

MARITIME LITHIUM-ION BATTERY EMERGENCIES

Ports of Long Beach and Los Angeles,
November 2024



Port of
LONG BEACH
THE PORT OF CHOICE



Training Outline



- Battery Basics
- Maritime Firefighting Operations and Tactics
- Safety and PPE
- De-energizing, Air Monitoring, and Site Cleanup
- Transport and Disposal



BATTERY BASICS

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



18650
18x65mm



2170
21x70mm



Prismatic
Cell

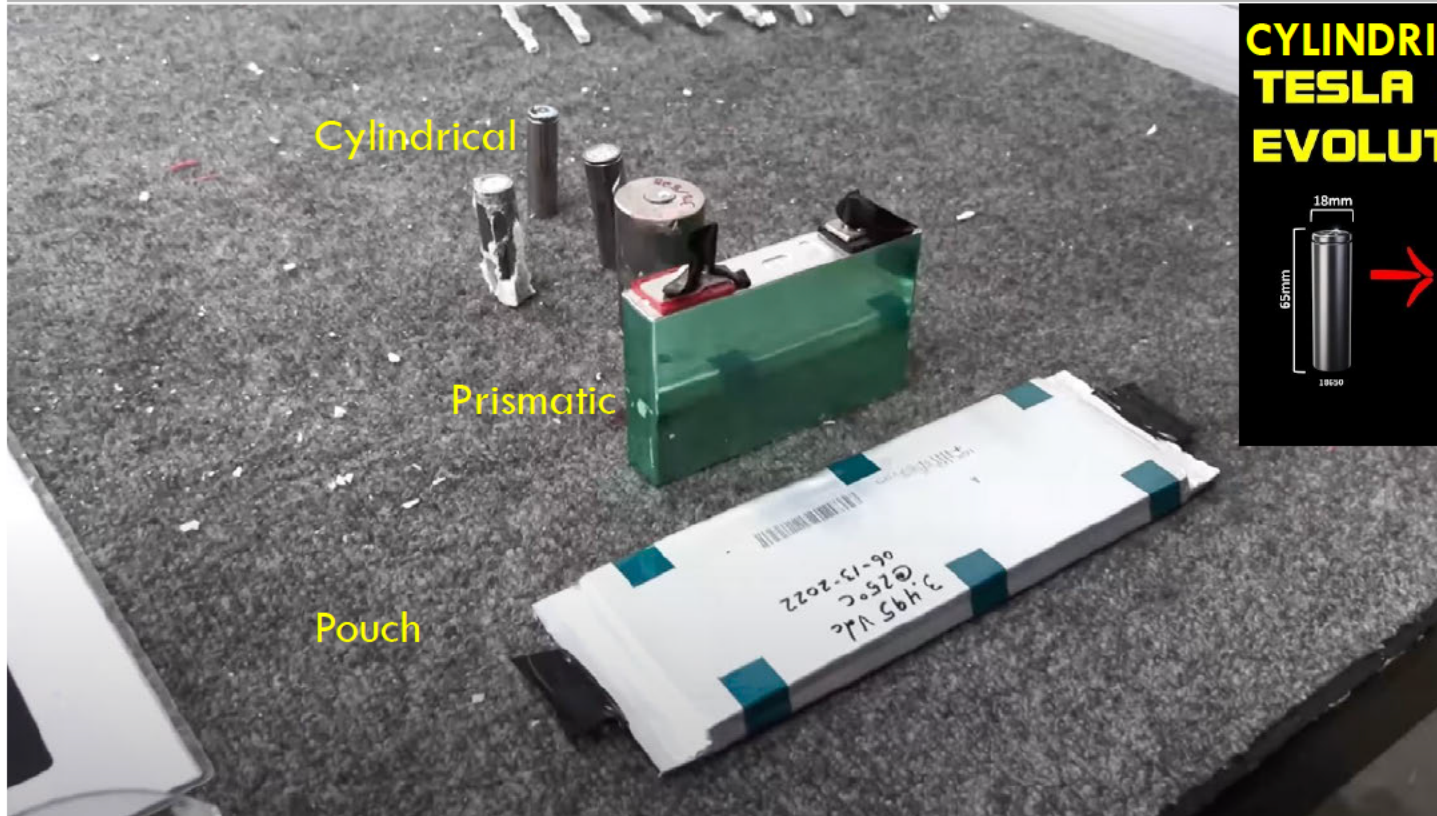


Pouch
Cell

Cylindrical Cells (18650) are the most common cell in mobility (bikes, scooters, etc.) and are used by electric vehicles with 3000 to 7000 cells

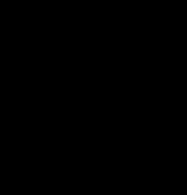
Prismatic and Pouch Cells are found in industrial and consumer electronics, respectively; both are used in electric and hybrid vehicles

Lithium-Ion Battery Types



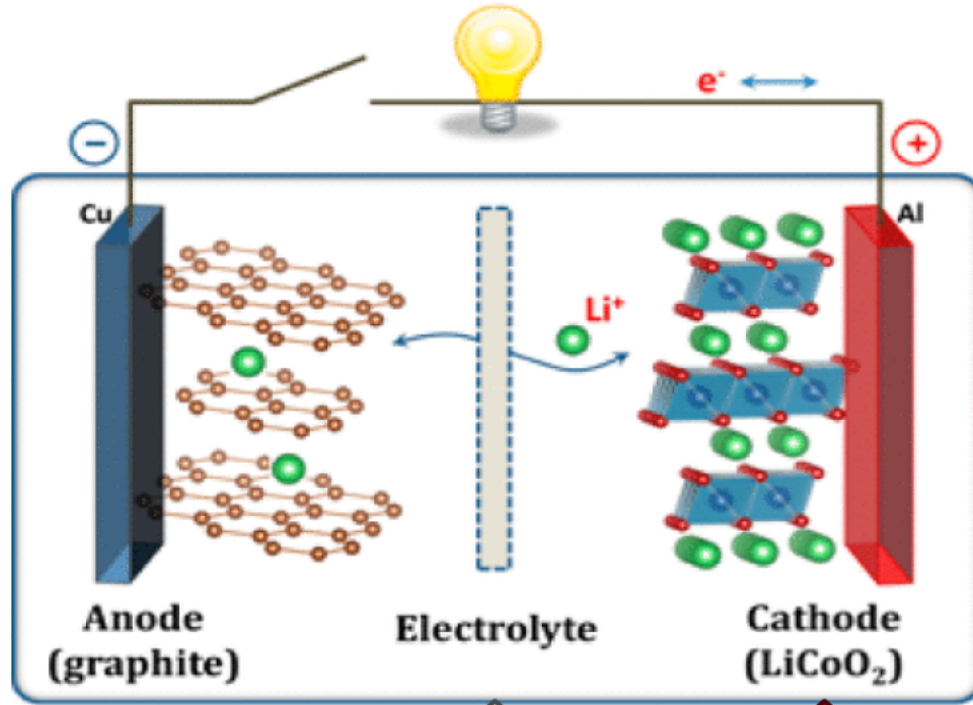
CYLINDRICAL TESLA BATTERY EVOLUTION





Li-Ion Battery Internal

H_2 & HF
Source



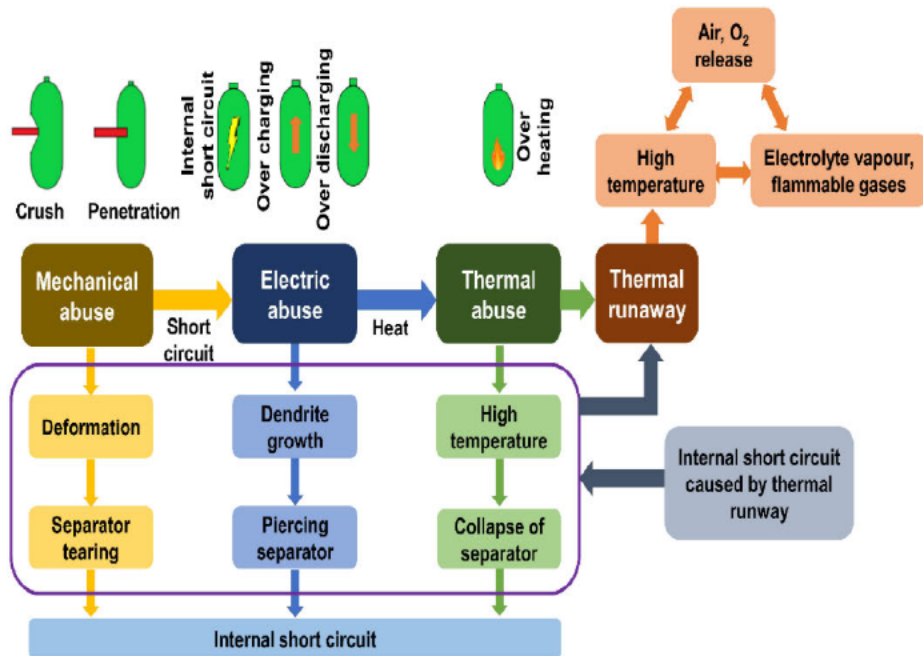
O₂ Source

Li-Ion Battery Hazards and Failure

Thermal Runaway

- ❑ Thermal Runaway – heat generated by the Li-ion battery reaches a stage where it becomes self-sustaining. Exponential rise in battery temperatures. Results in explosion, fire, and release of toxic and flammable vapors.
- ❑ Vapor Cloud – if the gasses evolved during thermal runaway do not ignite immediately, they create a vapor cloud. NOT ONLY COMBUSTION PRODUCTS!
- ❑ White smoke, cell projectiles, hissing/popping sounds

Additive Mechanism



Li-Ion Battery Toxic/Flammable Vapors

Toxic/Flam Vapors

- Hydrogen (30%-50%)
- Carbon Monoxide
- Hydrogen Fluoride
- Hydrogen Chloride
- Hydrogen Cyanide
- Phosphoryl Fluoride
- Organic Solvent Droplets
- Ammonia?
- Ethane, methane, and other hydrocarbons

Vapor Production

6,000 L/kWh of vapors can be released during battery failure (Single 18650 10Wh = 60L; Single 21700 15-20Wh = 90-120L)

Electrolyte is flammable, usually contains lithium hexafluorophosphate (LiPF_6) or another Li-salt with fluorine

HF can be generated at 20-200 mg/Wh

- Electric Vehicle (100 kWh)
600,000 L of vapor with **2-20kg of HF**
- Energy Storage System (3 MWh)
16M L of vapor with **60-600kg of HF**



FIREFIGHTING OPERATIONS AND TACTICS

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

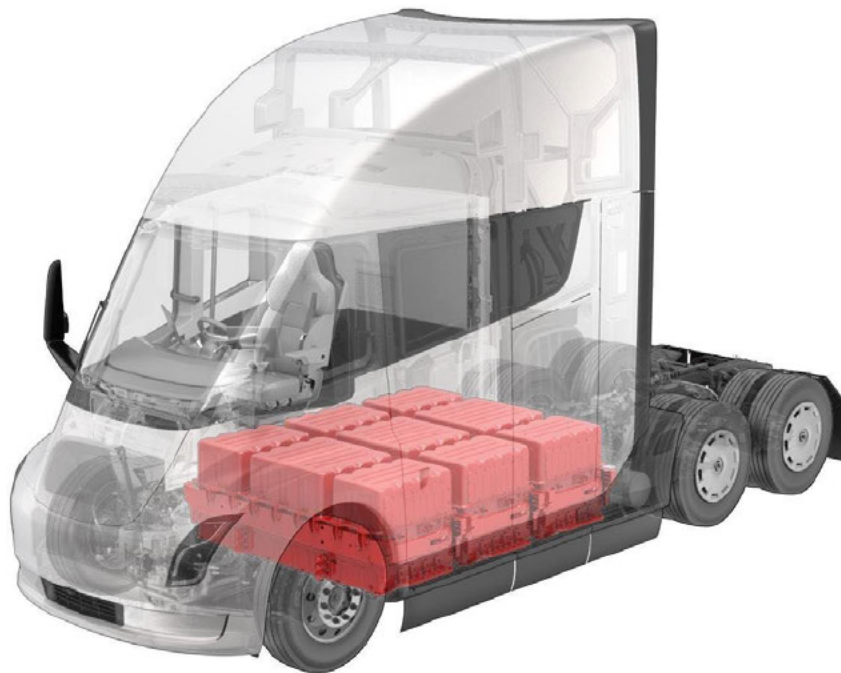
GMC Hummer = 400V

Ford Mach-e = 450V

Trolley = 600V

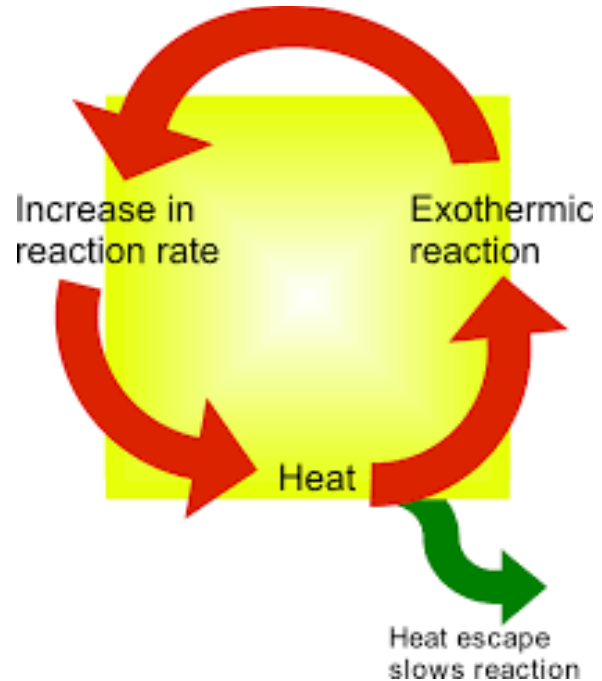
Tesla Truck = 800V (reported)

Tesla Semi = 1000V (reported)



Differences in Lithium-Ion Battery Fires

- Very toxic atmospheres: Smoke-gases, metals, particulates
- Burn temperatures peak more rapidly
- Fires at cell level can burn without external oxygen - **can't smother!**
- Explosive potential: Deflagration Detonation from **hydrogen** and carbon monoxide gases
- Thermal Runaway reaction
 - Chemical reaction – rapid degradation
 - Exothermic
 - Does not require external oxygen
 - Nearly impossible to stop once it starts
 - Initiation may be a matter of time and unpredictable
- Thermal re-kindle is common – **minutes, hours, days, weeks, months, years!**



Propagation

- Propagation
 - Domino effect
 - Thermal Runaway heat from one battery-cell is likely to trigger 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.)





Macro-Propagation

Rapid smoke and flame production

Four Primary Presentations of LIB

Energy Storage Systems

Electric Vehicles

Micro-mobility

Personal Electronics



48V10Ah 1305P USA Ship 5-7days delivery



Frequency of Incidents



- FDNY LIB fires:
 - 44 in 2020
 - 220 in 2022
 - 268 in 2023 (18 killed, 150 injured)
 - Now leading cause of fires and fire deaths in NY City, 2024.
 - Department Outreach and Ordinances are Reducing Incidents.
- San Diego LIB fires:
 - Approximately 50 in 2022
 - 104 in 2023
 - 67 as of 8/26/24 in 2024



Battery Energy Storage System (ESS)



Battery Energy Storage System (ESS)

- Large Systems
- Multiple racks of batteries
- Surprise, AZ – 2019
- Regulations
 - NFPA 855
 - Safety measures
 - UL 9540 & 9540A
 - Testing of system



Strategic-Tactical Considerations

If Batteries Are Involved



- LIB Thermal Runaway Telltale signs: Popping, hissing, smoking!
- If a fire is confirmed:
 - Non-Intervention or Defensive Operations
 - Establish water supply.
- **#1-Life safety**
 - Stay out of smoke!
 - PPE
 - Structural Firefighting Gear and SCBA.
 - Rescue
 - Evacuate / Shelter-in-Place
 - Use as much "ground truth" as possible.

Strategic-Tactical Considerations *If Batteries Are Involved*



■ **#2-Incident Stabilization**

- Let it burn? Shoreside vs Maritime
 - Applying water to the burning unit will only delay the event.
 - May take multiple operational periods.
 - During periods of module propagation, there may be no sign of fire, but the event can still be active and flare up can still occur.
 - Targeted application of fog stream, knock down smoke/particulates
- Environmental Protection
 - Minimize/contain/redirect runoff if possible
 - Sampling/Monitoring
 - Use lowest GPM needed

Strategic-Tactical Considerations *If Batteries Are Involved*



■ **#3-Property & Commerce Preservation:**

- Allow system safety devices to operate as designed.
- Monitor alarm panel and manually activate any safety devices if appropriate.
- Prevent propagation.
 - Water curtains and unstaffed lines
 - Apply from a distance and upwind if possible.
 - Protect exposed packs
 - Extinguish and protect other infrastructural exposures
 - Use 30-degree fog for water curtains to absorb heat and knock down toxic plume
- Protect other exposures.
 - Neighboring structures
 - Vegetation
 - Commerce
- Recovery
 - Address battery removal as site dictates
 - Use on-site resources and manufacturer for decommissioning and recovery plans.

Strategic-Tactical Considerations

If Batteries Are Involved in a Transportation Accident.



Strategic-Tactical Considerations

If Batteries Are Involved in a Transportation Accident.

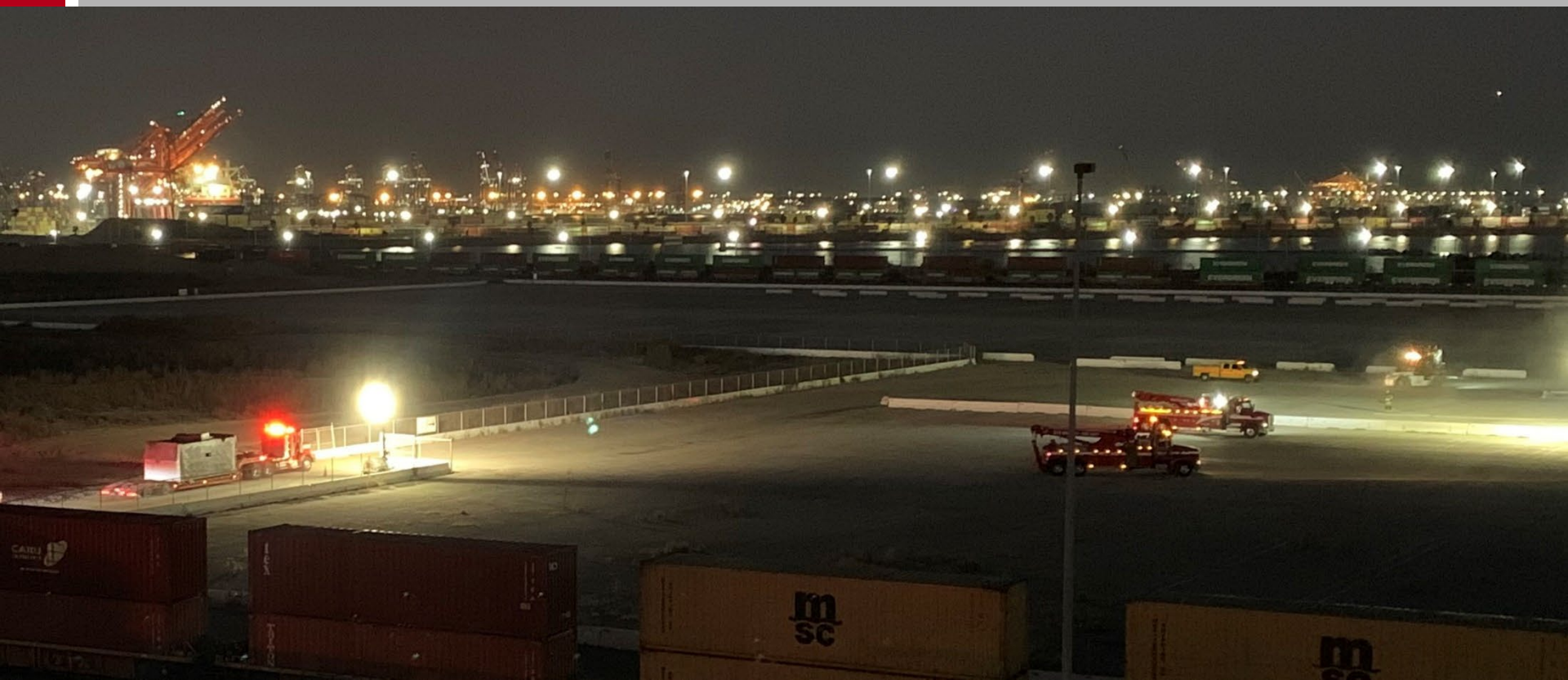


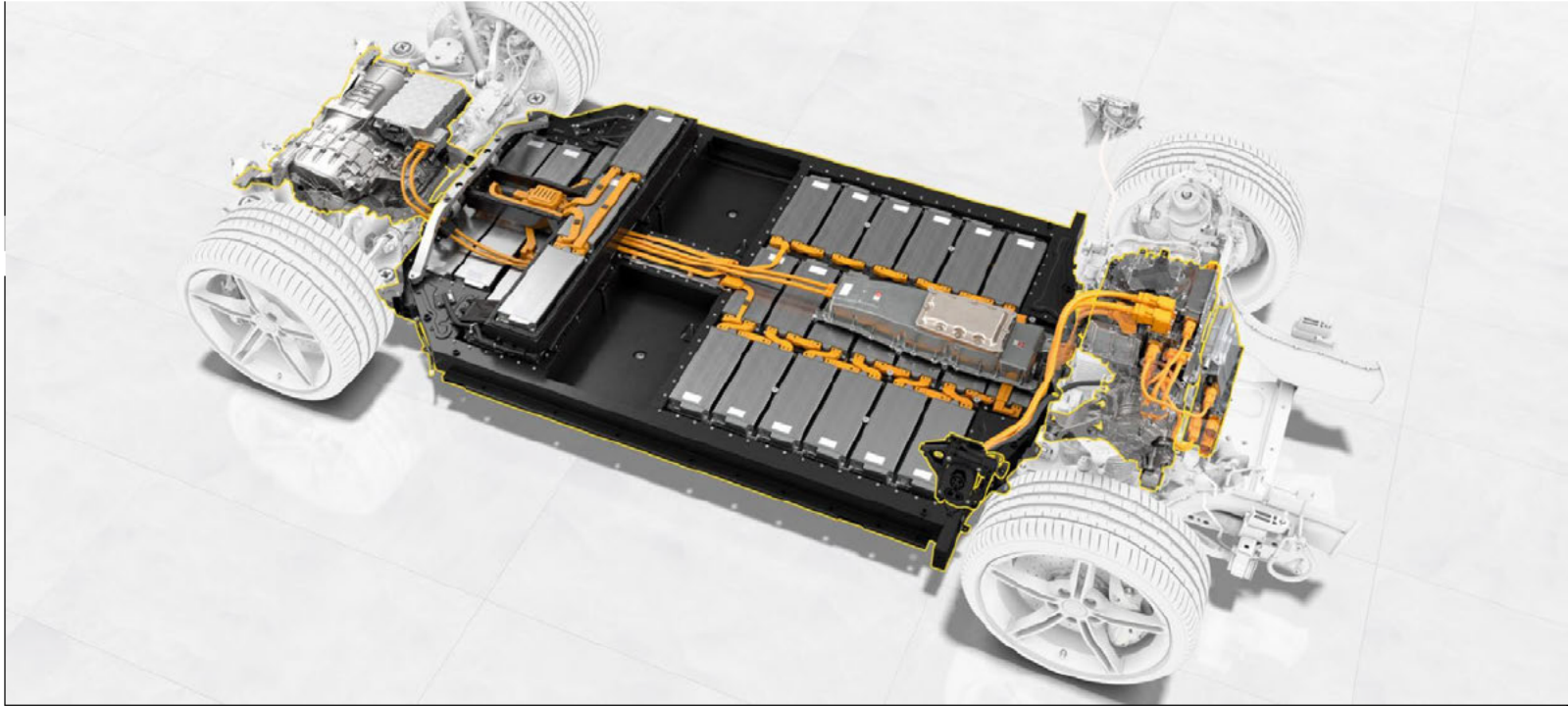
- If explosion hazard has been mitigated (membrane clearly compromised-no confinement) consider movement to re-open transportation-commerce:
 - Continuous size-up of G.E.T.
 - Balance safety with incident objectives.
 - Explosion: oxygen, fuel, dispersion, heat, CONFINEMENT!
 - Stay out of toxic smoke as much as possible!
 - Use PPV Fans or 30-degree fog for water curtains to absorb heat and knock down/push toxic plume while workers rig, right, or move unit.
 - Heavy move, 80,000 lbs. plus.
 - Identify hazard and exposure(s) and isolate hazard to approved staging location, consider: FD escorted move, defensible space, isolation distances, and environmental management.
 - If movement is chosen, ONLY HAZWOPER CERTIFIED AND COMPLIANT (HAZWOPER, HazMat FRO, HazMat Tech/Spec) shall work in the movement process, including heavy equipment operators, riggers, etc.



Strategic-Tactical Considerations

If Batteries Are Involved in a Transportation Accident.





Battery Electric Vehicles (BEV)

Significant Increase: Battery Electric Vehicles (BEV)



% of EVs Global Auto Sales

4.7% - 2020

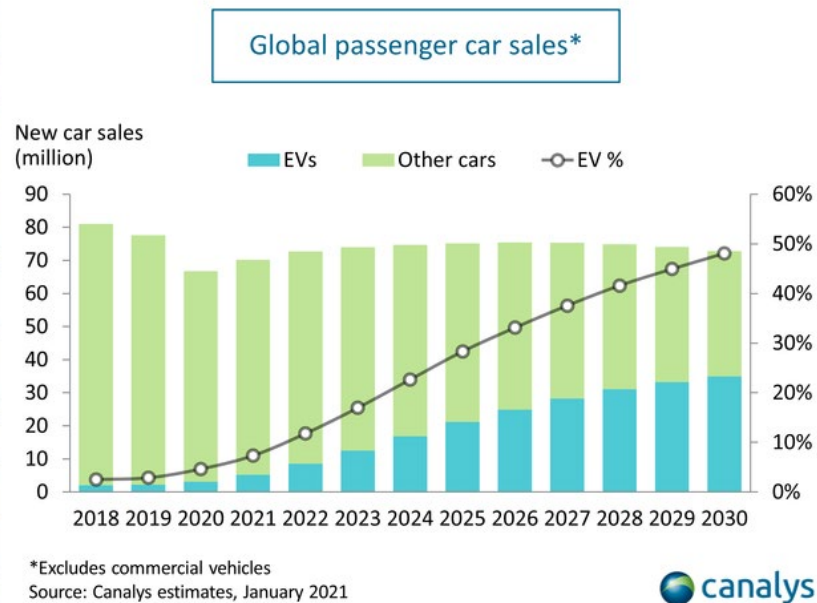
15% - 2025

48% - 2035

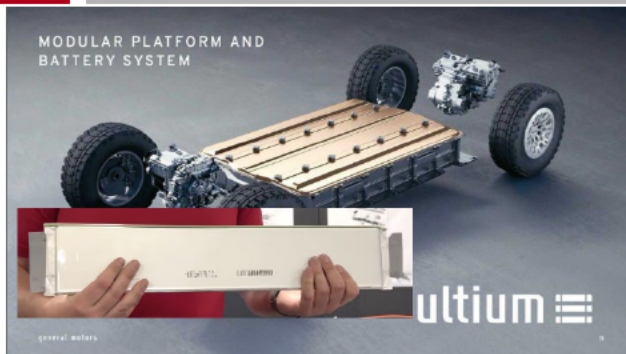
California forecasted to be much higher.

By 2035 100% of all vehicle sales in CA must be battery or hydrogen powered

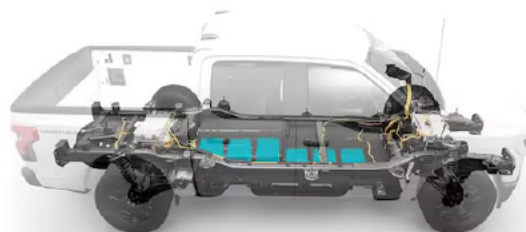
3.1 million EVs were sold in 2020, 4.7% of new passenger cars. EV sales will continue to rise, reaching 48% of passenger car sales by 2030.



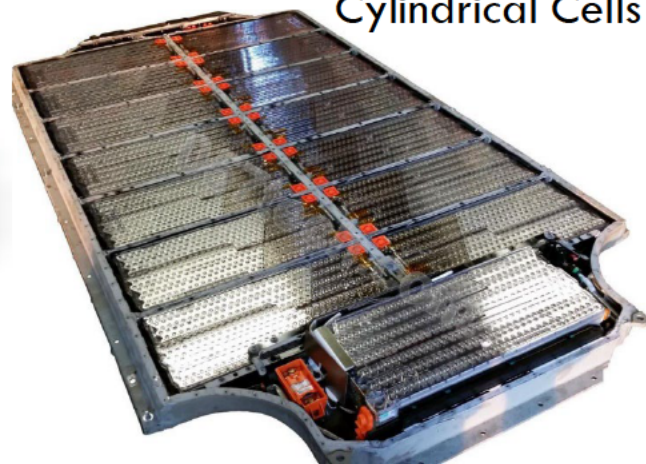
Battery Electric Vehicles (BEV) – Battery Packs



GM Battery Pack
Pouch Cells



Ford Lightning Battery Pack
Pouch Cells



Tesla Battery Pack
Cylindrical Cells

BEV Damage

- Lithium-Ion Batteries primarily located in underside of vehicle
- Identification of battery involvement is key:
 - White smoke
 - Battery cell projectiles
 - Hissing/popping sounds



Tesla – Cylindrical Cell Batteries
18650 cell generation

LOTS OF WATER?

BEV – Offensive Operations

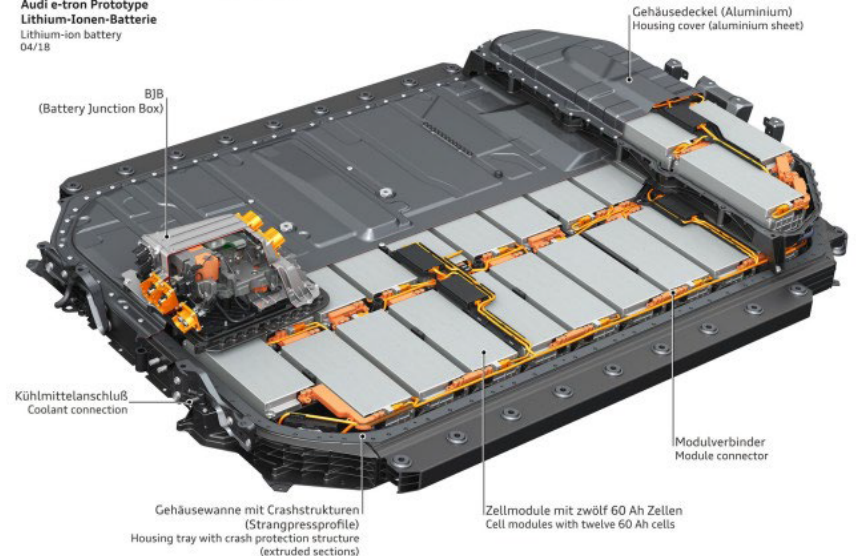


- Water is considered best cooling agent to prevent propagation
 - If offensive operation engaged:
 - Water should be applied under the vehicle and up at the batteries.
 - For pouch cell vehicles (i.e., GM), there may be access points near the wheel wells
 - Water application into access points to battery compartment can prevent propagation (manufacturer specific)

- **Thermal re-kindle can occur minutes, hours, days, weeks, months, years, later!**

Audi e-tron Prototyp

Audi e-tron Prototyp
Lithium-Ionen-Batterie
04/18



EV Semi-Trucks



- ❑ Carson, CA August 2023
- ❑ Volvo-BYD EV Semi-Truck owned by maritime shipping company
- ❑ Cause of fire: driver side swiped a slow-moving train, damaging 1 of 6 battery packs
- ❑ Average EV semi-truck cost: \$300k-500k

3 Keys to Success



BEV Identification
and Battery
Involvement



Let it Burn?
PROTECT
EXPOSURES!
(If possible)



Secure a
Water
Supply



BEV Fire Tactical Considerations

- Life safety
 - PPE
 - Rescue / Check for victims
 - Chock wheels
 - Evacuate / Shelter-in-Place
- Incident Stabilization
 - **Attack the fire like a normal vehicle fire.**
 - Foam will NOT improve cooling to prevent propagation
 - Most EV fires do not involve the batteries
 - After confirming it is an EV and batteries are involved, if possible, allow the batteries to burn and evacuate the area 330' in all directions and protect exposures.
 - Stay out of smoke, toxic.
 - Consider PPV fans to move smoke away from victims and responders.
 - Consider fog streams to knock down smoke and move smoke away from victims and responders.



BEV Fire Tactical Considerations

- Other considerations
 - Refer to the Emergency Response Guide (ERG) for the specific make and model of the vehicle for guidance on securing power to the lithium-ion battery.
www.NFPA.org
 - Some battery cooling mechanisms are powered by the 12-volt system
 - Once the lithium-ion battery has been cooled, stand-by and continue monitoring using the thermal imager and observe for any other signs of thermal runaway

BEV Fire Tactical Considerations



- Towing
 - Regenerative braking sends power to batteries. This may cause a fire with rotational force on wheels
 - Non-conductive separation between vehicle and metal bed to prevent further short circuit.
 - Store 50 ft away from all exposures



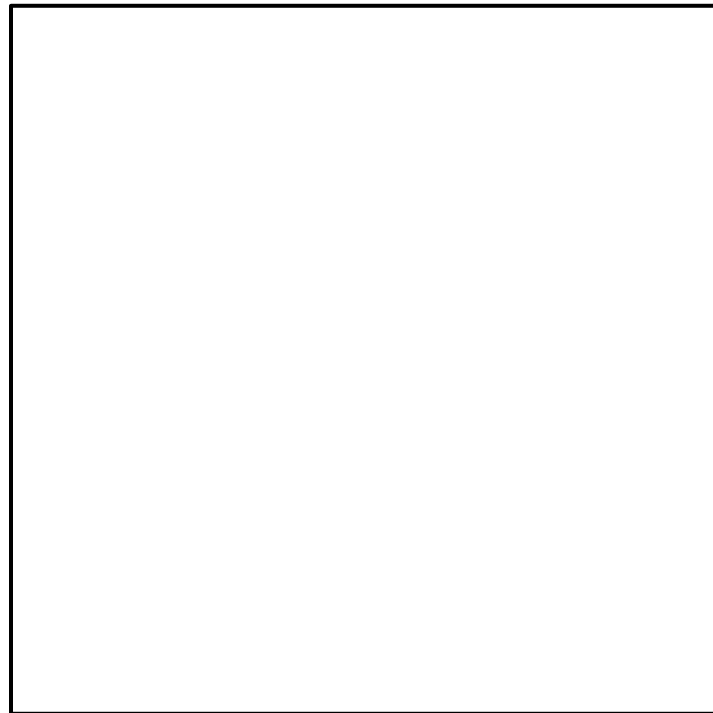
Micro-Mobility Devices

E-BIKES, SCOOTERS, HOVER BOARDS, ETC.

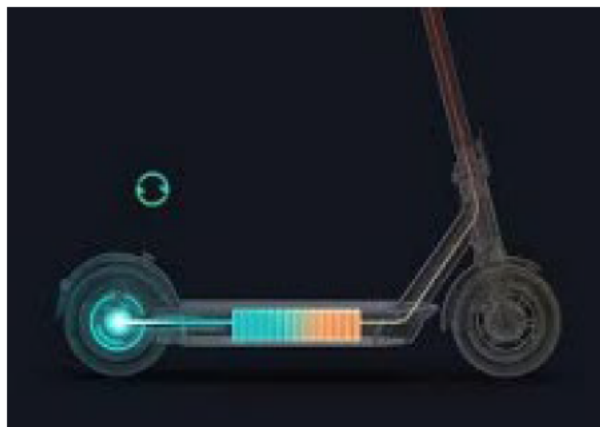
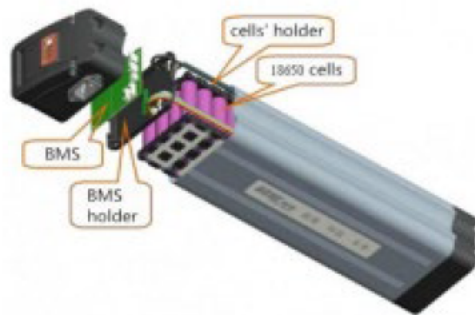
Micro-Mobility Devices



- 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 Devices



(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



Inside View

How Many GPMs?



- Lithium-Ion batteries do not require atmospheric oxygen to burn.
- Smothering also does not work
- Inerting with clean agent may inhibit class A fire but not battery fire, where flaming combustion is suppressed, explosive and toxic gases build-up and don't burn off; Surprise, AZ.
- Cooling to prevent cell propagation may be successful if water or a **proven** cooling agent can be applied at the cell level
- **DO NOT** force open the battery pack

Can you have more GPMs than this?



SAFETY AND PPE

Safety and PPE

- Safety
 - ▣ Front End and Back End
 - ▣ JHA-HASP (29 CFR, OSHA)
- Identification and Hazard Assessment/Analysis
 - ▣ **G**-as
 - ▣ **E**-lectrical
 - ▣ **T**-hermal

GAS



ELECTRICAL



THERMAL





Safety and PPE

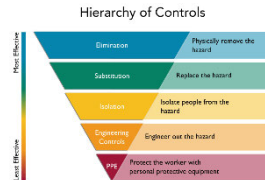
- HazMat Size-UP, Critical Factors
 - ▣ **G.E.T.**
- Incident Priorities L.I.P
- Recognition Prime Decision Making
- Risk Management Process: A lot, A little, Nothing
- Verify Standard Conditions, Standard Actions, Standard Outcomes:
 - ▣ **G.E.T.**
 - ▣ **S.I.N. C.I.A. P.C.P. D.D.D.D.**
 - ▣ Initial Action Plan: Strategy, Objectives (position and function)(use of tactics and task level work).
 - S.I.N. C.**I.A. P.C.P. D.**D.D.D.D.
- Re-assess



Safety and PPE

- ☐ Safety
- ☐ Isolate and deny entry
- ☐ Notifications
- ☐ Command
- ☐ Identification and hazard assessment
- ☐ Action planning
- ☐ Personal Protective Equipment (PPE)
- ☐ Countermeasures-Defensive
- ☐ Protective Actions
- ☐ Decontamination
- ☐ Debrief
- ☐ Documentation!!!!
- ☐ Disposal/Recycle

Safety and PPE



Personal Protective Equipment (PPE)

- **Fire/Thermal Risk**
 - Front End
 - FR-Structure Fire Ensemble
 - Interior-Exterior SCBA
 - Back End “Right of Boom!”
 - Administrative and Engineering Controls
 - FR-Ensemble
 - Interior-Exterior SCBA
- **No Fire/Thermal Risk at This Time?**
 - Back End “Right of Boom!”
 - Hierarchy of Controls
 - Consider particulate in air and exposure levels when selecting respiratory protection.
 - Level B or C
 - Interior-Exterior SCBA (Nanoparticles)
 - FR-Ensemble (consider decon)
 - Interior-Exterior SCBA (Nanoparticles)

San Diego LIB Field Experiment



San Diego LIB Field Experiment



San Diego LIB Field Experiment



SAN DIEGO LITHIUM-ION BATTERY FIELD STUDY DATA SUMMARY:

AIR MONITORING

Run	Test Media	Air Monitoring Data							
1	4 LiFePO4 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	-2.7	-1	0	0	0.001	
		Max	20.9	0	5	0	0.8	0.58	0.707
2	4 LiFePO4 18500 SOC Unknown	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	-2.7	0	0	0	0	
		Max	20.9	9.8	36	0	1.1	20	10.082
3	8 LiFePO4 18500 "Low SOC"	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	-2.1	0	0	0	0	
		Max	20.9	66.5	171	2	3.9	0.95	7.567
4	8 LiFePO4 18500 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	-0.6	3	0	0	0	
		Max	20.9	36.4	52	0	1.4	20	35.439
5	12 NMC (Nuo) 18650 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	-1.8	-2	0	-0.8	0	
		Max	20.9	1.1	3	0	0	1.62	23.533
6	44 NMC 21700 Zhejiang Skateboard 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	19.4	0	0	0	-0.6	0	
		Max	20.9	135	2460	3	18.2	1.08	100
7	8 NMC Mollicel ISS 21700 <100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.2	0	14	0	1.6	0	
		Max	20.9	50.5	1190	3	5.8	0	1.439
8	65 NMC KULR Ebike & Amazon 18650 SOC "as shipped"	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	0.3	5	0	0.6	0	
		Max	20.9	26.4	206	0	1.4	0	0.188
9	18 NMC Mollicel ISS 21700 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	0	0	0	0	0.004	
		Max	20.9	0.6	3	0	0.6	0	100
10	2 LiFePO4 ESS (Prismatic) 1 charged, 1 uncharged	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	20.9	2.1	3	0	0	NA	
		Max	20.9	165	350	3	4.2	0	NA
11	48 NMC Zhejiang Skateboard 21700 <40V SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	18.9	2.8	12	0	0	0.005	
		Max	20.9	94.5	910	3	3	0.49	100
12	48 NMC Zhejiang Skateboard 21700 100% SOC (49.6V)	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	18.9	2.1	10	0	-2.6	0	0.003
		Max	20.9	87.5	1560	3	13.1	20	100
13	3 x NMC Zhejiang Skateboard in Akugrain Box (144 cells total) 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
		Min	19.1	0.4	0	0	0	0.005	
		Max	20.9	780	11400	37	80.5	0	100

Yellow = over OSHA PEL, Green = H2 over MIE 4% LEL

Contaminant/Sensor	Action Level
Hydrofluoric Acid (HF)	Cal/OSHA PEL = 0.4 ppm, STEL 1 ppm
Hydrogen Cyanide (HCN)	Cal/OSHA PEL = 10 ppm, Ceiling = 4.7 ppm
Hydrogen (H2) LEL%	Minimum Ignition Energy (MIE) is 4,000 ppm or 4% by volume
Carbon Monoxide (CO)	Cal/OSHA PEL = 25 ppm, Ceiling = 200 ppm Also a 40% cross-sensitivity with H2

SAN DIEGO LITHIUM-ION BATTERY FIELD STUDY DATA SUMMARY:

AIR SAMPLING

Sampling Method	Media	Target Analytes
ASTM-D-1945	Tedlar Bag, vacuum box, pump	H2, CO, O2 ppm (v/v) and (m/m)
NIOSH 6010	Colorimetric tubes, pump	HCN
NIOSH 7902	Filter cassette, pump	HF (Fluoride ion vapor and soluble particulate)
NIOSH 7303	Filter cassette, pump	Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sb, Se, Tl, V, Zn Expanded list: Al, Fe, Mn, Sr, Sn, Ti

Run #	Test Media	Air Sampling Data									
3	8 LiFePO4 18500 "Low SOC"	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	260	<100	277k	ND	25	0.23			
		µg/m3	Cu	Ni	Sb	Zn	350	7	130	60	
7	8 NMC Mollicel ISS 21700 <100% SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	230	740	265K	ND	0.58	43			
		µg/m3	Ag	Ba	Co	Cu	Ni	Pb	Sb	Tl	Zn
		6	19	18000	29000	1900	30	570	130	9500	
		Al	Fe	Mn	Sr	Ti					
		mg/m3	2500	140	21	64					
9	18 NMC Mollicel ISS 21700 100% SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	400	790	255k	2.5	0.94	1.3			
		µg/m3	Ba	Co	Cu	Ni	Sb	Tl	Zn		
		3	2800	650	26000	210	20	350			
		Al	Mn	Sr	Ti						
		mg/m3	2400	6.6	0.76	2.9					
11	48 NMC Zhejiang Skateboard 21700 <40V SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	230	740	265k	ND	0.58	43			
		µg/m3	Co	Cu	Ni	Sb	Zn	220	43	1900	120
		Al	Mn								
		mg/m3	70	0.24							
12	48 NMC Zhejiang Skateboard 21700 100% SOC (49.6V)	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	240	1480	247k	0.87	0.77	24			
		µg/m3	Ba	Co	Cu	Ni	Pb	Sb	Tl	Zn	
		21	7600	7500	70000	430	1400	60	1100		
		Al	Fe	Mn	Sr	Sn	Ti				
		mg/m3	1000	12	6.9	0.83	21	4.2			
13	3 x NMC Zhejiang Skateboard in Akugrain Box (144 cells total) 100% SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	14400	16720	264k	ND	0.56	17			
		µg/m3	Ba	Co	Cu	Ni	Pb	Sb	Zn		
		46	3600	2300	33000	220	240	470			
		Al	Fe	Mn	Sr	Sn	Ti				
		mg/m3	650	13	0.54	0.15	21	1.8			

Yellow = over OSHA PEL, Green = H2 over MIE 4% LEL



AIR SAMPLING

Sampling Method	Media	Target Analytes
ASTM-D-1945	Jedlar Bag, vacuum box, pump	H ₂ , CO, O ₂ ppm (v/v) and (m/m)
NIOSH 6010	Colorimetric tubes, pump	HCN
NIOSH 7902	Filter cassette, pump	HF (Fluoride ion vapor and soluble particulate)
NIOSH 7303	Filter cassette, pump	Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sb, Se, Tl, V, Zn Expanded list: Al, Fe, Mn, Sr, Sn, Ti

Run #	Test Media	Air Sampling Data									
3	8 LiFePO4 18500 "Low SOC"	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	260	<100	277k	ND	25	0.23			
		µg/m3	Cu	Ni	Sb	Zn					
7	8 NMC Mollicel ISS 21700 <100% SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	230	740	265K	ND	0.58	43			
		µg/m3	Ag	Ba	Co	Cu	Ni	Pb	Sb	Tl	Zn
9	18 NMC Mollicel ISS 21700 100% SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	400	790	255k	2.5	0.94	1.3			
		µg/m3	Ba	Co	Cu	Ni	Sb	Tl	Zn		
11	48 NMC Zhejiang Skateboard 21700 <40V SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	230	740	265k	ND	0.58	43			
		µg/m3	Co	Cu	Ni	Sb	Zn				
12	48 NMC Zhejiang Skateboard 21700 100% SOC (49.6V)	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	240	1480	247k	0.87	0.77	24			
		µg/m3	Ba	Co	Cu	Ni	Pb	Sb	Tl	Zn	
13	3 x NMC Zhejiang Skateboard in Akkugrain Box (144 cells total) 100% SOC	H2	CO	O2	HCN	HF (vapor)	Fluoride (particulate, mg/m3)				
		ppm	14400	16720	264k	ND	0.56	17			
		µg/m3	Ba	Co	Cu	Ni	Pb	Sb	Zn		
Yellow = over OSHA PEL, Green = H2 over MIE 4% LEL											

Yellow = over OSHA PEL, Green = H₂ over MIE 4% LELOccupational/Industrial Limits for Metals of Concern (µg/m³)

Metal	Carcinogen?	IDLH	NIOSH REL (10-hr TWA)	OSHA PEL (8-hr TWA)
Aluminum	No	-	10,000	15,000
Antimony ^a	No	50,000	500	500
Arsenic ^{a,b}	Yes	500	2b	10
Barium	No	50,000	500	500
Beryllium ^{a,c}	Yes	400	0.5	2
Cadmium ^a	Yes	900	N.E.	0.005
Chromium ^a	No	250,000	0.5	1
Cobalt ^a	No	20,000	0.05	0.1
Copper ^d	No	100,000	1	1
Iron	Yes	2,500,000	5,000	10,000
Lead ^{a,e}	No	100,000	50	50
Manganese ^{a,f}	No	500,000	1,000	5,000
Mercury ^{a,g}	No	10,000	0.1	100
Molybdenum	No	1,000,000	5,000	5,000
Nickel ^{a,h}	Yes	10,000	15	1000
Selenium ^{a,i}	No	100	200	200
Silver	No	10,000	10	10
Strontium	No	-	-	-
Thallium	No	15,000	100	100
Titanium	No	-	-	15,000
Tin	No	25,000	2,000	2,000
Vanadium ^j	No	35,000	50	50
Zinc	No	500,000	5,000	15,000

IDLH = Immediately Detrimental to Life and Health
NIOSH = National Institute of Occupational Safety and Health REL = Recommended Exposure Limit
OSHA = Occupational Safety and Health Administration PEL = Permissible Exposure Limit
a Metals designated as Hazardous Air Pollutants by the EPA.
b NIOSH REL for arsenic is a 15-minute ceiling
c OSHA PEL for beryllium has a 30-minute ceiling of 5 µg/m ³
d Additional REL of 0.1 and PEL of 0.1 for copper fume
e NIOSH REL for lead is an 8-hour TWA standard
f NIOSH short term exposure limit (STEL) for manganese is 3,000 µg/m ³ and the PEL is a
g NIOSH REL for mercury for skin is 50 µg/m ³ and the REL is a ceiling
h Nickel as Ni(CO) ₄ has an IDLH of 14,000 µg/m ³ and an REL and PEL of 7 µg/m ³
i Selenium as SeF ₆ has an IDLH of 2000 µg/m ³ and an REL and PEL of 400 µg/m ³
j NIOSH REL for vanadium is a 15-minute limit

San Diego Data Summary:



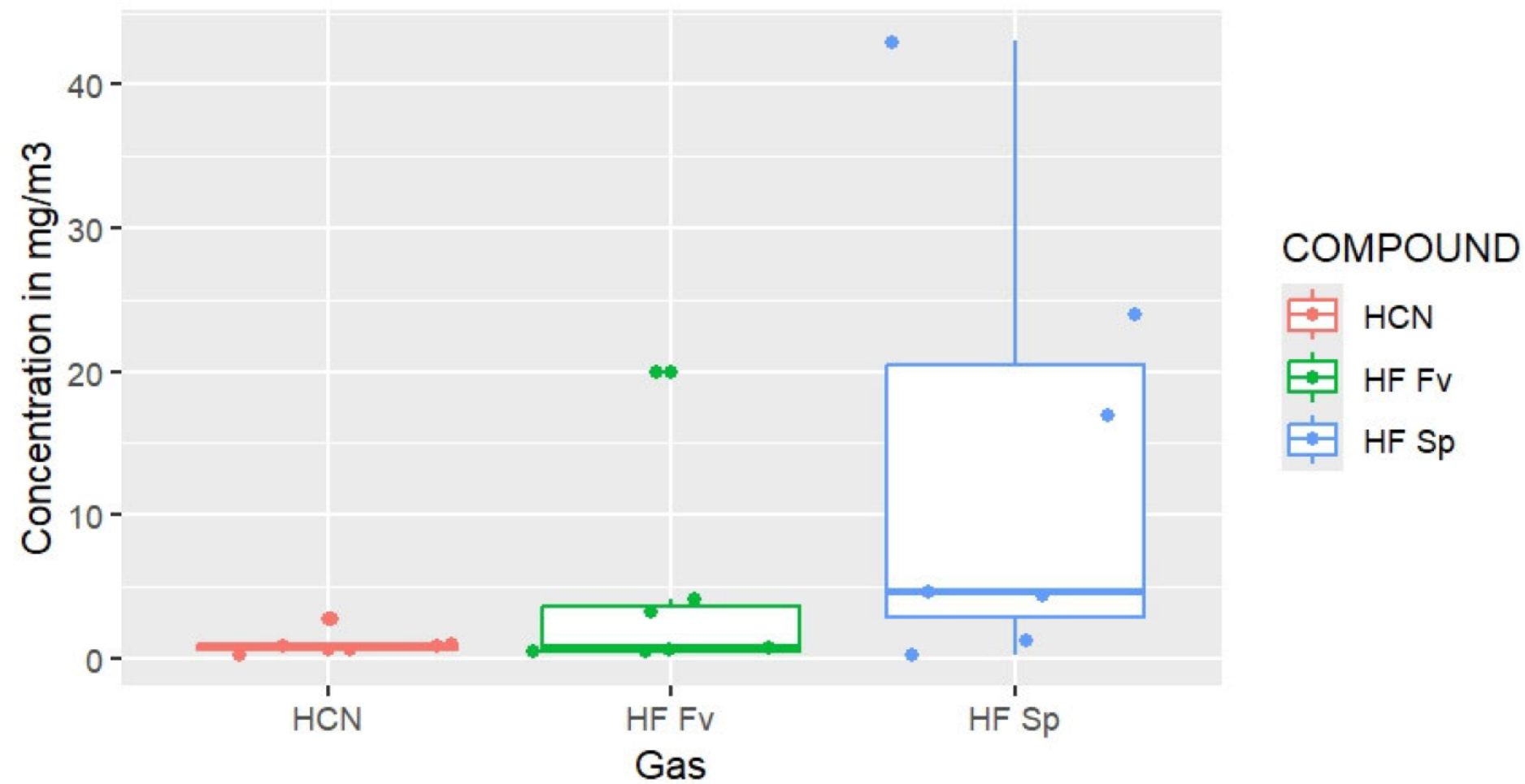
Air Monitoring Devices

- ❑ Industrial health exceedances on every single run, 4 cells to 144 cells
- ❑ Immediately Dangerous to Life or Health (IDLH) limit reached for Hydrogen Cyanide (HCN) and Carbon Monoxide (CO)
- ❑ Sensors maxed out for Hydrogen Fluoride (HF) several times @20ppm
 - ❑ HF IDLH is 30 ppm

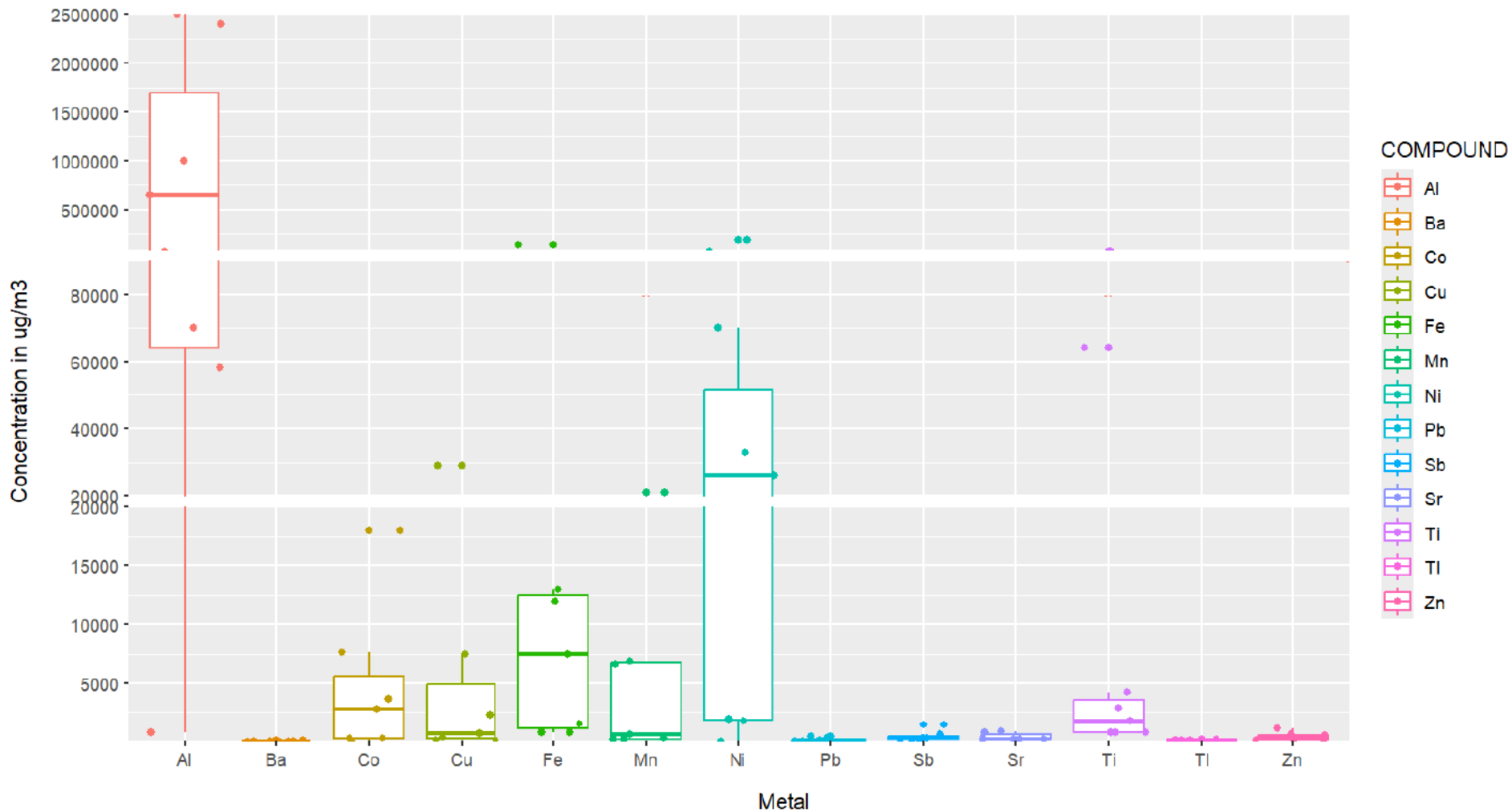
Air Sampling Results

- ❑ Industrial health exceedances on every single run in gases (CO or HF) AND for metals
 - ❑ 11 out of the 22 metals we tested for had exceedances.
- ❑ IDLH limit reached 4 times for Nickel, and just under for Cobalt.
 - ❑ 1 instance was 19x IDLH for Nickel

Gas in Burn Chamber Air Samples



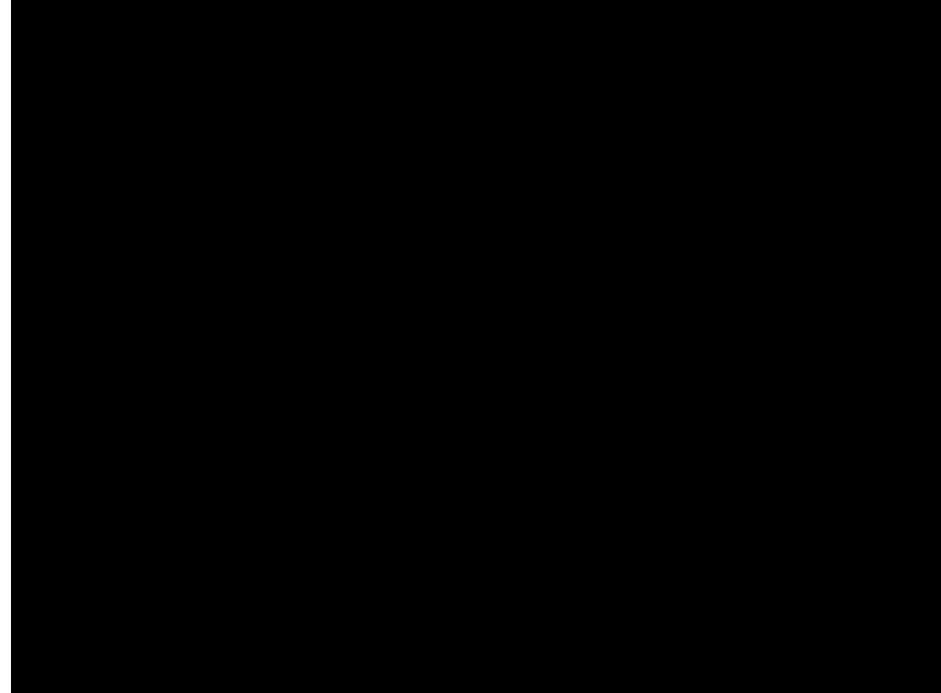
Metals in Burn Chamber Air Samples



Metals Particulate Size



- ❑ National Renewable Energy Lab (NREL) confirms sizes down to nano-particle scale
- ❑ 0.1 to 3 μm easily penetrates lungs and impacts respiratory health
- ❑ Transition metals contribute to DNA strand breaks, lung inflammation and cancer, asthma, pneumonia, neurological and nervous system effects.
- ❑ Size may be able to pass through P100 cartridges





Safety and PPE

- Decontamination Practices / Concerns
 - ▣ Field decon capability?
 - ▣ Equipment decon?
 - ▣ Garment Decon-Isolation-Decon/Disposal (PPE Level and Type)
 - Metals and other toxic chemicals
 - Traditional washer extractor
 - San Diego Study (UCLA)
 - ATF-TEEX: preliminary data shows cleaning is possible, but is it worth it?
 - ▣ Disposable Fire-Retardant PPE, the Future?



AIR MONITORING

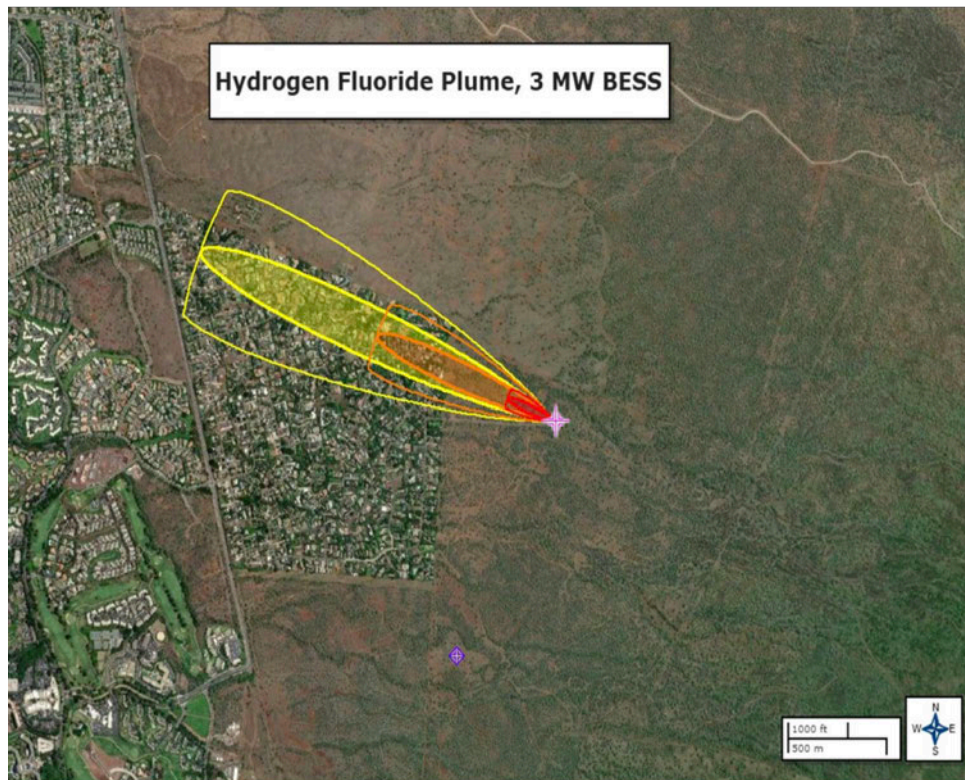


Air Monitoring (Strategic)

- First Responder (Fire, Haz-Mat, Police):
 - ▣ Site Characterization: assumed and actual
 - Front end gases-materials
 - ▣ Isolation distances and site access control
 - ▣ Protective actions
- Second Responder (Environmental Response-Protection; Contractors):
 - ▣ Site Characterization: assumed and actual
 - Back end gases-materials
 - ▣ Isolation distances and site access control
 - ▣ Protective actions

Air monitoring capabilities and decision making (Tactical)

- Like most fires quantifying the constituents of the smoke is difficult, even with the appropriate instruments immediately available
 - ▣ Particulate monitoring may be useful to indicate direction of plume
- Typical public statement consistent with an industrial fire is appropriate for a battery fire
 - ▣ “No amount of smoke is healthy.”





Air Monitoring (Tactical)

▣ Site Characterization: assumed and actual

- ▣ hydrogen
 - ▣ carbon monoxide
 - ▣ hydrogen fluoride
 - ▣ hydrogen chloride
 - ▣ hydrogen cyanide
 - ▣ phosphoryl fluoride
 - ▣ organic droplets
 - ▣ ethane
 - ▣ methane
 - ▣ other hydrocarbons-VOC
 - ▣ Smoke particulates / metals
-
- Isolation distances and site access control
 - Protective actions

Air Monitoring – Potential EPA Approach



Target Compound	Equip	Sensor	Concerns
Carbon Monoxide	MultiRAE AreaRAE	CO+H2S	CO cross-sensitive to H2; H2S sensitive to SO2
Carbon Dioxide	None		
Hydrofluoric Acid (Hydrogen Fluoride)	SPM Flex	Mineral Acid	Quantity of tapes available
Sulfur Dioxide	MultiRAE Drager	SO2	SO2 sensor not always installed
Hydrogen	MultiRAE AreaRAE	H2+LEL+ CO	Reduced sensitivity in low O2
Particulates	DustTrak	PM2.5	Metals not distinguishable from smoke



Air Monitoring – RAE Sensors



Target Compound	Ionization Potential	RAE Sensor	Detection Range
Carbon Monoxide	14.01 eV	CO	0-500 ppm
Hydrofluoric Acid (Hydrogen Fluoride)	15.98 eV	HF	0.5-10 ppm
Sulfur Dioxide	12.3 eV	SO2	0-20 ppm
Hydrogen	15.43 eV	LEL H2	0-100% (0-30% O2) 0-1000 ppm



Air Monitoring – Dräger Tube



Target Compound	Tube Available	CMS Chip Available	Detection Range
Carbon Monoxide	✓	✓	.3 - 7 % Vol.
Carbon Dioxide	✓	✓	1 - 20 % Vol.
Hydrofluoric Acid (Hydrogen Fluoride)	✓		0.5-15 ppm, 10-90 ppm
Sulfur Dioxide	✓	✓	≥0.1-3 ppm
Hydrogen	✓		0.2 - 2 % Vol. 0.5 - 3 % Vol.



SAN DIEGO LITHIUM-ION BATTERY FIELD STUDY DATA SUMMARY:

AIR MONITORING

Run	Test Media	Air Monitoring Data							
1	4 LiFePO4 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	-2.7	-1	0	0	0	0.001	
	Max	20.9	0	5	0	0.8	0.58	0.707	
2	4 LiFePO4 18500 SOC Unknown	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	-2.7	0	0	0	0	0	
	Max	20.9	9.8	36	0	1.1	20	10.082	
3	8 LiFePO4 18500 "Low SOC"	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	-2.1	0	0	0	0	0	
	Max	20.9	66.5	171	2	3.9	0.95	7.567	
4	8 LiFePO4 18500 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	-0.6	3	0	0	0	0	
	Max	20.9	36.4	52	0	1.4	20	35.439	
5	12 NMC (Nuon) 18650 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	-1.8	-2	0	-0.8	0	0	
	Max	20.9	1.1	3	0	0	1.62	23.533	
6	44 NMC 21700 Zhenjiang Skateboard 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	19.4	0	0	0	-0.6	0	0	
	Max	20.9	135	2460	0	18.2	1.08	100	
7	8 NMC Mollicel ISS 21700 <100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.2	0	14	0	1.6	0	0	
	Max	20.9	50.5	1190	3	5.8	0	1.439	
8	65 NMC KULR Ebike & Amazon 18650 SOC "as shipped"	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	0.3	5	0	0.6	0	0	
	Max	20.9	26.4	206	0	1.4	0	0.188	
9	18 NMC Mollicel ISS 21700 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	0	0	0	0	0	0.004	
	Max	20.9	0.6	3	0	0.6	0	100	
10	2 LiFePO4 ESS (Prismatic) 1 charged, 1 uncharged	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	20.9	2.1	3	0	0	0	NA	
	Max	20.9	165	350	0	4.2	0	NA	
11	48 NMC Zhenjiang Skateboard 21700 <40V SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	18.9	2.8	12	0	0	0	0.005	
	Max	20.9	84.5	246	3	3	0.45	100	
12	48 NMC Zhenjiang Skateboard 21700 100% SOC (49.6V)	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	18.9	2.1	10	0	-2.6	0	0.003	
	Max	20.9	87.5	1560	0	13.1	20	100	
13	3 x NMC Zhenjiang Skateboard in AkkuRain Box (144 cells total) 100% SOC	O2 %	VOC	CO	LEL %	HCN	HF	Particulate	
	Min	19.1	0.4	0	0	0	0	0.005	
	Max	20.9	780	11400	37	80.5	0	100	

Yellow = over OSHA PEL, Green = H2 over MIE 4% LEL

Contaminant/Sensor	Action Level
Hydrofluoric Acid (HF)	Cal/OSHA PEL = 0.4 ppm, STEL 1 ppm
Hydrogen Cyanide (HCN)	Cal/OSHA PEL = 10 ppm, Ceiling = 4.7 ppm
Hydrogen (H2) LEL%	Minimum Ignition Energy (MIE) is 4,000 ppm or 4% by volume
Carbon Monoxide (CO)	Cal/OSHA PEL = 25 ppm, Ceiling = 200 ppm Also a 40% cross-sensitivity with H2

SAN DIEGO LITHIUM-ION BATTERY FIELD STUDY DATA SUMMARY:

AIR SAMPLING

Sampling Method	Media	Target Analytes
ASTM-D-1945	Tedlar Bag, vacuum box, pump	H2, CO, O2 ppm (v/v) and (m/m)
NIOSH 6010	Colorimetric tubes, pump	HCN
NIOSH 7902	Filter cassette, pump	HF (vapor and soluble particulate)
NIOSH 7303	Filter cassette, pump	Ag, As, Ba, Be, Cd, Co, Cr, Cu, Mo, Ni, Pb, Sb, Se, Ti, V, Zn Expanded list: Al, Fe, Mn, Sr, Sn, Ti

Run #	Test Media	Air Sampling Data									
3	8 LiFePO4 18500 "Low SOC"	H2 ppm	CO 260	O2 <100	O2 277k	HCN ND	HF (vapor) 25	HF (particulate, mg/m3) 0.23			
		Cu µg/m3	Ni 350	Sb 7	Zn 130						
7	8 NMC Mollicel ISS 21700 <100% SOC	H2 ppm	CO 230	O2 740	O2 265K	HCN ND	HF (vapor) 0.58	HF (particulate, mg/m3) 43			
		Ag µg/m3	Ba 6	Co 19	Cu 18000	Ni 29000	Pb 190k	Sb 30	Tl 570	Zn 130	
		Al mg/m3	Fe 2500	Mn 140	Sr 21	Ti 1.1					
9	18 NMC Mollicel ISS 21700 100% SOC	H2 ppm	CO 400	O2 790	O2 255k	HCN 2.5	HF (vapor) 0.34	HF (particulate, mg/m3) 1.3			
		Ba µg/m3	Co 3	Cu 2800	Ni 850	Sb 26000	Tl 210	Zn 20			
		Al mg/m3	Mn 2400	Sr 6.6	Ti 0.76						
11	48 NMC Zhenjiang Skateboard 21700 <40V SOC	H2 ppm	CO 230	O2 740	O2 265k	HCN ND	HF (vapor) 0.58	HF (particulate, mg/m3) 43			
		Co µg/m3	Cu 220	Ni 43	Sb 1900	Zn 120					
		Al mg/m3	Mn 70								
12	48 NMC Zhenjiang Skateboard 21700 100% SOC (49.6V)	H2 ppm	CO 240	O2 1480	O2 247k	HCN 0.87	HF (vapor) 0.77	HF (particulate, mg/m3) 24			
		Ba µg/m3	Co 21	Cu 7600	Ni 7500	Pb 70000	Sb 430	Tl 1400	Zn 60		
		Al mg/m3	Fe 1200	Mn 12	Sr 6.9	Ti 0.83					
13	3 x NMC Zhenjiang Skateboard in AkkuRain Box (144 cells total) 100% SOC	H2 ppm	CO 14400	O2 16720	O2 84k	HCN ND	HF (vapor) 0.56	HF (particulate, mg/m3) 17			
		Ba µg/m3	Co 46	Cu 3600	Ni 2300	Pb 33000	Sb 220	Tl 240	Zn 470		
		Al mg/m3	Fe 650	Mn 13	Sr 0.54	Ti 0.15					
Yellow = over OSHA PEL Green = H2 over MIE 4% LEL											

Yellow = over OSHA PEL, Green = H2 over MIE 4% LEL



Air monitoring capabilities and decision making (Tactical)



ONE TO SIX GAS PORTABLE MONITOR

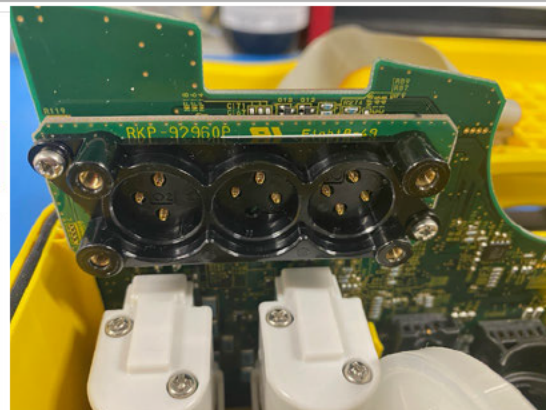
Gas Detection For Life

EAGLE 3 Model



Features

- Monitor up to 6 different gases
- PPM, % LEL, or % Vol. auto-ranging combustibles
- EC / PID / TC / CAT / IR Sensor technologies
 - Standard 4 Gases (LEL, O2, H2S, CO)
 - Toxic Gases
 - 10.6 eV, 10.0 eV and 11.7 eV PID
- Powerful long-life pump up to 125' range
- Low flow pump shut off and alarm
- Methane elimination for environmental use
- Li-ion rechargeable battery pack
- Internal hydrophobic dust filter
- External probe with hydrophobic filter
- RFI / EMI / chemical / weather resistant enclosure
- Intrinsically safe design
- Datalogging standard
- Bluetooth communication





Air Monitoring and Sampling

- **Air Monitoring (Real-time/Near real-time):**
 1. Smoke plume modeling (IMAAC: Inter Agency Modeling and Atmospheric Assessment Center, (877) 240-1187), down range monitoring.
 2. Particulate/vapor real-time air monitoring (Dust Trak, Multi-RAE, Real-time instruments)
 3. Field Portable GC/MS, MS, GAS ID
 4. Dust concentration in air calculations (concentration in soil, dust, air)

- **Air Sampling (Not real-time requires laboratory analysis):**
 1. Air sampling: pump to cassette for perimeter
 2. Air sampling: pump to cassette for personnel
 3. Summa Canister or Tedlar bags



TRANSPORTATION INCIDENTS



Lithium Battery Incident

PHMSA – 2023



U.S. Department of Transportation
Pipeline and Hazardous Materials
Safety Administration



Houston TX – April 23, 2017



Shipping container exploded while in transportation by rail.

There was no warning or indication that lithium batteries were involved.

San Antonio, TX – February 10, 2022



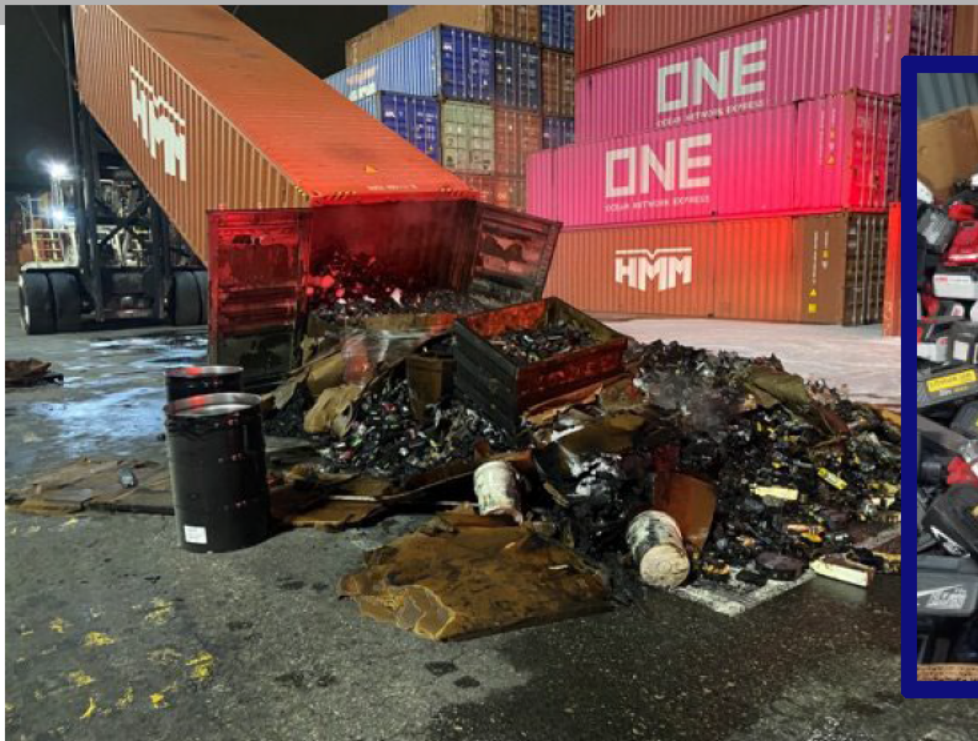
Use of black shrink-wrap made it difficult to see damage that impacted the cellphones/batteries in the packages.

Port – L.A. Long Beach – March 4, 2022



- Shipper described the contents as **Synthetic Resins N.O.S.**
- Many other containers were found in the port and loaded on ships with the same description

Port – L.A. Long Beach – March 4, 2022



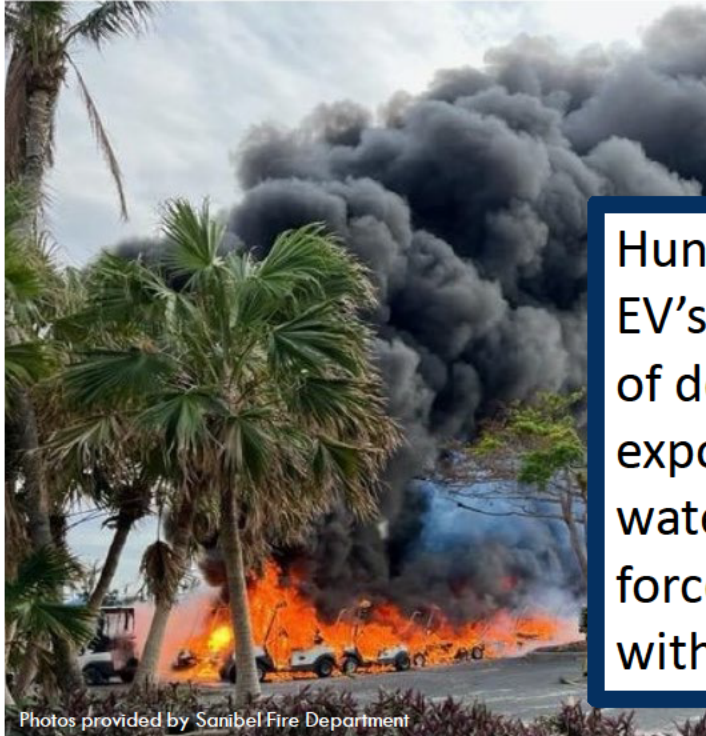
Port – L.A. Long Beach – March 4, 2022



Container of undeclared li batteries involved associated with the previous container contains laptop batteries.



Hurricanes – September 28, 2022



Photos provided by Sanibel Fire Department



Hundreds of EV's and thousands of devices exposed to sea water and other forces associated with hurricanes.

Hurricanes – 2022 and 2024



Photos provided by Sanibel Fire Department



Birmingham, AL– March 31, 2023



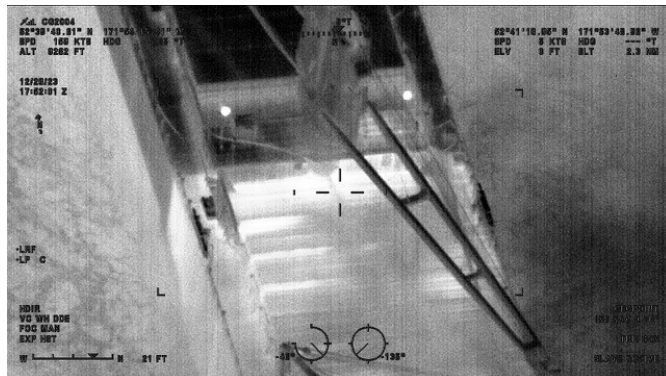


Genius Star XI, December 25, 2023

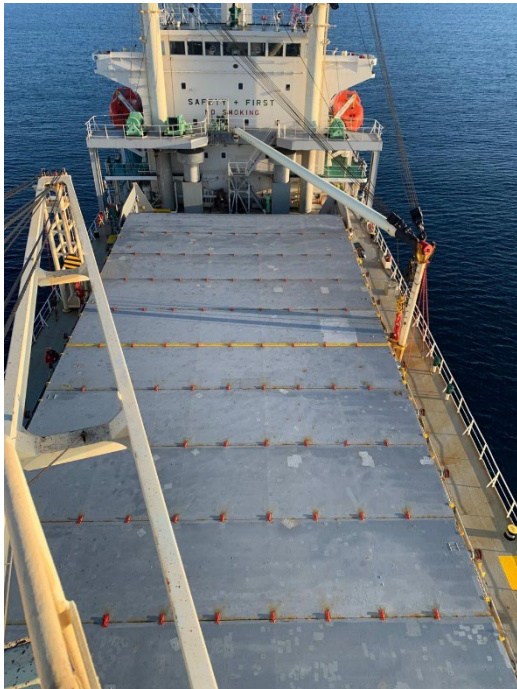
Genius Star IX



Genius Star IX



Genius Star XI



Genius Star XI



Genius Star XI



Genius Star XI



10 cells
x
3 modules
x
28 packs
x
180 stacks
=
>150k cells

Genius Star XI





M/V Magellan

M/V Magellan



M/V Magellan



M/V Magellan



Photo by Fairmont City FD Facebook

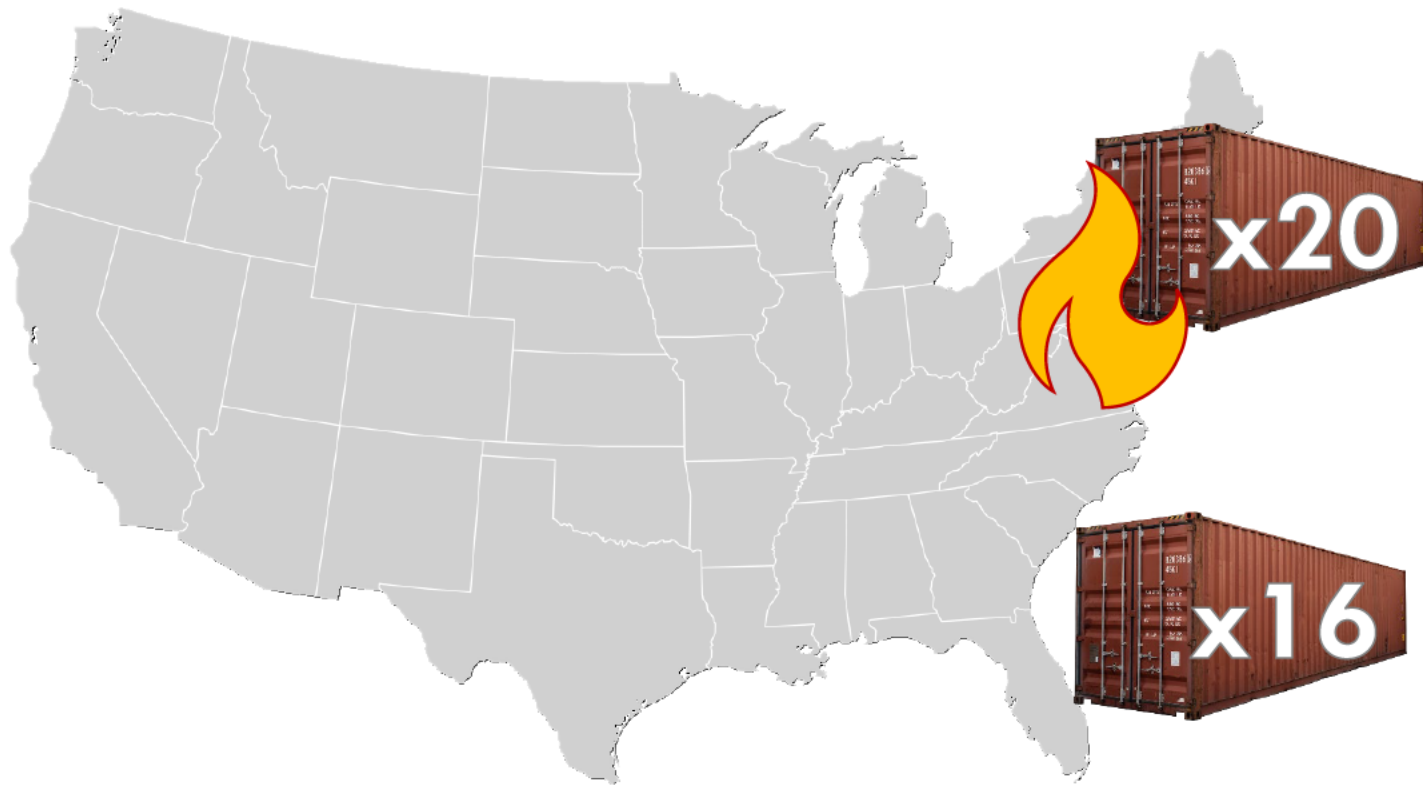
M/V Magellan



M/V Magellan



M/V Magellan



Port of Oakland Fire – May 12, 2024



Fire near Port of Oakland spreads dark smoke plume along the bay

I-75 Explosion – June 29, 2024



Interstate-15 BESS Accident— June 26, 2024



I-15 reopens after 44-hour closure, truck fire is still burning



San Pedro BESS Accident – Sept. 26, 2024



LIB Transport – Review

- ❑ Poor battery handling
 - ❑ Poor and inconsistent packaging
 - ❑ Mis-declared and mislabeled
 - ❑ Unprotected Damaged, Defective, Recalled (DDR)
 - ❑ Poor management of End-Of-Life (EOL)
 - ❑ Mixing DDR and EOL batteries
- ❑ Incidents can be new batteries, not just DDR and EOL
- ❑ Current domestic shipping regulations and SP are not fully protective and are slow/difficult to change



RISK(S) FROM LITHIUM-ION BATTERIES IN THE MARITIME ENVIRONMENT.

Objectives

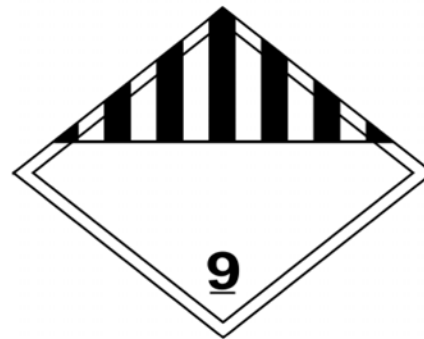


- Understand risk(s) from lithium-ion batteries of different chemistries, state of charge, and physical condition-status in the maritime environment.
- Validate plans and procedures for fire management of a hazmat fire involving lithium-ion batteries for a vessel at sea or at mooring.
- Identify plans and procedures for shore-based firefighting support aboard a vessel or at mooring/pier.
- Identify agreements to support fire management and salvage operations of a hazmat fire involving lithium-ion batteries for a vessel at sea or at mooring.

Li-ion Battery Risks-Maritime Environment



- Unpredictable chemistry
- Electric vehicles in Ro/Ro spaces
- Electric vehicles and Li-ion batteries in shipping containers
- Li-ion batteries moving by vessel under current regulations
- DDR or end-of-life Li-ion batteries moving by vessel under current regulations.
- Different presentations of Li-ion batteries in use or stored on a vessel.
- Incidents on pier or vessel
- Vessel crew may be well trained but should not be compared to the capabilities of career firefighters.
- Approved CO2 suppression systems have limited effectiveness.



§172.560

Not required for domestic transportation. A bulk packaging containing a Class 9 material must be marked with the appropriate ID number displayed on a Class 9 placard, an orange panel, or a white square-on-point display.

Li-ion Battery Risks-Maritime Environment



- Full-SOC
 - Off-gassing
 - Fire
 - Rapid propagation
 - Deflagration-detonation
- Lower-SOC
 - Off-gassing
 - Fire with ignition source
 - Rapid propagation if thermally insulted
 - Deflagration-detonation

Li-ion Battery Risks-Maritime Environment



“The Good the Bad and the Ugly”:

- **Good**-Containers Above Deck
- **Bad**-Ro/Ro Spaces
- **Ugly**-Containers Below Deck in Cargo Holds



Li-ion Battery Risks-Maritime Environment



“The Good the Bad and the Ugly”:

- **Good-Containers Above Deck**
 - Fight long-duration fire and protect exposures/superstructure from an exterior position.
 - Fire stream water runs overboard through scuppers.
 - Lowest vessel stability concerns.
 - Optimal crew access and deployment of manned/unmanned firefighting appliances.
 - Acceptance procedures and stowage location key.

Li-ion Battery Risks-Maritime Environment



“The Good the Bad and the Ugly”:

- **Bad-Ro/Ro Spaces**

- Fight long-duration fire and protect exposures/superstructure from an interior position via ladderways and confined spaces is high risk.
- Fire stream water collects at lower level of vessel/bilge and may overwhelm engineered dewatering systems.
- Vessel stability concerns if adequate dewatering is not achieved.
- High risk crew access and deployment of manned/unmanned firefighting appliances.
- Acceptance procedures and stowage spacing for crew access is critical.

Li-ion Battery Risks-Maritime Environment



“The Good the Bad and the Ugly”:

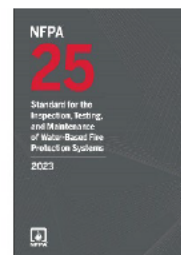
- **Ugly-Containers Below Deck in Cargo Holds**
 - Fight long-duration fire and protect exposures/superstructure from an interior position via ladderways and confined spaces is high risk.
 - Fire stream water collects at lower level of vessel/bilge and may overwhelm engineered dewatering systems.
 - Vessel stability concerns if adequate dewatering is not achieved.
 - High risk crew access and deployment of manned/unmanned firefighting appliances.
 - Acceptance procedures are critical.

Li-ion Battery Risks-Maritime Environment



Critical Factors (influenced by VRP and FCP:

- Confined space hazmat fire!
- Hazmat involved or an exposure
- Orientation and personnel accountability
- Fuel and power secured or isolated
- Ventilation profiles and system status
- Communications (operability of radios below deck)
- Fire Stations Locations
- Fire equipment/appliance compatibility and capabilities
- GPM over BTUs (International Shore Connection)
- Gangway
- Bulkheads
- Hatches
- Ladderways (NFPA 101 Life Safety Code; NFPA 25)
- Orientation to ingress egress paths
- Fixed fire suppression system status/activation
- Dewatering (Vessel fixed systems and portable systems)
- Air supply management
- Entrapment and entanglement hazards
- Smoke explosions (gas deflagration detonation phenomena)
- Resources, staging, logistics, work rest cycles



Li-ion Battery Risks-Maritime Environment



USS Bonhomme Richard (LDH-6) was a Wasp-class amphibious assault ship of the United States Navy commissioned on 15 August 1998:

- Third ship of the U.S. Navy to bear the name given by John Paul Jones to his Continental Navy frigate, named in French “Good Man Richard” in honor of Founding Father Benjamin Franklin, the publisher of Poor Richard’s Almanac who at the time served as U.S. Ambassador to France.
- **Ironically, Benjamin Franklin was also...**
- On 12 July 2020 fire started on lower vehicle-storage deck while the ship was undergoing maintenance at Naval Base San Diego.
- It took four days to extinguish the fire.
- At least 63 sailors and civilians were injured.
- The ship was severely damaged at cost of \$3.2 billion and 7 years to repair so the ship was decommissioned and sold for scrap.
- The fire investigation revealed arson, but the sailor was acquitted at trial; Li-ion batteries were found at AOO and ruled out as cause but their presence may have influenced decision...
- **Firefighter safety and risk analysis for a ship with no life hazard...**

Figure 15 shows BONHOMME RICHARD burning in the evening on 12 July 2020

Li-ion Battery Risks-Maritime Environment



Informational Summary Report of Serious or Near Serious Injuries, Illnesses and Accidents



GREEN SHEET

San Diego Fire-Rescue Department

Firefighter Injury / "Pier" Incident FS20098410

Sunday, July 12, 2020

Li-ion Battery Risks-Maritime Environment



Shipboard Firefighting Challenges - USS Bonhomme Richard

- Lack of communications between agencies other than face to face
- Unknown burn time
- Unfamiliar layout and unknown location of fire
- Smoke may travel long distances before exiting. Visualizing smoke may not help in locating the fire.
- Large spaces that may be open or compartmentalized
- Unknown amount of resources already at scene
- Unfamiliar accountability system in place (different agency)
- Unknown incident objectives prior to arrival
- Unable to make contact with or locate person coordinating attack (operations)
- Multiple possible entry points
- Unknown status of ship fire protection system. On scene personnel may or may not know status or operation considerations
- Unknown capacity of water supply on pier
- First engine on scene from a different agency. Pumping multiple lines. No radio communication with pump operator.
- Direct channel usage – may need radio relays
- Personnel in staging on the pier eager to work and crowding the entry point
- Difficulty coordinating fire attack efforts with efforts already in progress
- Compressed time – easy to lose track of elapsed incident time
- Conflicting reports on whether evacuations have been completed. Ship crew accountability challenges.
- Extreme heat and smoke. High potential for injuries and equipment damage.
- Ship construction presents challenges in adjacent compartments due to radiant and/or conductive heating
- Crowded incident command post. Difficult to hear radio traffic and determine who has valuable input or information.



VALIDATE PLANS AND PROCEDURES
FOR FIRE MANAGEMENT OF A
HAZMAT FIRE INVOLVING LITHIUM-
ION BATTERIES FOR A VESSEL AT SEA
OR AT MOORING.



IDENTIFY PLANS AND PROCEDURES
FOR SHORE-BASED FIREFIGHTING
SUPPORT ABOARD A VESSEL OR AT
MOORING.



Plans and Procedures

■ **Federal On-Scene Coordinators (FOSC):**

- Outlined under:
 - National Oil and Hazardous Substances Pollution Contingency Plan (NCP, 40 CFR Section 300)
 - Comprehensive Environmental Response, Compensation, and Liability Act. of 1980 (CERCLA).
- The federal incident commander during an emergency response.
- Highly skilled personnel who conduct, direct, and coordinate emergency response actions as needed; taking necessary actions consistent with federal law to remove a pollution or contamination threat.
- EPA and USCG are the primary agencies that coordinate NCP preparedness and response activities and provide FOSC.
- Other agencies (Dept. of Energy (DOE), Dept. of Defense (DoD)) may have FOSC dependent on the incident and their roles and authorities.



Plans and Procedures

■ **Federal On-Scene Coordinators (FOSC):**

- Are located in and deploy from EPA regional offices and USCG Sectors across the nation.
- Have the authority to conduct, direct, and coordinate all response efforts at the incident scene
- Protect the environment, public health, and worker safety and health.
- Are responsible for developing Area Contingency Plans (ACPs) and chairing Area Committees.



Plans and Procedures

■ **Federal On-Scene Coordinators (FOSC):**

- EPA is the lead for inland zone which may include some tributaries and bodies of water.
 - Approximately 230 pre-designated FOSC
 - EPA may assist USCG with special mission aspects such as hazmat operations, technical hazmat expertise, and air monitoring.
- USCG is the lead for Coastal Zone
 - 36 pre-designated USCG FOSC
- When AOR is a question, the agency with the greatest impact in the AOR per the NCP and ACP will take the lead.
- Regardless of AOR lead and as needed, FOSC for both EPA and USCG work collaboratively in support of mission objectives and outcomes.



Plans and Procedures

- United States Coast Guard:

- Title 33, CFR

- Chapter 1, Subchapter A, Part 6: Protection and Security of Vessels, Harbors, and Waterfront Facilities
 - Broad powers of the COTP
 - Part 155, Subpart I- Salvage and Marine Firefighting
 - Part 155, Subpart D- Response Plans
 - USCG Salvage Engineering Response Team (SERT)-Technical Support to USCG units during a vessel casualty
 - Classification Societies; Commercial Naval Architecture; Salvage and Emergency Response Firms

- Title 40, CFR

- Part 300- National Oil and Hazardous Substances Pollution Contingency Plan



Plans and Procedures

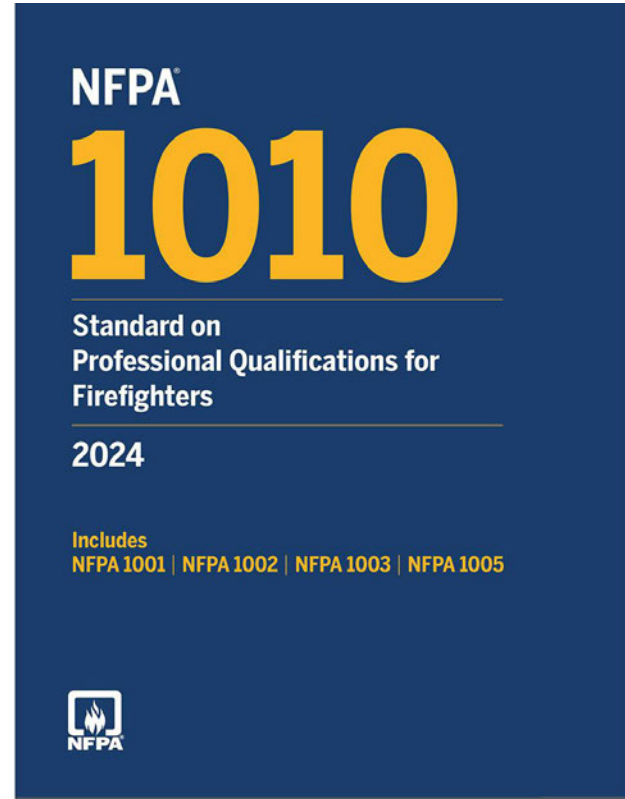
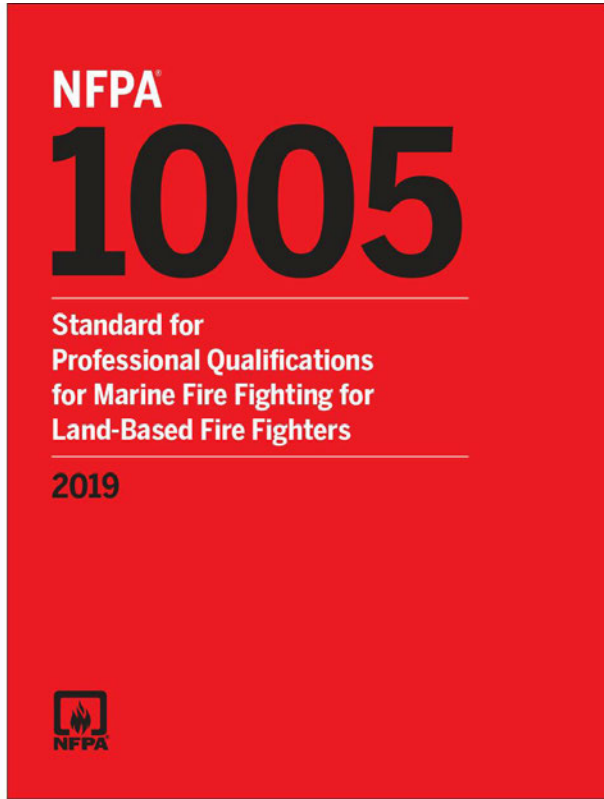
Salvage and Emergency Response Firms:

- Regulatory compliant and customer specific:
 - Contingency Plans
 - Emergency Response Plans or Vessel Response Plans (VRP)
 - Security Plans
- Incident management and emergency response

Classification Societies:

- Goal: protection of human lives, property, and marine and coastal environments
- Develops and sets specific standard regarding vessel/ship:
 - Design
 - Building
 - Functional Maintenance

Plans and Procedures (National Consensus Standards)



Plans and Procedures (National Consensus Standards)



NFPA[®]

1405

Guide for
Land-Based Fire Departments That
Respond to Marine Vessel Fires

2020



Plans and Procedures (National Consensus Standards)



NFPA

307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E	Marine Firefighting Onboard Vessels Within Municipal Jurisdictions	307- 28
----------------	---	----------------

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- Informs marine firefighters (MFF) that vessel owner-operators must meet with the groups contained within the scope of their vessel response plans (VRP).
- Federal Fire Prevention and Control Act of 1974 (PL93-498)
 - firefighting should remain a state and local function
 - U.S. federal government must help if significant fire losses are to be achieved

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- The basis for USCG firefighting activities and assistance for fires aboard commercial vessels in the U.S. is articulated in the following:
 - Ports and Waterways Safety Act of 1972 (PWSA)
 - Section 4202 of the Oil Pollution Act of 1990 (OPA 90)
 - 14 U.S.C 88(b).
- Although the USCG clearly has an interest and functions in marine firefighting (MFF) involving vessels, primary responsibility for maintaining necessary firefighting capabilities in U.S. ports and harbors lies with local authorities.

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307- 28

- Individual public/municipal authorities responsible to provide and maintain the necessary firefighting capabilities within U.S. ports and harbors have different policies for responding to marine fires:
 - Most will respond only at the pier
 - Some will not go aboard a vessel

Plans and Procedures (National Consensus Standards)



NFPA
307
Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves
2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307- 28

- Vessel Response Plan (VRP) holders (Carriers & Masters) are ultimately responsible for the safety of the vessel under their control, which includes:
 - Providing adequate firefighting protection, per 33 CFR 155.
 - Initiating response activities per the VRP:
 - Initiate fire control plan
 - Notifications including to the qualified individual (QI)
 - Description of shoreside activities for vessel fire response.

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307- 28

- **The Qualified Individual (QI):**
 - Standing contract with VRP holders to provide continuous response services during marine casualties.
 - Familiar with implementation of VRP
 - Provides rapid communications with authorities
 - Engages response resources
 - Commits funds on behalf of plan holder (\$ amount should be practicable)
 - Will conduct other notifications on behalf of vessel master and during a vessel fire, will notify the salvage and marine firefighting (SMFF) service provider listed in the VRP

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307- 28

- **The Salvage and Marine Firefighting (SMFF) Service Provider:**
 - External MFF team made up of trained personnel, aside from vessel crew, with capability of boarding and combating a fire aboard a vessel.
 - Brings external vessel MFF systems, personnel, equipment capable of combating a fire from other than aboard the vessel, as well as other needed support.
 - VRP holder must ensure that all SMFF resource providers are integrated into the the response organizations listed in the VRP and how they will coordinate with the same.
 - Currently four SMFF providers nationwide that meet the USCG regulatory standards of 15 selection criteria and 19 services.

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- **Public Firefighting Resources:**
 - Public MFF agencies can be listed as resource providers by agreeing in writing to be included in the VRP.
 - Many choose to respond within or outside their jurisdiction through means such as mutual-aid, but federal law or regulation does not suggest support-encourage response outside their jurisdictions.
 - Should the public MFFs and plan holder come to an acceptable agreement regarding when and where the public resource(s) can be used beyond jurisdictional limits, then that agreement must be included in the VRP.
 - Oil Pollution Act of 1990 (OPA 90) emphasizes the use of private over public resources, public MFF resource providers should only be listed when the plan holder has determined no private resources are available that can meet the response times and the public resource has a responsibility to respond to incidents in the area specified in the VRP.

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- **Public Firefighting Resources:**
 - Each VRP holder and resource should be actively involved in the port partners program(s) (e.g., AMSC, Los Angeles-Long Beach Area Contingency Plan (ACP), etc.) to enable communications between the resource provider and the local public firefighters and to have input into their locations area contingency plans (ACP) for emergencies and to create workable processes and VRPs for responding to a marine firefighting incident.

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307- 28

- **Initial Response to MFF:**
 - 26 questions asked by SMFF service providers during initial phases of MFF operations

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- **Movement of a Burning Vessel:**
 - The decision to allow a burning vessel to be moved within a port rests solely with the USCG under authorities granted by the Ports and Waterways Safety Act of 1972 (PWSA) and implemented in 33 CFR 160
 - Considerations and criteria for allowing and denying movement of a burning vessel

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- **Drills and Exercises** (Clear understanding of each participant's role):
 - Remote assessment and consultation exercises.
 - Quarterly emergency procedures exercises.
 - Annual Shore-based salvage and shore-based MFF management team tabletop exercises.
 - Annual response provider equipment deployment exercises.
 - Triennial exercise of the entire VRP (compliance with the National Preparedness for Response Exercise Program Guidelines (NPREP) will satisfy VRP exercise requirements).
 - Plan holders must meet exercise requirements within 33 CFR 155.4052

Plans and Procedures (National Consensus Standards)



NFPA®

1405

Guide for
Land-Based Fire Departments That
Respond to Marine Vessel Fires

2020

NFPA

307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels
Within Municipal Jurisdictions

307-28

Preincident Information and Arrangements:

- Plan holders required to develop prefire plans in accordance with NFPA 1405 and attached to the VRP.
- If plan meets another regulation or recognized international standard it must also be given to the resource provider in lieu of the 1405 plan and attached to the VRP.
- Integral part of contingency planning.
- Outlines the responsibilities and actions during a marine fire incident.
- Principle purpose is to explain the resource provider's role, and support that can be provided, during MFF incidents.
- Policies, responsibilities, and procedures for coordination of on-scene forces
- Should be designed for use in conjunction with other state, regional, and local contingency and resource mobilization plans.
- The SMFF resource provider must also be given prefire plans and certify in writing to the plan holder that it is acceptable and agrees to implement it to mitigate a potential or actual fire.

Plans and Procedures (National Consensus Standards)



NFPA 307

Standard for the
Construction and Fire Protection
of Marine Terminals, Piers,
and Wharves

2021



Annex E Marine Firefighting Onboard Vessels Within Municipal Jurisdictions 307– 28

- **9 Recommendations for Owners/Operators and Managers of Marine Terminals, Piers, and Wharves that generally advise on:**
 - Communications
 - Considerations
 - Engagement
 - Coordination
 - Plans
 - Agreements
 - Exercises
 - Participation
 - Product development

Plans and Procedures (National Consensus Standards)



Marine Fire Fighting for Land-Based Fire Fighters



Marine Fire Fighting for Land-Based Fire Fighters Course Plan



IDENTIFY AGREEMENTS TO SUPPORT FIRE
MANAGEMENT AND SALVAGE OPERATIONS OF A
HAZMAT FIRE INVOLVING LITHIUM-ION BATTERIES
FOR A VESSEL AT SEA OR AT MOORING.

Agreements to Support Fire Management and Salvage Operations



- **The Salvage and Marine Firefighting (SMFF) Service Provider:**
 - In place?
 - In process of development or update?

- **Public Firefighting Resources:**
 - In place?
 - In process of development or update?

- **Other:**
 - In place?
 - In process of development or update?

How to contact EPA



☐ **Direct line - 24-hour Duty Officer:
800-300-2193**

☐ **National Response Center:
800-424-8802**

Today's Course Material



□ Link: response.epa.gov/SoCalPortsLIBTTX

THANK YOU!
QUESTIONS???