle manufacturers endorse tools being marketed to inject water



Submerging The Battery

European city method for fast extinguishment which addresses both battery and plastics

Some ERGs permit this while Tesla and other makers state not to, due to hydrogen and re-ignition risk

Water electrolysis may create flammable gas on surface or after removal, salt water worse than fresh

No electrical risk

Whether intentional or due to floods - Recover to open area and isolate to dry out

NOTE: Water becomes haz-mat after submerging vehicle



Parking Garages, Commercial

- Beware vapor clouds and potentially flammable smoke
 - Beware entrapment due to smoke or flashover from vehicle to vehicle
- A means to vent smoke is required. Building power may fail due to short circuits.
- Prepare for vehicle to vehicle spread unless countermeasures are taken (blankets, panels, copious water)
- Plan minimum 3,000 gallons water for EV versus 1,000 for ICE
- Overall fire size in heat release is roughly equivalent to ICE, peaking at about 8 MW per vehicle
 - Each flashover results in adding again this amount of heat energy
 - EVs take approximately 6 to 49 minutes to extinguish compared to 5 minutes to extinguish a typical ICE. About 13% of EVs re-ignite.
- ICE tends to have a single peak heat release rate (HRR), followed by a steady reduction as the fuel and combustible components of the vehicle are burnt. EV fires tend to have two peaks: one when the combustible materials in the car ignite; and another when the battery becomes involved in the fire.
- **Loadbearing elements of the structure may have fire resistance periods of only 15 minutes,** increased to 30 minutes where those elements were designed to protect means of escape.
 - Chains may be used to drag out vehicle or create fire breaks

Tunnels – Need Both Plans and Tests

The "fuel" will not burn off as fast as petroleum fuels
The smoke will be both toxic and flammable

Smoke? Flame? Passengers?
Train third rail?



Table 16. Observations made during the tests with regard to the fuel tank and batteries.

ICEV A		BEV A		BEV B	
5:00	External fire ignition	5:00	External fire ignition	5:00	External fire ignition
9:44	Fuel tank rupture	24-27	Continuous and intense gas release from underneath	27-32:30	Battery venting and popping (most intense)
16-18	Diesel pool fire almost gone	30:30	Gas release from underneath almost gone	44-47	Gas release from underneath almost gone

3 X Time

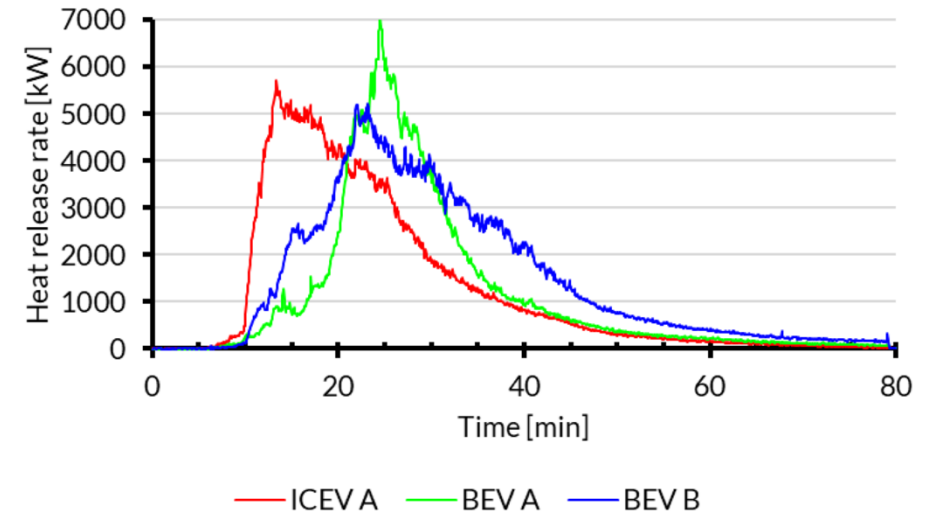


Figure 11. Heat release rate (oxygen consumption calorimetry) for the three vehicles.

Tools: Car fire blankets are tools for specific tasks

PROS:

May use to isolate vehicles in enclosed spaces or next to other vehicles

Can contain or be used to redirect flames

May smother burning plastic and other materials to reduce temps

CONS:

For smoldering cases a blanket can trap hydrogen to create explosive environment beneath

Does not halt an EV battery fire



Charger Hazards:

- No protective vehicle barrier for many
- HV source enters base, below contactors
- Housing can energize – **HV SHOCK HAZARD**
- No visible emergency "panic buttons"
- Must find power source and shut it off



Differences in ICE/EV Smoke Hazard Toxic AND Flammable

Initial Battery Smoke Content

(Think plastic fire with nasty additives)

Some variation with constituent materials

NTSB spectrum analysis by UL of release from burning batteries found:

Carbon Monoxide

Carbon dioxide

Hydrogen (up to 36%)

Methane

Ethylene

Acetylene

H₂O

Dimethyl carbonate

Ethylmethyl carbonate

Eye & lung irritating acids

} Can not breath

} Can ignite

} Hazardous Materials



SCBA MANDATORY

COVER ALL SKIN

PROTECT BYSTANDERS

Soot may contain cobalt oxide, nickel oxide, manganese oxide, and other heavy metal skin irritants

Heavy Metal Hazards in EV Smoke Embed in Soft Tissues

Conductive lithium ions and metals make smoke conductive

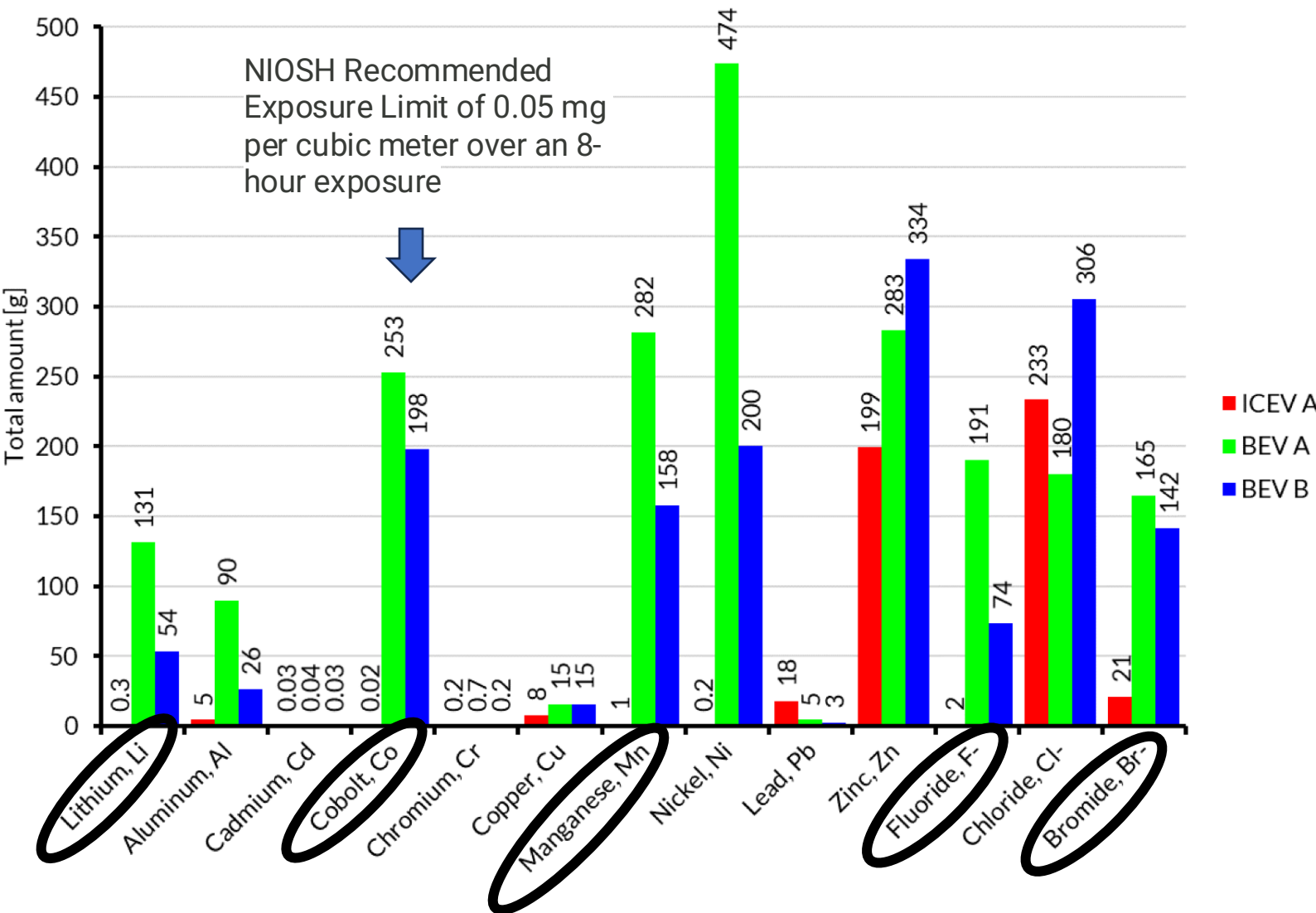


Figure 13. Total amounts of metals and anions on soot particles.

Table 19. Soot particles and substances on these particles measured from the exhaust duct, and ash analysis from the burnt vehicles. Results expressed as weight of substances per total weight of particles.

Soot		ICEV A	BEV A	BEV B
Particles	Dry, [kg]	9.0	10.7	17.0
Metals	Lithium, [mg/g]	0.03	12	3.2
	Aluminum, [mg/g]	0.5	8.5	1.5
	Cadmium, [mg/g]	0.003	0.004	0.002
	Cobalt, [mg/g]	0.003	24	12
	Chromium, [mg/g]	0.03	0.07	0.01
	Copper, [mg/g]	0.9	1.4	0.9
	Manganese, [mg/g]	0.1	26	9.3
	Nickel, [mg/g]	0.03	45	12
	Lead, [mg/g]	2.0	0.4	0.2
Anions	Zinc, [mg/g]	22	27	20
	Fluoride, [mg/g]	0.2	18	4.3
	Chloride, [mg/g]	26	17	18
	Bromide, [mg/g]	2.3	16	8.3
Organic compounds	PAH, [mg/g]	1.0	0.03	0.5
Ash		ICEV A	BEV A	BEV B
Anions	Fluoride, [mg/g]	0.02	0.2	0.1
	Chloride, [mg/g]	31	62	16
	Bromide, [mg/g]	0.4	0.07	0.5

This work by RISE Research Institutes of Sweden is, except where otherwise noted, licensed under CC BY 4.0. To view a copy of this license, visit <https://creativecommons.org/licenses/by/4.0>

NFPA 1971 technical committee is currently considering an Restricted substnaces List of chemicals and specific levels for those chemicals

NFPA 1851 Cleaning Gear Is A Major Challenge

Prevention is best - Try to remain upwind

Heavy contaminants bond to fibers

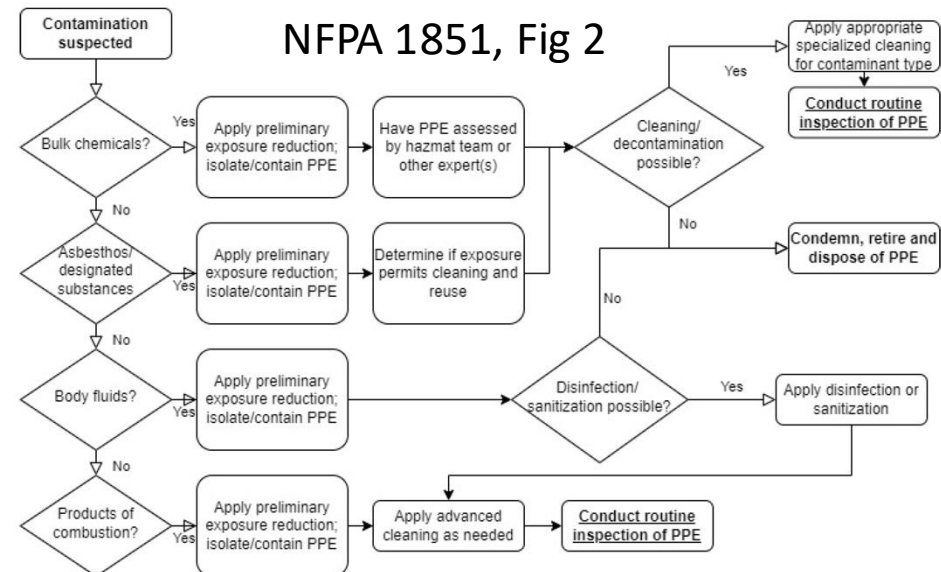
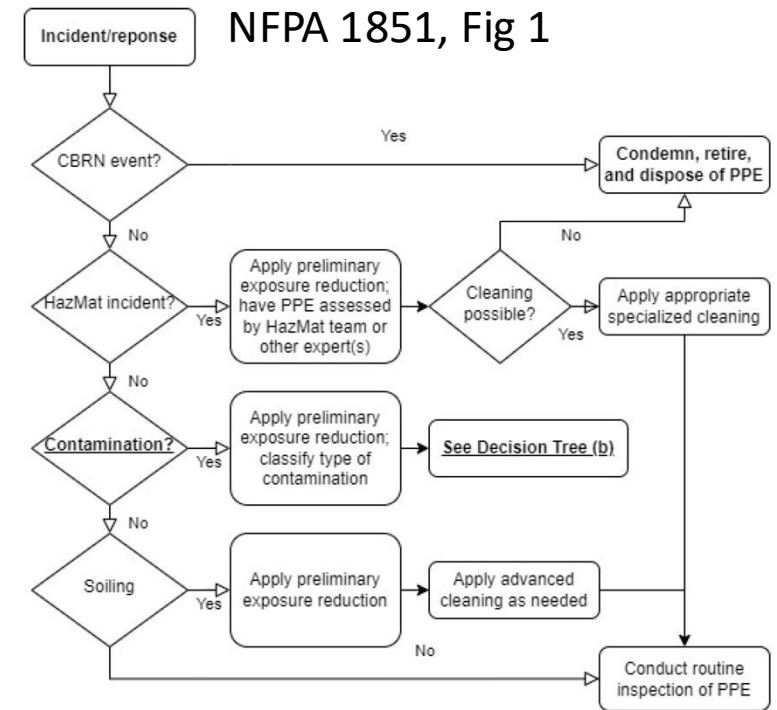
Inorganic acids attack materials

(example: Hydrogen Fluoride becomes hydrofluoric acid)

EPA/UCLA Testing not yet published. Found antimony, lead, etc

Typical extraction and wash methods do not remove heavy contaminants

LCO2 is currently best method per testing at SWRA with TEEX (Texas A&M)



For more info:

<https://www.mdpi.com/1660-4601/19/19/12442>

NFPA 1851 Gear Cleaning Providers May Be Found on Web

These are NOT endorsements, just examples

Emergency Technical Decon Company

www.etdecon.com

458-201-8282

Gear Wash

www.gearwash.com

870-686-5386

FDIC International

www.fdic.com

610-857-8070

Dinges Fire Company

www.dingesfire.com

815-857-2000

LION

www.lionprotects.com

800-421-2926

TEN-8 Fire & Safety

www.ten8fire.com

877-989-7660

Tools: Emergency Plugs

Available from multiple manufacturers
Roughly \$800+

Consider for EMS calls when integrity of vehicle itself is not in question.

Not for use in fires or when orange HV circuits are exposed.

PRO:

Immobilizes vehicle by going into charging mode

CONS:

1. HV circuits may be energized outside of battery case
2. Does NOT work on all EVs



Source: eDarley

HowItBroke.com



Encapsulating Agents. NFPA-18A Section 7.7

NFPA 18A SECTION 7.7

Tests an Encapsulator Agent's ability to render hydrocarbon based fuel nonflammable and nonignitable.

NFPA 18A ANNEX 4.3

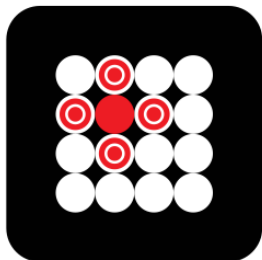
Recognizes third-party scientific testing of Encapsulator Agents on lithium-ion battery fire hazards.

UL NFPA 18

Tests a wetting agent's ability to mitigate Class A and Class B fire hazards as well as flammable spill control.

NEN NTA 8133

Tests a fire extinguisher's ability to extinguish lithium-ion battery fires under 600 Wh.



FLAMMABILITY

Encapsulate flammable corrosive electrolyte and rapidly reduce heat three-dimensionally, stopping the spread of cell-to-cell ignition. This halts thermal runaway propagation, preventing re-ignition.

Encapsulating Agents. NFPA-18A Section 7.7

Hazard Control Technologies F-500 EA

Water drops encapsulate fuel sources

Rapid heat reduction

Interrupts free radicals

Fluorine-free (no cancer concerns)

Non-corrosive

Biodegradable fire extinguisher agent

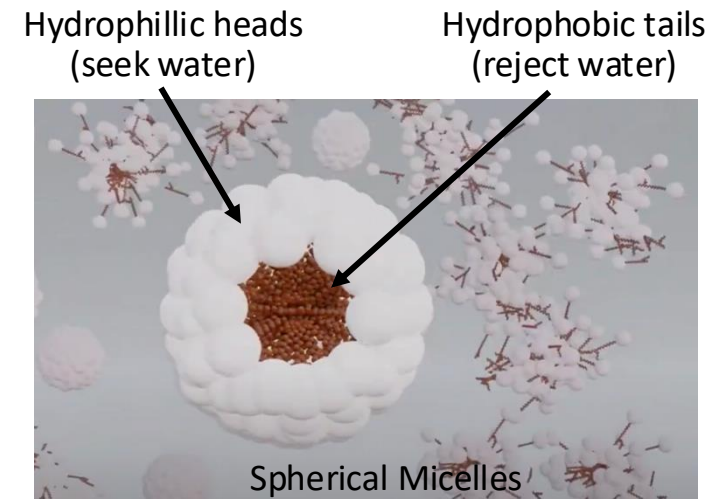
Effective on Class A, B, C, D, and lithium-ion battery fires Known for rapid knockdown, superior cooling, and reduced re-ignition risks.

Can be used as detergent on turn-out gear

Web: <https://hct-world.com>

info@hct-world.com

(770) 719-5112



Driveway fire, Ford F150 Lightning and charging Tesla Y



Resources

NFPA

Training developed with manufacturers, agencies, and organizations

Extensive resources

Online info, classes online & in person, field emergency guide

www.EVSafetyTraining.org

Energy Security Agency

24/7 Call center while working on site (no charge), online info, classes on-site

855-ESA-SAFE (855-372-7233)

Emergency Response Guides (Free on pc, phone, or tablet)

www.autorescueapp.com

UL FSRI

Firefighter Safety Research Institute

Firefighter research and training is online and free

www.ulfirefightersafety.org

RAIL

Lists contacts and cargo in each rail car

www.askrail.us

Australian Government EV data and training resource website

www.EVFireSafe.com

Battery recycling with instructions

<https://www.call2recycle.org>

SAE J2990

Hybrid and EV First and Second Responder Recommended Practices