LITHIUM-ION BATTERY CASE STUDIES, CHALLENGES AND LESSONS LEARNED

Tu-l1

3/25/25

Leon Wirschem, County of San Diego DEHQ-HIRT,
Rob Rezende, SDFD SD AEER Regional Coordinator,
Noelle Wondergem and Brian Abeel, DTSC ER,
Chris Myers, EPA R9 OSC & Greg Jenkins, EPA Contract Support/LIB SME,
Summer Hernandez & Justin Bechara, OCEH ER

27th California Unified Program
Annual Training Conference
March 24-27, 2025

Today's Agenda

- Wildfires & LIBs
- BESS Incidents
- Large E-Bike Facility Incident
- Air Monitoring & Lessons Learned

(2024 SD HIRT/EPA/Bomb Arson Study)

Disclaimer

- This group has a significant amount of experience dealing with lithium-ion battery emergencies. This presentation is not intended to discourage the use or pursuit of alternative energy including Lithium-Ion Batteries. It is intended to educate and help prepare responders and other stakeholders for the challenges they currently face. Each agency will speak to their knowledge and experience and are not attempting to speak for other agencies. There have been many lessons learned, however we are making no claims of how to handle LIB emergencies. They remain a case-by-case basis requiring risk analysis for each situation.

QUESTIONS

- You will have them!
- We want to help answer them if possible.
- In the interest of time, the instructor may ask you to hold off until the end of their presentation.
- During breaks instructors will be available for the more individual questions.

2025 LA Wildfires Battery Mission

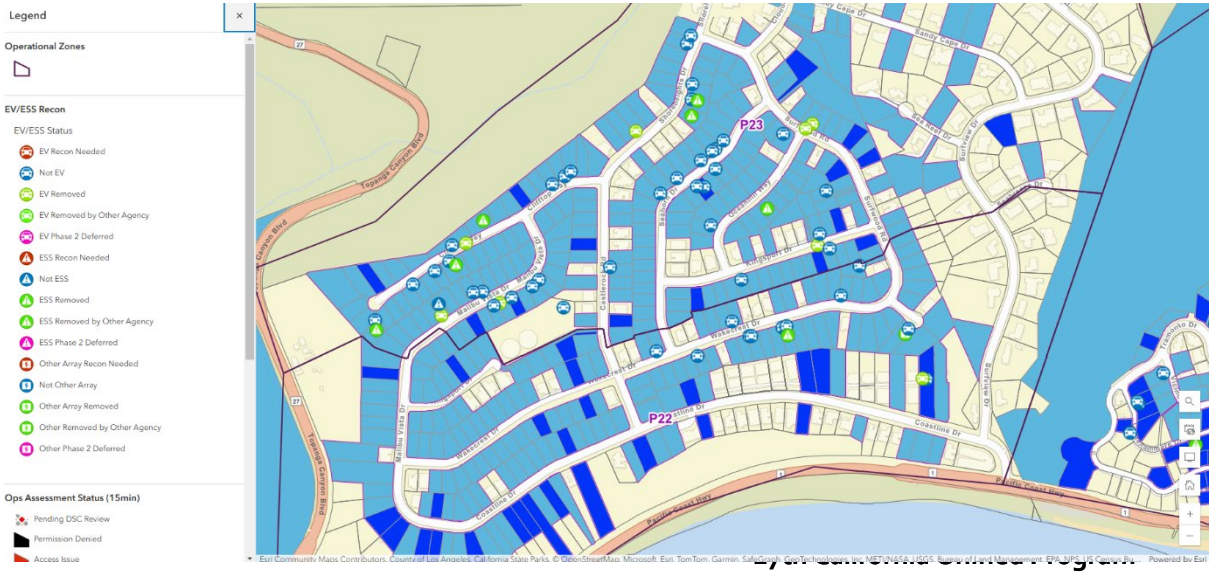
Christopher Myers
On-Scene Coordinator
USEPA Region 9

Overview

- Reconnaissance
- Recovery
- Treatment and Disposal

Reconnaissance

- Administrative
- Partner Agency
- Manual




Legend
Operational Zones
EV/ESS Recon
EV/ESS Status
EV Recon Needed
Not EV
EV Removed
EV Removed by Other Agency
EV Phase 2 Deferred
ESS Recon Needed
Not ESS
ESS Removed
ESS Removed by Other Agency
ESS Phase 2 Deferred
Other Array Recon Needed
Not Other Array
Other Array Removed
Other Removed by Other Agency
Other Phase 2 Deferred
DINS (Eaton)
Damage Categories
Destroyed (>50%)
Major (26-50%)
E04
E05
E07
E08
E09
E10
E11
E12
E13
E14
E15
E16
E17
Esri Community Maps Contributors, City of Pasadena, CA, County of Los Angeles, California State Parks, © OpenStreetMap, Microsoft, Esri, TomTom, Garmin, SafeGraph, GeoTechnologies, Inc, METI/NASA, USGS, Bureau of Land Management, EP...
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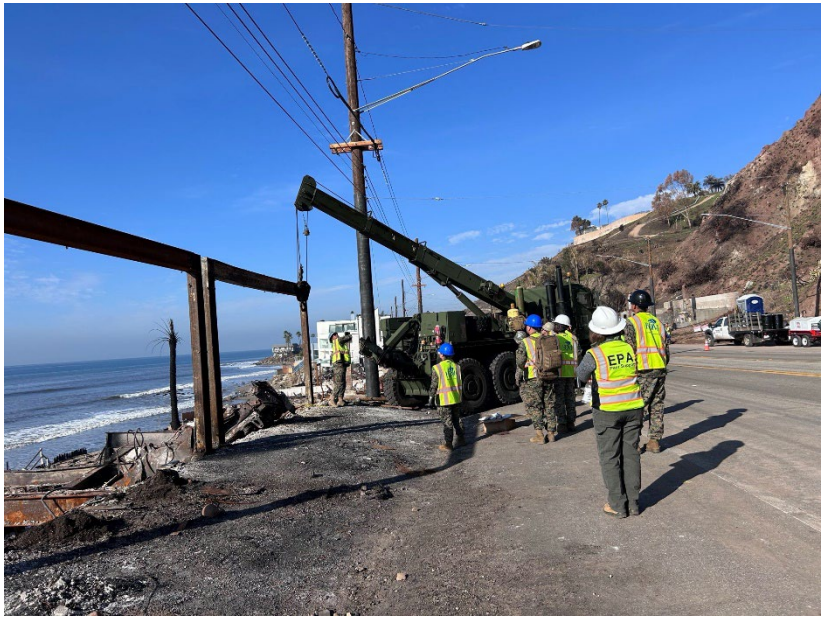
Recovery


EPA

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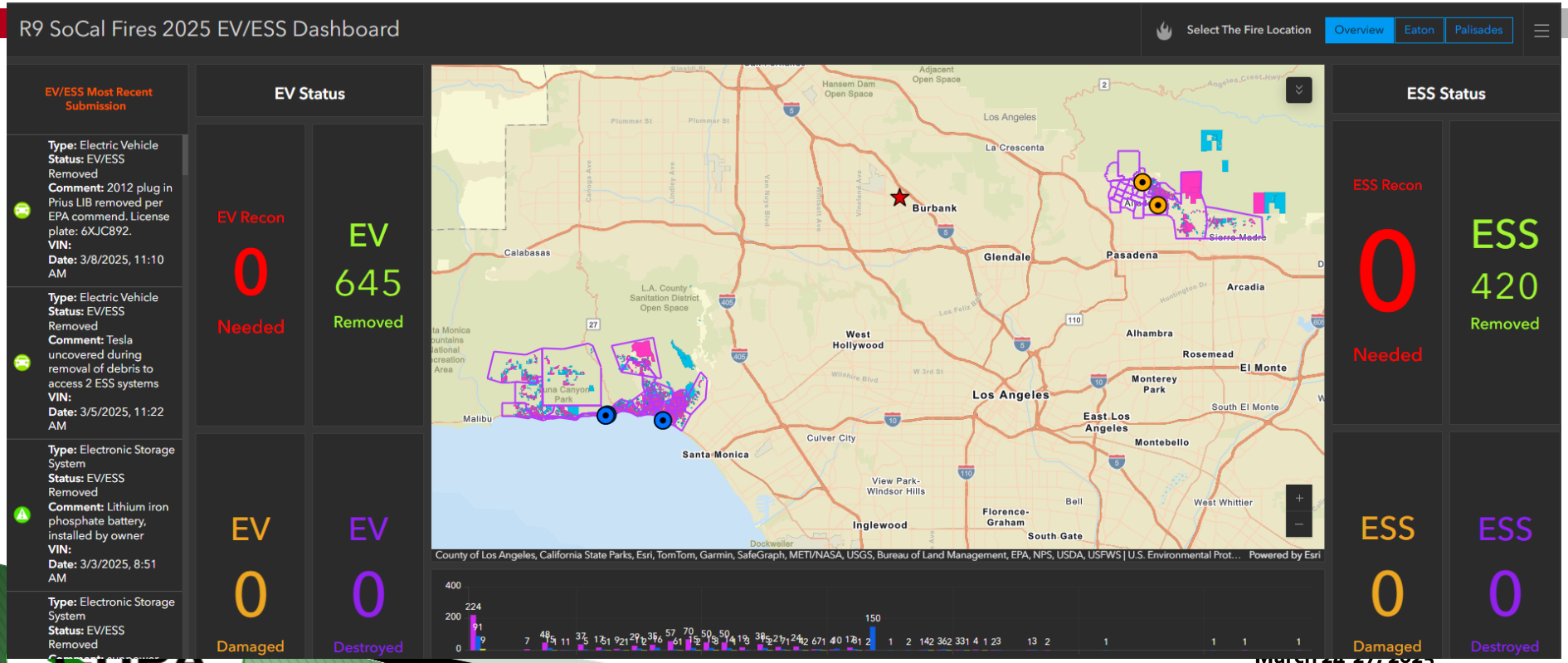
Treatment and Disposal

- On-Site Shredding
- Bulk Packaging


TL12V2
TAKEUCHI
United Rentals


CleanHarb


R9 SoCal Fires 2025 EV/ESS Dashboard
Select The Fire Location
Overview
Eaton
Palisades
EV/ESS Most Recent Submission
Type: Electric Vehicle
Status: EV/ESS Removed
Comment: 2012 plug in Prius LIB removed per EPA commend. License plate: 6XJC892.
VIN:
Date: 3/8/2025, 11:10 AM
Type: Electric Vehicle
Status: EV/ESS Removed
Comment: Tesla uncovered during removal of debris to access 2 ESS systems
VIN:
Date: 3/5/2025, 11:22 AM
Type: Electronic Storage System
Status: EV/ESS Removed
Comment: Lithium iron phosphate battery, installed by owner
VIN:
Date: 3/3/2025, 8:51 AM
Type: Electronic Storage System
Status: EV/ESS Removed
EV Status
EV Recon
0
Needed
EV
645
Removed
EV
0
Damaged
EV
0
Destroyed
Burbank
Glendale
Pasadena
Los Angeles
Santa Monica
Malibu
Culver City
Inglewood
West Hollywood
Alhambra
Arcadia
Rosemead
El Monte
Monterey Park
East Los Angeles
Montebello
South El Monte
Florence-Graham
South Gate
West Whittier
Bell
Calabasas
La Crescenta
Sierra Madre
Hansem Dam Open Space
L.A. County Sanitation District Open Space
View Park-Windsor Hills
County of Los Angeles, California State Parks, Esri, TomTom, Garmin, SafeGraph, METI/NASA, USGS, Bureau of Land Management, EPA, NPS, USDA, USFWS | U.S. Environmental Prot... Powered by Esri
ESS Status
ESS Recon
0
Needed
ESS
420
Removed
ESS
0
Damaged
ESS
0
Destroyed

Thank You

https://www.epa.gov/california-wildfires

myers.christopher@epa.gov

562-305-1225

Li-Ion Batteries from Wildfire

Presented by Noelle A. Wondergem & Brian ^beel

Department of Toxic Substances Control

CalEPA California Environmental Protection Agency

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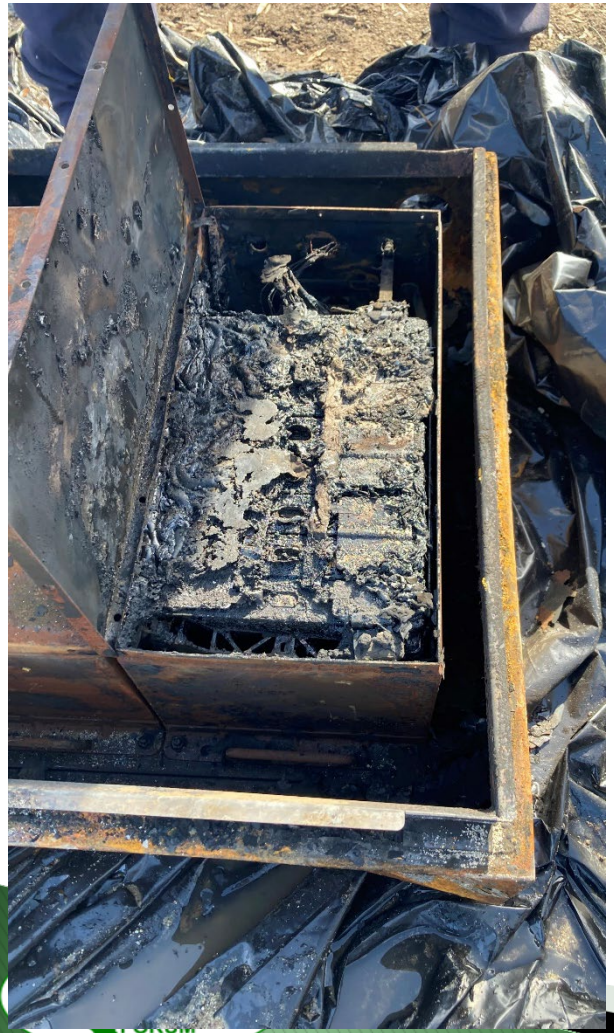
Loose Batteries

Packaged/Left On-Site for Later Pickup

Energy Storage System (ESS)



Vehicles from Fires

Transport to Staging











Storage at Staging Areas

Staging Area

Repackaging for Shipment

Other Incidents and When to Call Us

Questions?

- Noelle A. Wondergem

  Senior Environmental Scientist (Specialist)

  Emergency Response Unit, San Diego, DTSC

  Noelle.Wondergem@dtsc.ca.gov
- Brian Abeel

  Senior Environmental Scientist (Specialist)

  Emergency Response Unit, Cal Center, DTSC

  Brian.Abeel@dtsc.ca.gov

Call (800) 260-3972 for assistance

BREAK TIME!

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CAL FIRE
195.1°F
2 ×
FFC
IR
BATTERY STORAGE FIRE FLARES UP FOR SIXTH DAY
OTAY MESA
FOX 5
10:16 | 62°
OF GAS IN SAN DIEGO COUNTY IS $5.19 A GALLON
FOX 5
FEDERAL JUD
HEADLINES
NEXT: N/A

GATEWAY BATTERY ENERGY STORAGE SYSTEM
OTAY MESA, CA (SAN DIEGO)

Example BESS Frame

CAMINO INCIDENT SITE

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Initial Signs of Smoke

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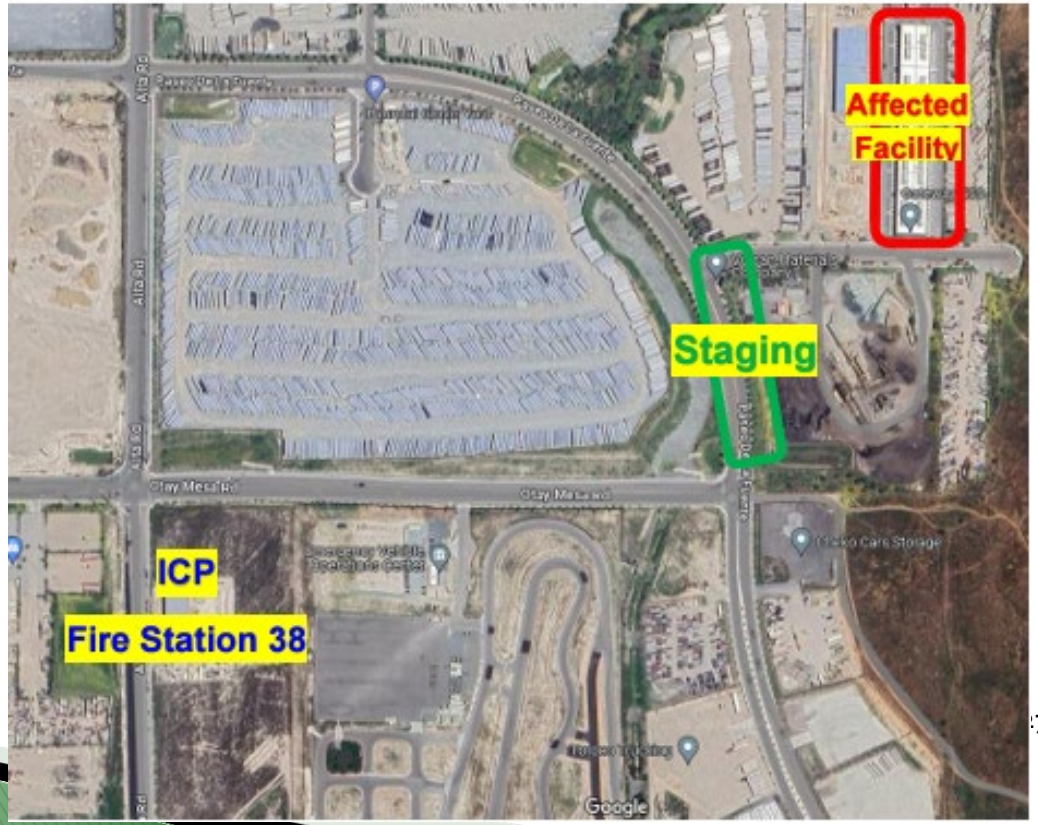
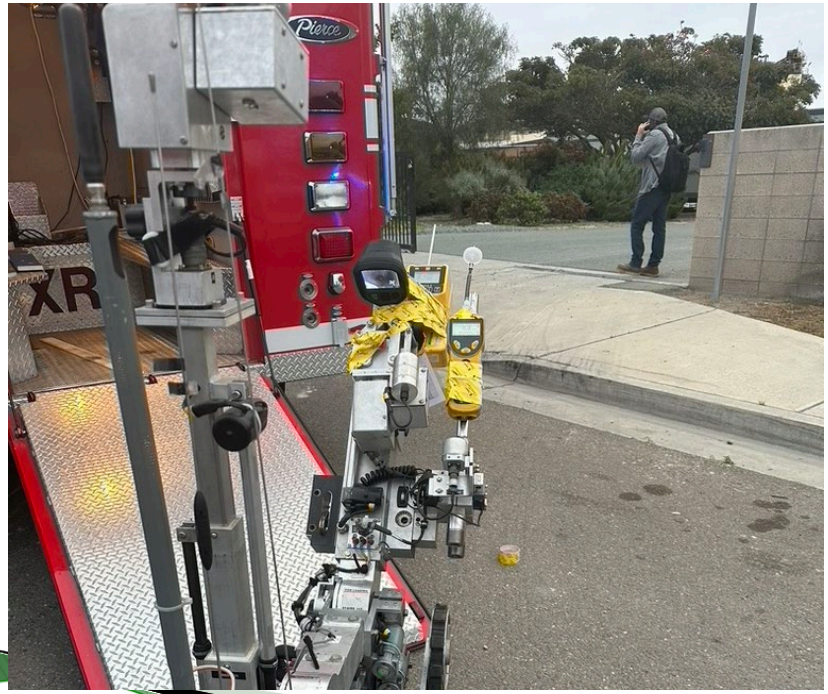
INCIDENT AREA



Full alarm + Specialty Units

4 Engines, 2 Trucks, 2 Battalion Chiefs, Hazmat, Bomb Squad, Ambulance

Robots



Hazmat Operations

Air monitoring
Made entry
Continuous area monitoring
Water runoff testing
EPA coordination
Private contractor coordination


3
4


57%
64%
DS
0:21:25
2 ×
ISO
FFC
FPV
CURRENT: Manual operation
360°
40°
632.9 FT
143°
WIND
9.8
MPH
NEXT: N/A
SPEED
HRZ
0.0 MPH
AGL 170 FT
HAT 163 FT


CAL FIRE
3353


82%
86%
BP
0:21:47
273.2°F | 46.4°F • 58.6°F
1x
FFC
IR
MAV
46.4°F
273.2°F
MAP
CURRENT: Manual operation
NEXT: N/A
4°
36°
461.9 FT
88°
SPEED
HEIGHT
HRZ
0.0 MPH
AGL
239.8 FT
VRT
0.0 MPH
HAT
GIMBAL ANGLES
DRONE/HOME DIST

OFFICIAL NOTICE

Site Investigation for a Fire Response

On 5/15/2024, the Hazardous Incident Response Team (HIRT) responded at the request of CalFire to conduct environmental monitoring and assist in mitigation of hazards associated with a lithium ion battery fire at this location. A worker heard a "water flow alarm", observed light smoke and saw sprinkler water coming from Building 3 and phoned 911.

One of 5 adjacent buildings, Building 3, was experiencing a fire in one of its 12,000 batteries. The sprinklers, with support from fire personnel, were operating at 300 gallons per minute in an attempt to keep the fire from propagating. A CalOES report was made (Control #24-2793) as water was running off site into the storm water conveyance system and into unlined retention ponds.

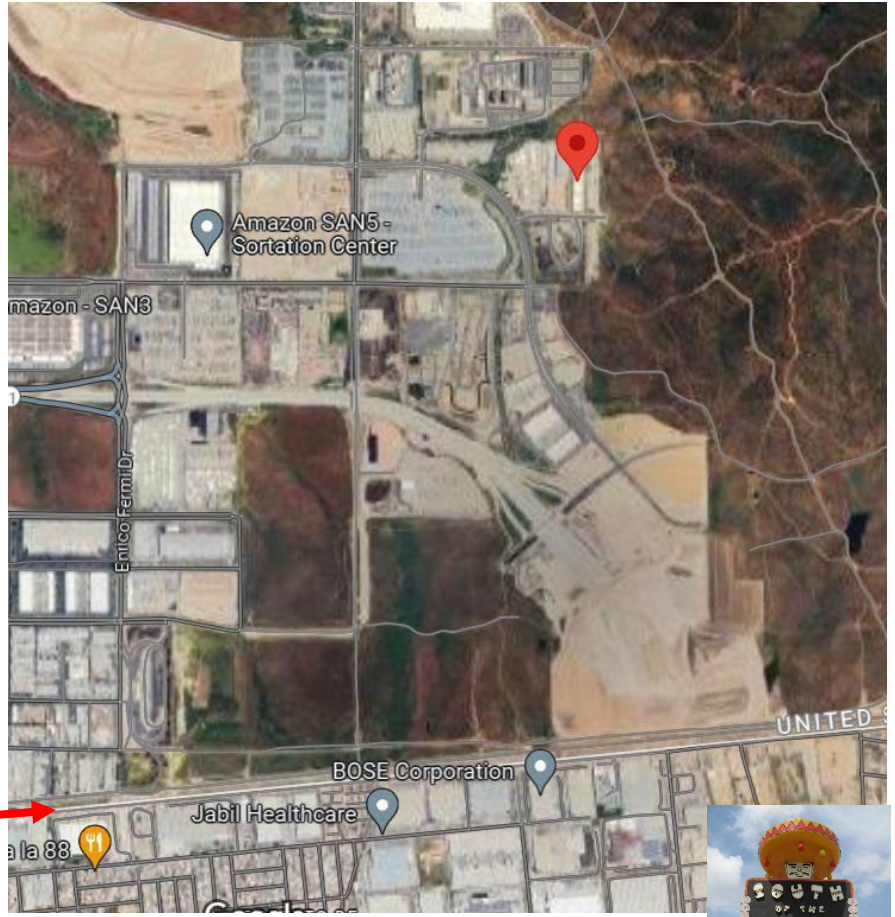
Contact was made at the incident command post with Brent Yatman, Asset Manager, Nick Shobey, Environmental Manager, and Greg Johnson, Site Manager, of Rev Renewables.

Action Items:

- As discussed at the incident command post, continue to minimize runoff, and properly characterize any waste generated. Be prepared to provide results of waste and runoff characterization as requested.

- Continue to work with the incident command to provide perimeter air monitoring and provide air monitoring to ensure safety of any personnel that need to enter the facility on behalf of the business.

US/Mexico Border



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Enviro-Chem, Inc. Laboratories
1214 E. Lexington Avenue,
Pomona, CA 91766
Tel: (909) 590-5905 Fax: (909) 590-5907
CA-DHS ELAP CERTIFICATE #1555

RUSH

Turnaround Time
- ✓ Same Day
- 0 24 Hours
- 0 48 Hours
- 0 72 Hours
- 0 1 Week (Standard)
- Other:

Fri morning

Misc./PO# Patriot Job # 1445

SAMPLE ID	LAB ID	SAMPLING DATE	SAMPLING TIME	MATRIX	No. OF CONTAINERS	TEMPERATURE	PRESERVATION	Title 22 Metals + Lead + Titanium	VOC's	Oil & Grease	PH	TPH	Analysis Required	COMMENTS
Site # 1	240516-14	5/16/24	0800	L.	3	800 mL jar	ice	✓	✓	✓	✓	✓		
Site # 2	-15	"	0812	"	3		"	"	"	"	"	"		
Site # 3	-16	"	0817	"	3		"	"	"	"	"	"		
Site # 4	-17	"	0824	"	3		"	"	"	"	"	"		

Company Name: Patriot Environmental Services
Address: 197 Vernon Way
City/State/Zip: El Cajon CA 92020

Project Contact: Jason Reed
Jreed@patriotenv.com
Tel: 562-244-5599
Fax/Email: jreed@patriotenv.com

Sampler's Signature:

Project Name/ID: REV Renewable fire water
641 Camino De La Fuente,
San Diego CA 92154

Relinquished by: Jason Reed	Received by:	Date & Time: 5/16/24 1pm
Relinquished by:	Received by:	Date & Time:
Relinquished by:	Received by:	Date & Time:

Instructions for Sample Storage After Analysis:
O Dispose of O Return to Client ✓ Store (30 Days)
O Other:

CHAIN OF CUSTODY RECORD

Date: 5/16/24

WHITE WITH SAMPLE - YELLOW TO CLIENT

Page 1 of 1

SAMPLE I.D.: **Site #2** LAB I.D.: 240516-15

TOTAL THRESHOLD LIMIT CONCENTRATION (TTLC) ANALYSIS
UNIT: mg/Kg = MILLIGRAM PER KILOGRAM = PPM

ELEMENT ANALYZED	SAMPLE RESULT	PQL	DF	TTLC LIMIT	STLC LIMIT	EPA METHOD
Antimony(Sb)	ND	0.02	1	500	15	6010B
Arsenic(As)	ND	0.01	1	500	5.0	6010B
Barium(Ba)	0.104	0.1	1	10,000	100	6010B
Beryllium(Be)	ND	0.01	1	75	0.75	6010B
Cadmium(Cd)	ND	0.01	1	100	1.0	6010B
Chromium(Cr)Total	ND	0.01	1	2,500	560/5@	6010B
Chromium VI (Cr6)	--	0.10	-	500	5.0	7196A
Cobalt(Co)	0.283	0.02	1	8,000	80	6010B
Copper(Cu)	0.084	0.02	1	2,500	25	6010B
Lead(Pb)	ND	0.01	1	1,000	5.0	6010B
Mercury(Hg)	ND	0.0005	1	20	0.2	7470A
Molybdenum(Mo)	ND	0.1	1	3,500	350	6010B
Nickel(Ni)	0.299	0.05	1	2,000	20	6010B
Selenium(Se)	ND	0.02	1	100	1.0	6010B
Silver(Ag)	ND	0.02	1	500	5.0	6010B
Thallium(Tl)	ND	0.02	1	700	7.0	6010B
Tin(Sn)	ND	0.10	1	---	---	6010B
Titanium(Ti)	ND	0.05	1	---	---	6010B
Vanadium(V)	ND	0.1	1	2,400	24	6010B
Zinc(Zn)	1.13	0.01	1	5,000	250	6010B

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION IX
75 Hawthorne Street
San Francisco, CA 94105

Notice of Federal Response Action

Issued to: Gateway Energy Storage, LLC Date: 05/22/2024

Location: 641 Camino De La Fuente, San Diego, CA 92154

The U.S. Environmental Protection Agency (EPA) has been informed of a release or threatened release of hazardous substances, pollutants, or contaminants into the environment at the Camino Incident site, located at 641 Camino De La Fuente, San Diego, CA 92154 (the site).

Under the authority of the National Contingency Plan (NCP), 40 CFR Part 300, and the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended, 42 U.S.C. Section 9601, et seq., EPA evaluates whether responsible parties or other agencies are properly responding to such releases.

This site is within the jurisdiction of EPA and the EPA On-Scene Coordinator (OSC) is charged with coordinating, directing, and reviewing the work of responders to ensure compliance with the NCP. The OSC for this site is Robert Wise.

Responsible parties generally include the current or former operator and/or owner of the site and persons who generated or were involved in the transportation, management, or disposal of the materials at the site. Before EPA initiates a response, potentially responsible parties, where practicable, are offered the opportunity to conduct the response. If the responsible party decides

NFRA Requirements

- Immediately implement an air surveillance program.
- The instrumentation must run 24-hours per day and have full telemetry.
- The data must be able to be visualized in the command post to the Unified Command.
- must include at a minimum NIOSH Method 7300 for metals, percent Oxygen, Lower Explosive Limit, total Volatile Organic Compounds (VOCs), Carbon Monoxide, Hydrogen Cyanide and Hydrogen Fluoride
- Immediately implement a sampling program of fire suppression runoff if firefighting suppression water is migrating off-site
- Maintain a Health and Safety Plan (HASP) that meets the requirements pursuant 29 CFR 1910.120(b)(4)
- Maintain a Quality Assurance Project Plan for the air surveillance and water sampling activities.

NFRA Requirements (partial list)

- Maintain site security and restrict site access to the CRZ, EZ and SPZ.
- Prevent all discharges of hazardous substances from site. This includes any fire suppression water that fail the action levels. Flow of fire suppression water should be prevented from entering Mexico.
- Maintain a Work Plan detailing the dismantling of the structural components necessary to gain access to the building for firefighting operations or removal of hazardous materials. The Work Plan should also address the demolition of all Damaged, Defective and Recalled (DDR) battery packs/racks impacted by fire or water damaged, as well as the proper packaging, shipment, and disposal of all DDR batteries and other CERCLA hazardous substances on-site


901


3
DANGER

CALIFORNIA CUPA FORUM

ied Program
Conference
2025

CALIFORNIA CUPA FORUM

ied Program
Conference
2025


3

March 2025

Roof removed, Battery racks wrapped to prevent rain impacts

Processing Area

Staging, Assess voltages, remove battery cases

LG Batteries

Samsung Batteries

Crates, Bi ith bung vent

Bung Vent

Program
erence
March 24-27, 2025

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4D/X118/S/24/USA/M6770

Largest BESS, Monterrey County

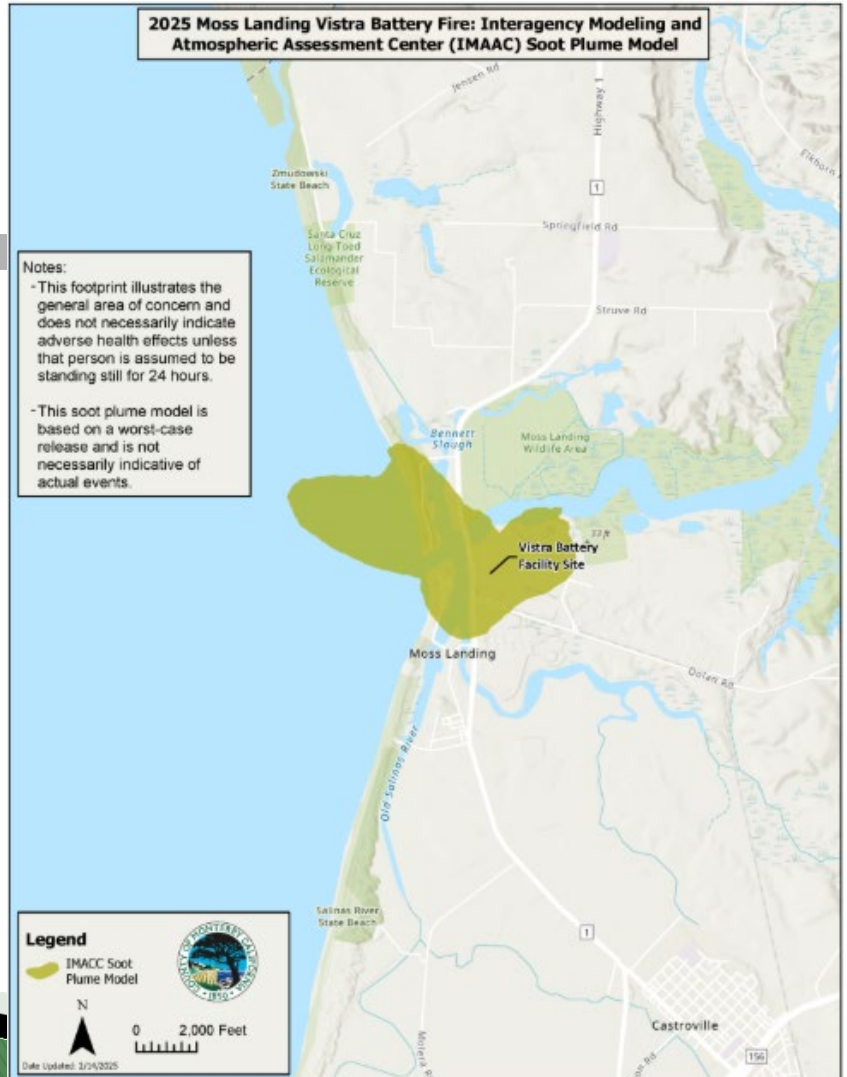
Vistra completes world's largest BESS at Moss Landing

August 26, 2021

Moss Landing Energy Storage Facility

Vistra has completed construction on Phase II of its Moss Landing Energy Storage Facility in

Air Modeling



LITHIUM ION BATTERY INCIDENTS In the OC Ebikes & BESS (modular unit style)

Tu-l 1, 3/25/25

Justin Bechara, Hazardous Materials Specialist
Summer Hernandez, Hazardous Materials Specialist

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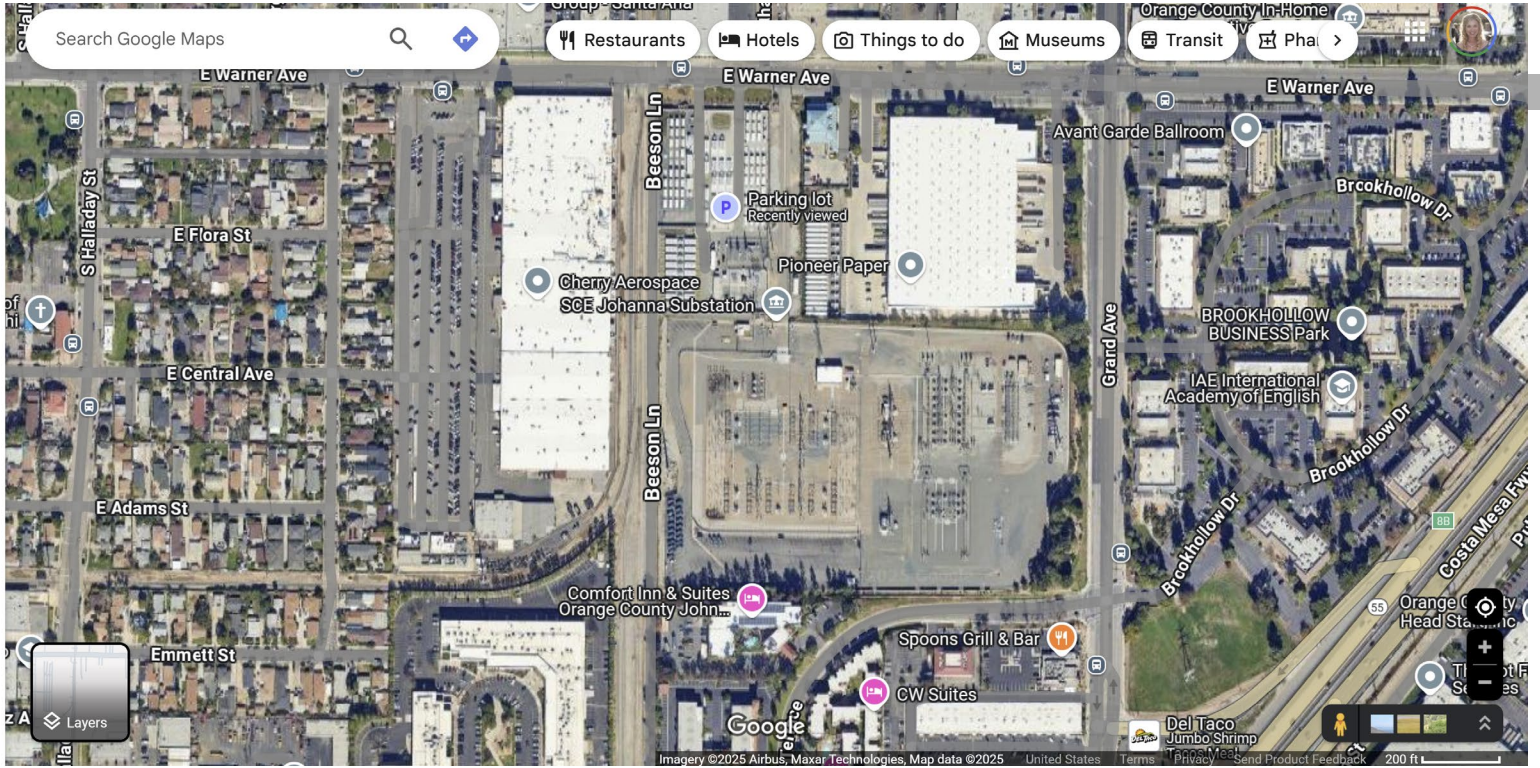
OC Health Hazmat Team

Emergency Response & CUPA

- Deputy Public Health Officer
- Assist JHAT Partners
- CUPA Oversight

BESS Fire – Santa Ana 7/17/24 & 1/27/25



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- Three different BESS facilities
- Facility with container fire was unmanned

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[redacted] Santa Ana Energy Storage Project is an 80 MW/320 MWh battery energy storage project that brings energy and grid reliability to Orange County, California. This site can power **80,000 homes for up to four hours.**

In Santa Ana, California our portfolio includes 3 co-located battery storage facilities – Santa Ana 1, 2 and 3 – with 80 MW of battery storage capacity.

More About Santa Ana Battery Storage Project →

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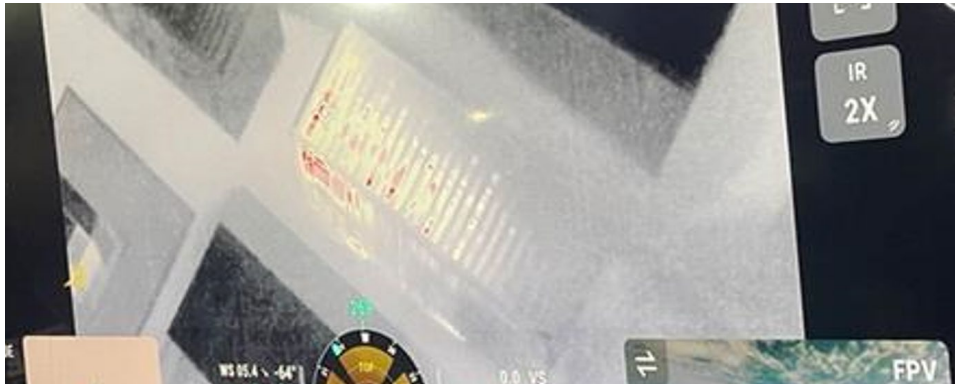

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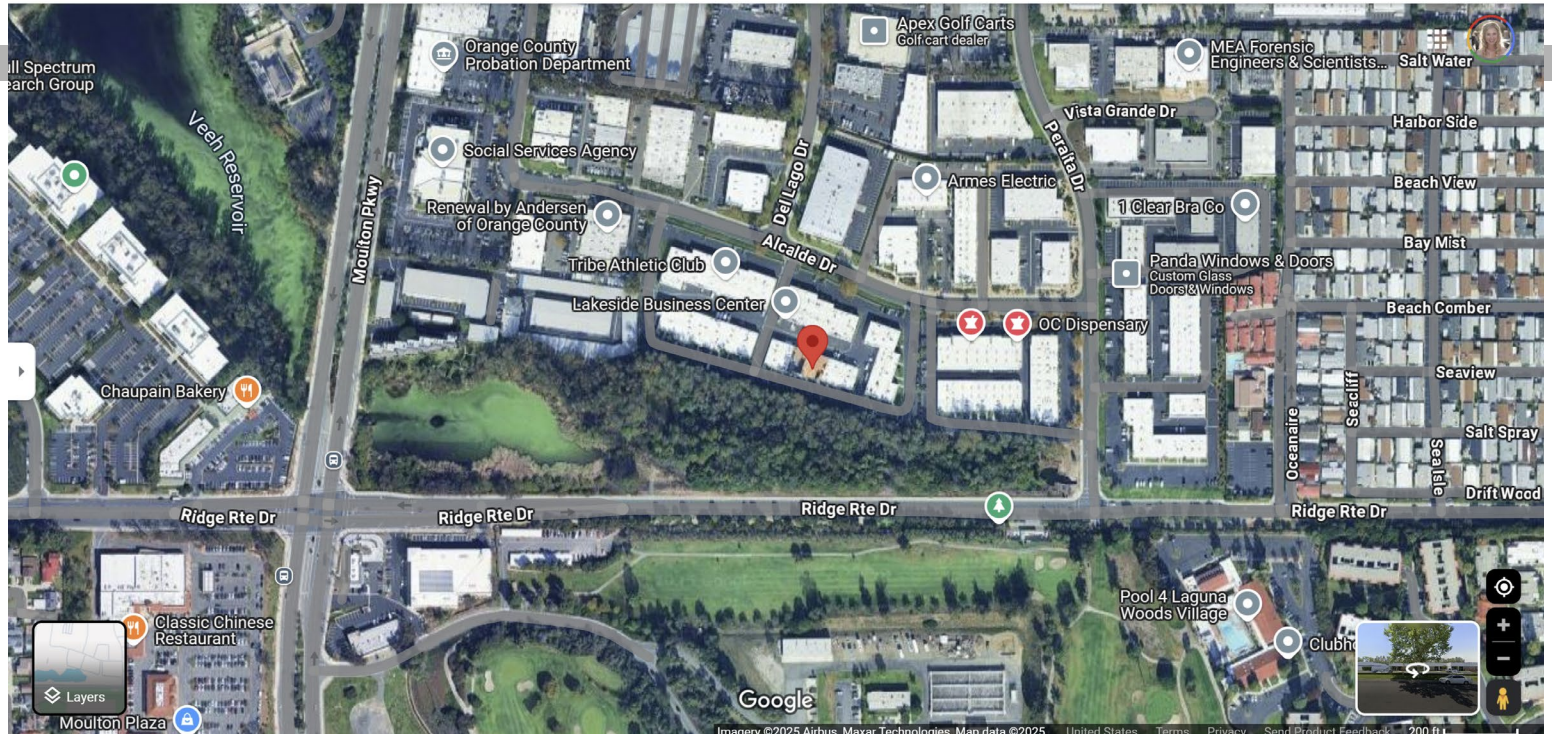
E-Bike Shop Fire – Laguna Hills 2/28/23



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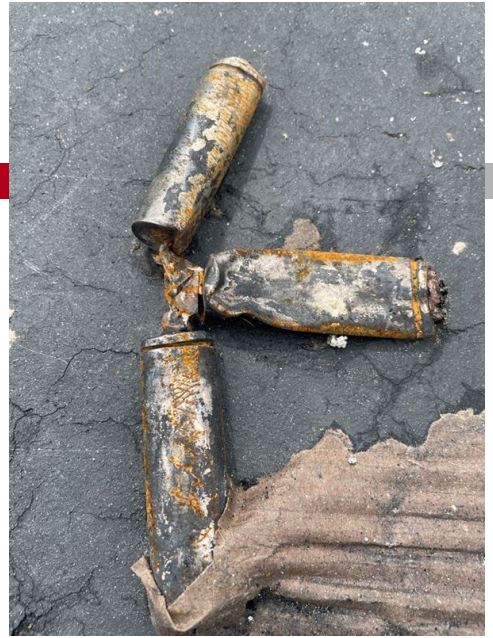

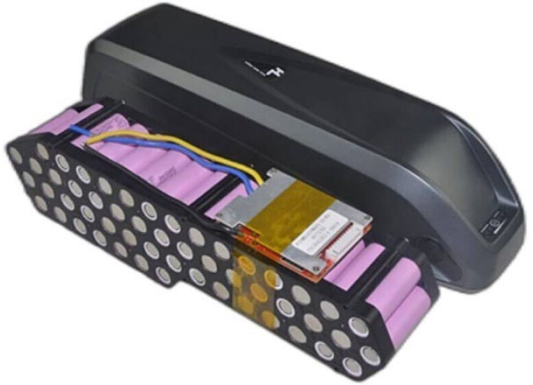

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Electric Vehicle Challenges

San Diego Fire-Rescue Department
Health & Safety Office

SAFETY ALERT

Div/Sec: All Personnel	**Issue/Incident: Tesla Vehicle Arson**
Date: 3/19/25	

Robert Logan
Fire Chief

Daniel Eddy
Assistant Chief Emergency Operations

James Gaboury
Assistant Chief Business Operations

Kyle Smith
Battalion Chief Health & Safety Officer

New Safety Tailboards, Messages, Feedback Suggestions and/or Reporting to the OHSC SDFDHEALTH&SAFETY @SANDIEGO.GOV

Background:
Recently, multiple incidents of vandalism and arson targeting the Tesla brand have been reported across the U.S. and Europe. Vandals have used tactics including arson, breaking windows, and spray-painting on Tesla vehicles, charging stations, and facilities.
In light of these threats, it is recommended that all personnel review the department Electric Vehicle Fires SOPs and discuss tactical considerations with your crews.

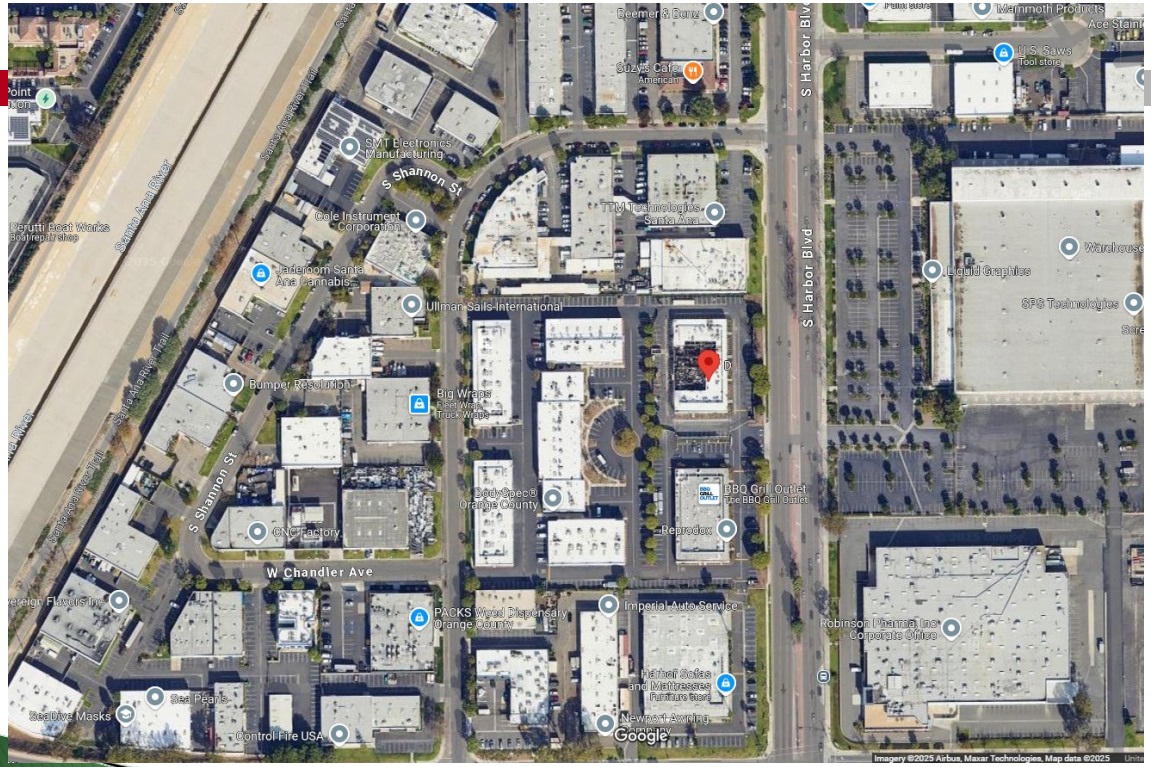
To increase safety, review existing SOPs and follow "Best Practices" including:

- Wear full PPE and respiratory protection
- Check for victims
- Stabilize vehicle (i.e. chock tires)
- Attack the fire as you would a normal vehicle fire
  - If batteries are confirmed to be involved
    - Notify ECDC of a lithium-ion battery fire
    - Request Hazmat as needed. (i.e. if batteries cells are loose, air monitoring needs, etc.)
    - If safe to do so, allow batteries to burn, protect exposures, and evacuate the area 330 feet in all directions
- Secure a water supply
- If the battery compartment is compromised
  - Consider applying water into the battery compartment
- Once stabilized
  - The vehicle should be monitored for at least one (1) hour prior to releasing the vehicle to law enforcement, tow company, or RP
    - Advise them that the vehicle may reignite without warning

Action Items:

- Refer to the vehicle Emergency Response Guide (ERG)
  - Locating the battery and other electrical components of the vehicle
- Review Department SOPs for Electric Vehicle Fires

Hybrid Battery Repair Fire – Santa Ana 9/7/23



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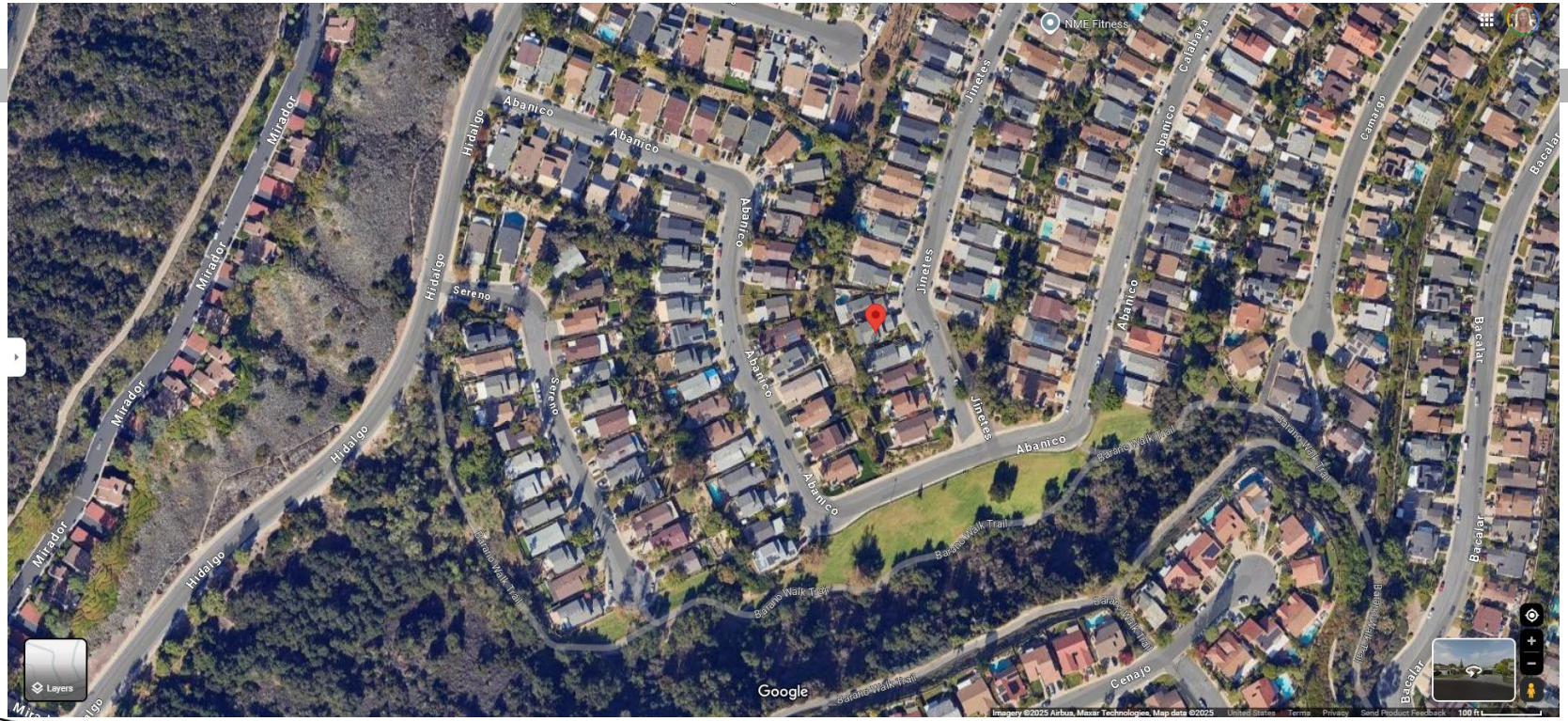
Electric Car Fire – Mission Viejo 7/4/24



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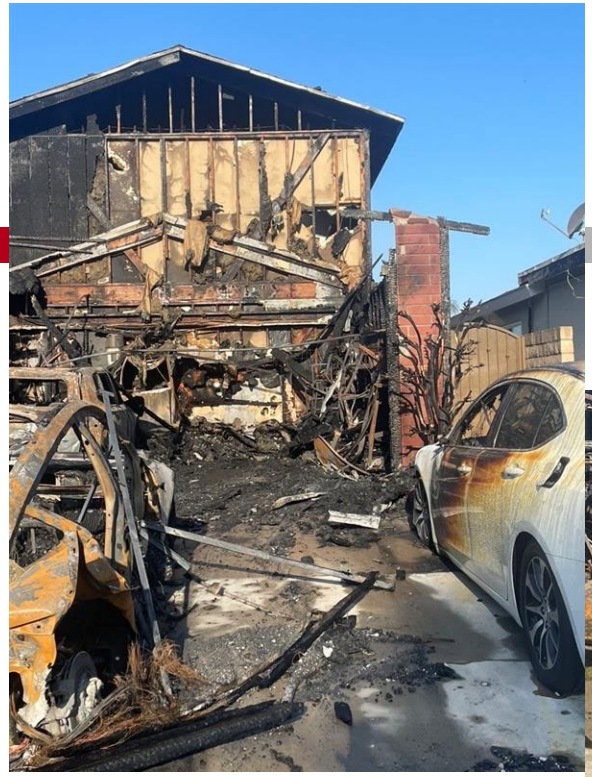

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Any Questions?

Jbechara@ochca.com
Suhernandez@ochca.com

Any Questions?

Justin Bechara, jbechara@ochca.com
Summer Hernandez, suhernandez@ochca.com

BREAK TIME?

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Other BESS Incidents- Modular Units
San Diego County

September 2023 (Valley Center, CA)

September 2024 (Escondido, CA)

Valley Center BESS Fire 9-2023

Response Summary

One Li Ion battery storage structure was involved in a fire at this ESS. This structure housed approximately 133,000 Lbs of LIBs. Initial fire response observed flames and a light gray smoke at top of structure, indicating a battery fire. All battery storage structures are equipped with a sprinkler deluge system that activates automatically at high temperatures, flames or smoke. Fire suppression was actively discharging when fire personnel arrived. Fire companies took a defensive posture measuring temperature of structure with a thermal imaging device. Providing cooling of surrounding structures as needed. No personnel approached closer than 75 ft. Upon arrival at scene, no flames or smoke visible and storage container showed a cooling trend by thermal imaging device of fire personnel. Facility emergency representative and IC stated Facility Emergency Response Plan had been implemented and followed for a Thermal Runaway event. That no personnel were to approach closer than 75 ft of container for up to multiple days. Part of the Emergency Response plan that was initiated was an evacuation order of the nearest home, and shelter in place of homes in the downwind side within 1/4 mile.

- IC and facility environmental contact requested air monitoring and pH test of firefighting runoff water. Deluge runoff water was collected in designed catch basin around facility. Storage containers are within a 8-10 ft concrete wall. Air monitoring was conducted outside of entire perimeter of wall, with non detect for any gases on CGI 4 gas, Multi RAE pro and PID. Firefighting water tested for pH in two places at South wall where water was collecting in catchment. pH was neutral.
- After air quality assessment and continued cooling trend of structure, the incident was terminated.
- Container to remain closed, HIRT follow up to be conducted in approximately one week

One Week Later- Monitored & Opened


SKYFOX
BREAKING NEWS
FIRE AT SDG&E BATTERY FACILITY
ESCONDIDO
SUPER BOWL
FOX 5
4:01 | 87°
5 FOX 5 TRUMP PLEADS NOT GUILTY TO NEW 2020 ELECTION INTERFERE
HEADLINES

Escondido Response Summary 9-2024

On September 5 at 12:09, units from the Escondido Fire Department responded to a fire at the SDG&E battery storage facility at 571 Enterprise Street. Upon arrival, crews found an active fire in a Lithium-Ion battery bank. Due to the specific hazards of such fires, a defensive strategy was employed, focusing on protecting adjacent structures containing additional batteries by applying water to those adjacent structures. Evacuations of the surrounding area began at approximately 13:00 on September 5 and remained in effect until September 7. San Diego County Hazmat arrived to conduct air monitoring from 14:30 to 18:30 at which time only normal products combustion of a structure fire were detected and at levels considered by NIOSH and OSHA to be well below exposure thresholds. Haley & Aldrich Inc., SDG&E's third party contractor, began air quality monitoring later that evening and concluded on September 7. The fire was fully extinguished at 01:10 on September 6, with precautionary air monitoring continuing for an additional 12 hours into the afternoon of September 7. At no time during the incident did the levels of Oxygen deviate from 20.9 percent which is considered normal atmospheric level. Any decrease in the percentage of Oxygen would indicate that there was some unknown gas in the atmosphere that was not able to be detected by monitoring equipment. Fortunately, no such deviation was detected. The use of Fluoride reactive test strips was negative at all locations. Additionally, Hydrofluoric acid was not detected at any of the sampling locations.

Official Notice Issued to Facility early on:

- Provide Air Monitoring as directed by IC
- Keep Data and records
- Provide Firefighting runoff water sample data
- Provide updates to CalOES as incident progresses 24-5015
- Work with CUPA for accurate reporting of batteries/containers.
- Discussed Hazardous waste disposal

Monitoring locations and readings- a joint effort

SD County Hazmat Readings in Parts Per Million (PPM)

Location	Distance from Incident (ft)	Time	PH3	CL2	H2S	CO2	HCN	CO
Main Gate	315	14:30	0	0	0	0	0	0
Venture and Simpson	784	14:35	0	0	0	0	0	0
State St (All	1447	14:36	0	0	0	0	0	0
Enterprise and Auto Park	776	18:15	0	0	0	0	0.5	0
Enterprise Gate	262	18:16	0	0	0	18	2	0
Venture and Simpson	784	18:21	0	0	0	0	0.5	0
Venture and State	1108	18:22	0	0	0	0	0.5	0
Market and Auto Park	2227	18:25	0	0	0	0	0	0
Vinewood and Industrial	2280	18:27	0	0	0	0	0.5	0
Andreasen and Simpson	2522	18:29	0	0	0	0	0.5	0
1287 Simpson	3943	18:32	0	0	0	0	0.5	0

Haley & Aldrich, INC (SDG&E) Monitoring locations denoted in blue

Air & Water Quality Testing

City News & Updates

Posted on: September 19, 2024

Air Quality Report and Water Run Off Report for the SDG&E Battery Storage Fire

On September 5 at 12:09, units from the Escondido Fire Department responded to a fire at the SDG&E battery storage facility at 571 Enterprise Street. Upon arrival, crews found an active fire in a Lithium-Ion battery bank. Due to the specific hazards of such fires, a defensive strategy was employed, focusing on protecting adjacent structures containing additional batteries by applying water to those adjacent structures. Evacuations of the surrounding area began at approximately 13:00 on September 5 and remained in effect until September 7.

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- Air Quality Report
- Water Run Off Report

FORUM

gram
nce

Method: EPA 200.7 Rev 4.4 - Metals (ICP) - Total Recoverable

Client Sample ID: Used Fire Hydrant Water
Date Collected: 09/05/24 18:30
Date Received: 09/06/24 17:00

Lab Sample ID: 570-197947-1
Matrix: Water

Analyte	Result	Qualifier	RL	MDL	Unit	D	Prepared	Analyzed	Dil Fac
Cadmium	ND		0.0100	0.000450	mg/L		09/09/24 07:01	09/09/24 13:15	1
Antimony	ND		0.100	0.0147	mg/L		09/09/24 07:01	09/09/24 13:15	1
Beryllium	ND		0.0100	0.000660	mg/L		09/09/24 07:01	09/09/24 13:15	1
Barium	**0.115**		0.0100	0.000730	mg/L		09/09/24 07:01	09/09/24 13:15	1
Thallium	ND		0.0500	0.00863	mg/L		09/09/24 07:01	09/09/24 13:15	1
Molybdenum	**0.00750**	J	0.0500	0.00592	mg/L		09/09/24 07:01	09/09/24 13:15	1
Nickel	ND		0.0500	0.00146	mg/L		09/09/24 07:01	09/09/24 13:15	1
Vanadium	**0.00510**	J	0.0100	0.00171	mg/L		09/09/24 07:01	09/09/24 13:15	1
Silver	ND		0.0100	0.00340	mg/L		09/09/24 07:01	09/09/24 13:15	1
Arsenic	ND		0.100	0.00965	mg/L		09/09/24 07:01	09/09/24 13:15	1
Copper	**0.0216**	J	0.0500	0.00159	mg/L		09/09/24 07:01	09/09/24 13:15	1
Lead	ND		0.0500	0.00598	mg/L		09/09/24 07:01	09/09/24 13:15	1
Zinc	**0.0767**	J	0.250	0.00460	mg/L		09/09/24 07:01	09/09/24 13:15	1
Selenium	ND		0.100	0.0118	mg/L		09/09/24 07:01	09/09/24 13:15	1
Chromium	ND		0.0500	0.00300	mg/L		09/09/24 07:01	09/09/24 13:15	1
Cobalt	**0.00140**	J	0.0500	0.00125	mg/L		09/09/24 07:01	09/09/24 13:15	1

- EPA Method 200.7 uses ICP-OES for regulatory compliance for drinking water analysis. The method can also be used for analysis of other matrices, such as wastewater, groundwater, soil, sediments, and solid waste.
- Method 6010 was developed for RCRA regulations and the method cannot be used for regulatory compliance monitoring [illegible] Drinking Water Act and Clean Water Act.

San Diego Lithium-Ion Battery Study

DEHQ SDFD EPA

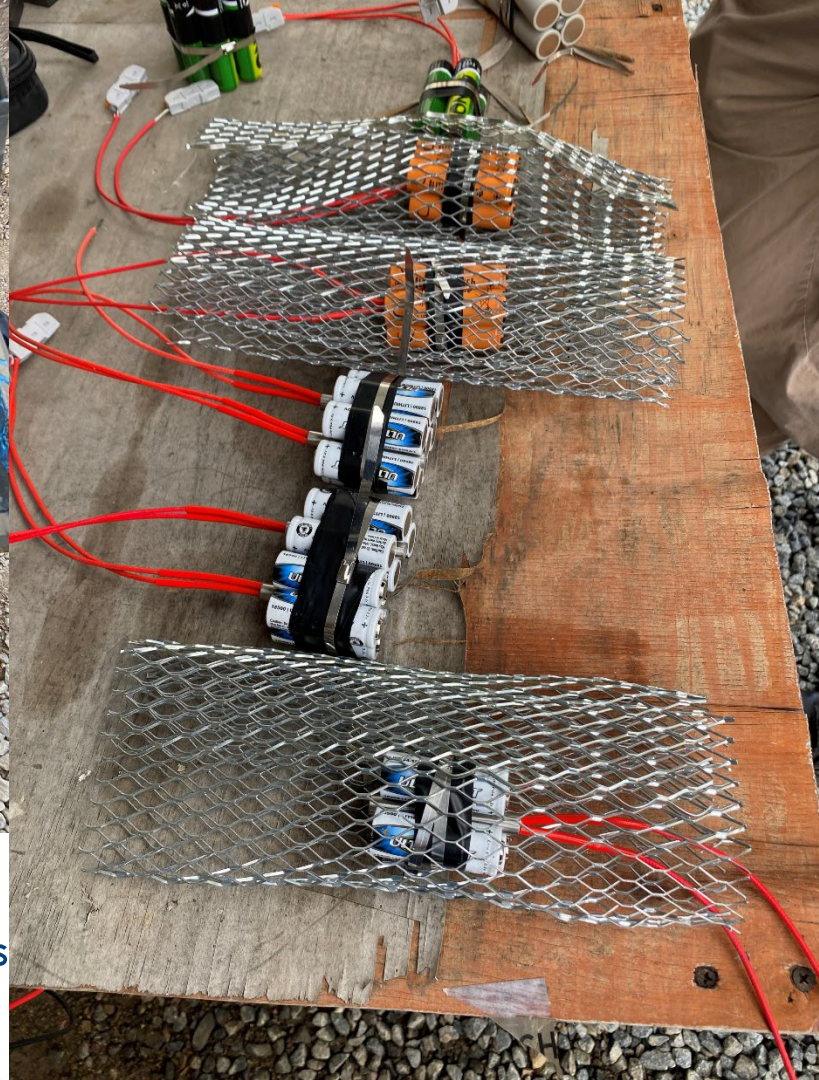
Study Design

- A simulated fire room with four walls, a ceiling and a floor was constructed using typical construction materials. The front wall included plexiglass window for observation. Various holes were made in the room so monitoring equipment could draw air into the devices for measurement
- Method of causing thermal runaway involved the use of a heating element via 120V. The batteries and heating element were placed into a rat cage for safety and monitored until completion of the reaction.
- Batteries of LiFePo4 and NMC chemistry at various states of charge and configurations were tested.
- Data was collected during the thermal runaway event. Monitors for gasses, particles, pH and temperature were used.
- Room clearance was conducted between tests using fans and monitors.

Burn Room

South California Unified Program
Annual Training Conference
March 24-27, 2025

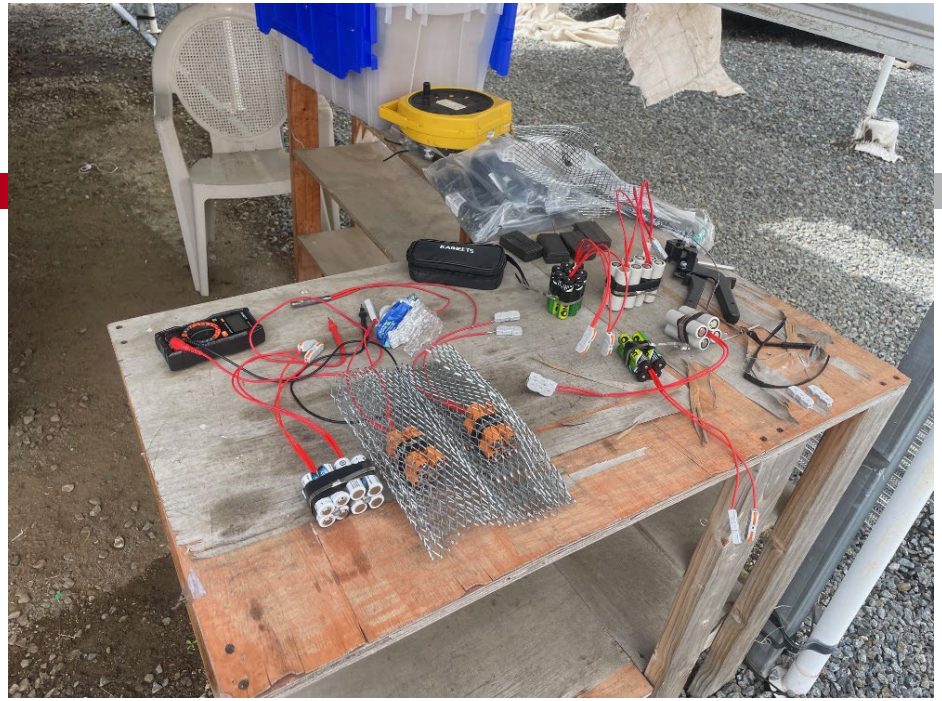
Red Wave ExplorIR, RKI Eagle, Gasmet, HoneyWell AreaRae, Honeywell Single-Point Monitoring (SPM) Flex unit with a mineral acid cassette



Battery Configurations

Thermal Runaway initiated via heating elements

CALIFORNIA CUPA FORUM

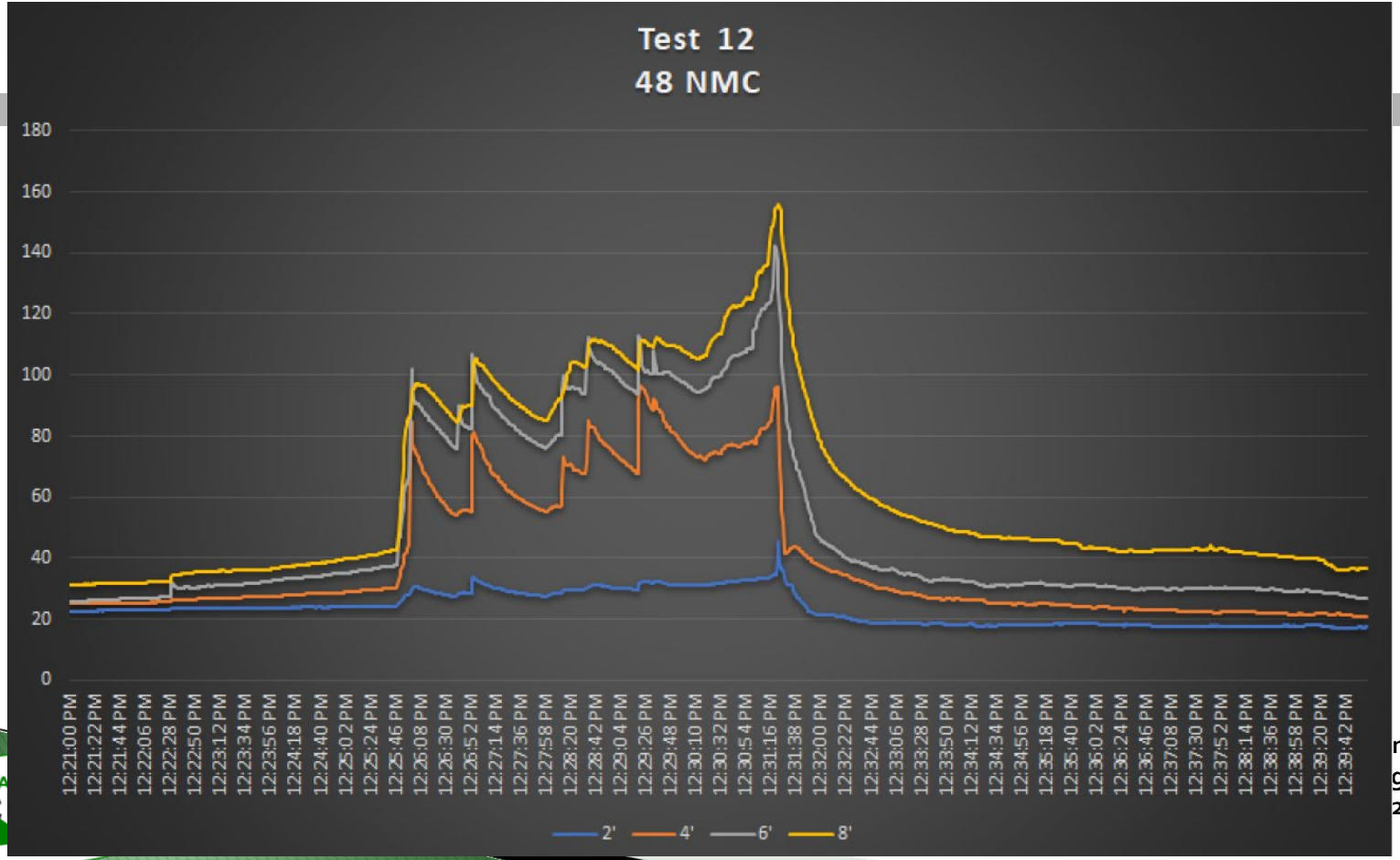


Some Key Takeaways:

- These tests included anywhere from 4 cells to 144 cells of varying state of charge.
- Some of the tests were conducted with LiFePO4 (lithium iron phosphate) batteries, while others were conducted with NMC (nickel, manganese, cobalt) batteries.
- Some of the tests showed low levels of HF, HCL, and Nitrous Oxide indicating the ability to filter these out effectively.
- CO sensors are cross-sensitive to hydrogen gas, which could be misleading.
- Several of the toxic gases measured are byproducts of burning plastic – This includes hydrogen cyanide, formaldehyde, acetaldehyde, benzene, styrene, and toluene.

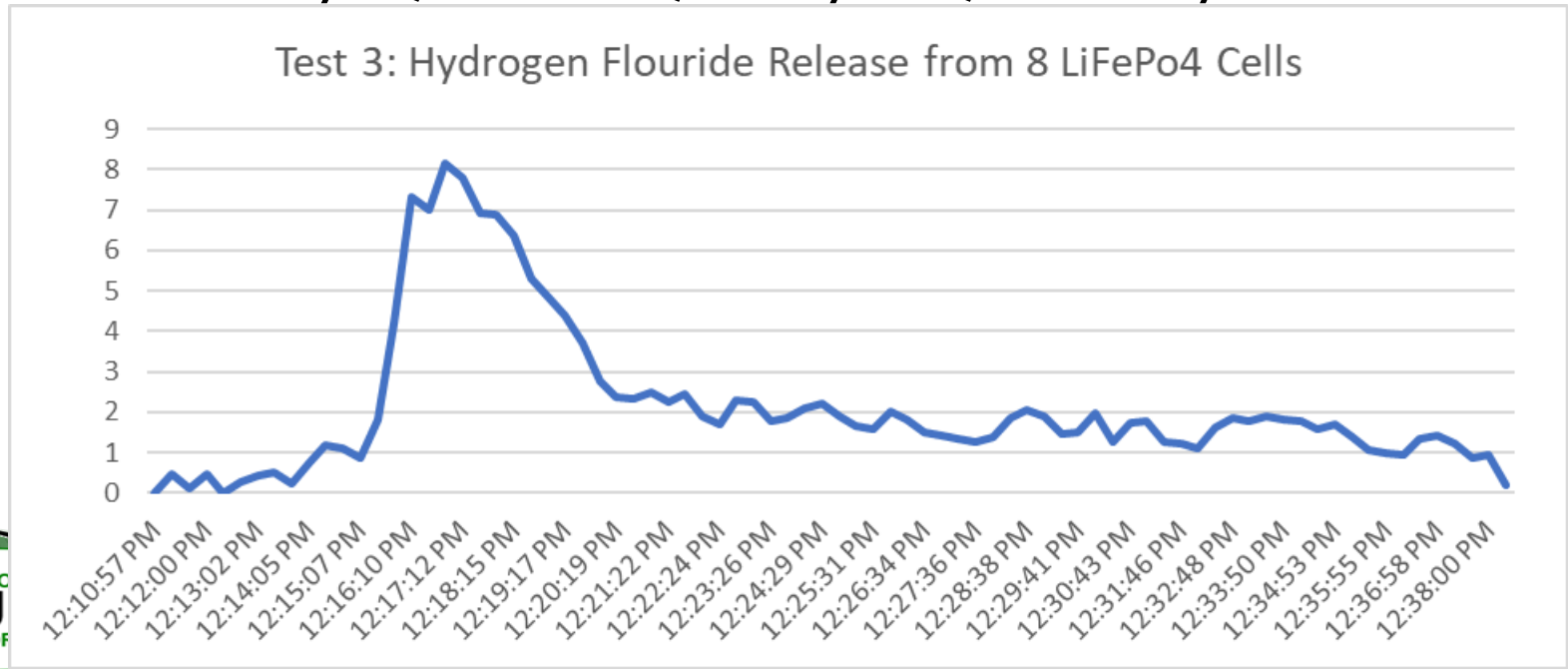
Test #	Description
1	4 LiFePO4 18500 Solar - 100% SOC
2	4 LiFePO4 18500 Solar
3	8 LiFePO4 18500 Solar - Low SOC
4	8 LiFePO4 18500 Solar - 100% SOC
5	12 NMC (Nuon) 18650 - 100% SOC
6	44 NMC 21700 Zhejang Skateboard - 100% SOC plus some reacted cells
7	8 NMC Mollicel ISS 21700 - <100% SOC
8	65 NMC KULR Ebike & Amazon 18650
9	18 NMC Mollicel ISS 21700 - 100% SOC
10	2 LiFePO4 ESS (Prismatic) - 1 charged, 1 uncharged
11	48 NMC Zhejang skateboard 21700, <40V
12	48 NMC Zhejang skateboard 21700 - 100% SOC, 49.6V
13	3 x NMC Zhejang Skateboard in Akkugrain Box - 100% SOC, 144 cells total

Room Temps at 2/4/6/8 feet



Hazardous Gases Detected

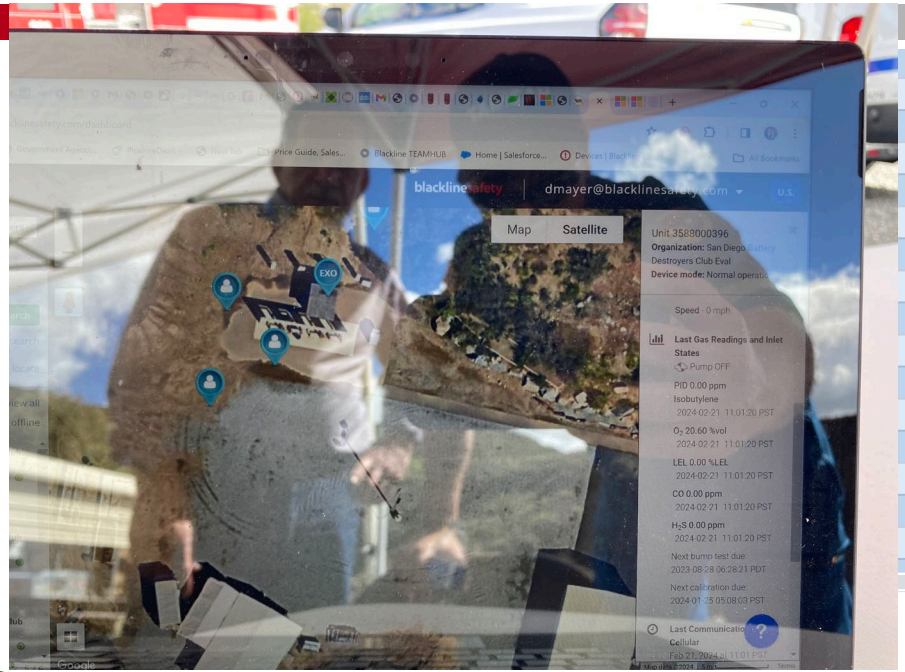
- Hydrogen, Hydrogen Fluoride, Hydrogen Cyanide, Carbon Monoxide, Ethyl Methyl Carbonate, Ethylene Carbonate, Diethyl Carbonate, Dimethyl Carbonate, Formaldehyde, Acetaldehyde, Methane, Acetylene, and Ethylene



Hazardous Gas Concentrations

Test Number	Formaldehyde	Acetaldehyde	Methane	Acetylene	Ethylene
1	0.46 ppm	1.13 ppm	3.18 ppm	0.77 ppm	0.79 ppm
2	1.06 ppm	9.42 ppm	5.62 ppm	0.78 ppm	5.56 ppm
3	0.86 ppm	10.64 ppm	10.71 ppm	0.76 ppm	9.75 ppm
4	0.39 ppm	18.48 ppm	10.63 ppm	0.43 ppm	15.88 ppm
5	14.03 ppm	2.93 ppm	47.11 ppm	5.46 ppm	32.96 ppm
6	22.25 ppm	7.07 ppm	163.47 ppm	45.32 ppm	110.22 ppm
7	10.2 ppm	1.95 ppm	69.67 ppm	11.6 ppm	38.28 ppm
8	1.19 ppm	6.25 ppm	111.72 ppm	16.49 ppm	76.95 ppm
9	8.59 ppm	8.76 ppm	59.76 ppm	4.38 ppm	34.75 ppm
10	16.08 ppm	279.26 ppm	224.16 ppm	3.88 ppm	366.25 ppm
11	14.26 ppm	14.36 ppm	113.09 ppm	67.32 ppm	107.2 ppm
12	11.58 ppm	7.9 ppm	83.02 ppm	17.9 ppm	67.68 ppm
13	34.35 ppm	143.38 ppm	2335.28 ppm	209 ppm	2319.72 ppm

Blackline



14080.0	H2	2/22/24 11:27	30.0	HCN
6933.3	H2	2/22/24 11:31	5.6	HCN
17800.0	H2	2/21/24 11:33	0.6	HCN
4000.0	H2	2/22/24 11:25	10.0	HCN
22400.0	H2	2/22/24 11:28	30.0	HCN
21800.0	H2	2/22/24 11:45	4.0	HF
24000.0	H2	2/22/24 11:46	4.0	HF
2400.0	H2	2/22/24 11:49	3.6	HF
8133.3	H2	2/22/24 11:49	3.3	HF
21800.0	H2	2/22/24 11:43	5.7	HF
40000.0	H2	2/22/24 11:49	3.3	HF
6400.0	H2	2/22/24 11:06	1.3	HF
5400.0	H2	2/22/24 11:02	1.4	HF
4800.0	H2	2/22/24 11:03	1.4	HF
6400.0	H2	2/22/24 11:40	10.0	HF
28600.0	H2	2/22/24 11:36	10.0	HF

RedWave

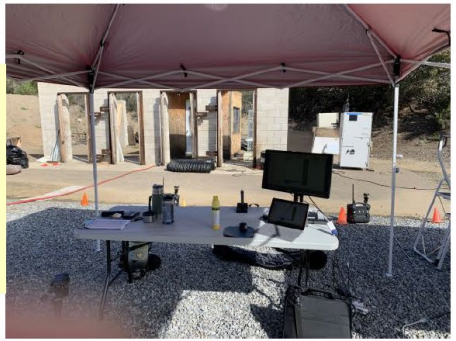
- Dimethyl Carbonate (DMC) electrolyte aka Carbonic Acid Dimethyl Ester (14/15 runs)
- Carbon Monoxide (3/15 runs)
- Methane, Ethylene on LFP ESS
- Methyl Acetate (1/10 runs on NMC)

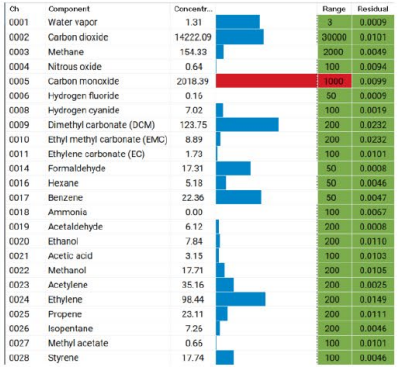
GT5000 FTIR Gas Analyzer _ Setup & Sampling Strategy

GT5000 **Sample probe** with integral 2 µm Teflon Filter fixed to mess on interior wall

GT5000 setup outside the “reaction chamber”
~ 10ft Teflon sample tube

GT5000 operated from Tablet/Laptop by WiFi.
Calcmet EASY software programmed to update gas readings each 20s
Computer screen used to display & trend results
(~ 40ft back from reaction chamber)





Ch	Component	Concentr...	Range	Residual
0001	Water vapor	1.31	3	0.0009
0002	Carbon dioxide	14222.09	30000	0.0101
0003	Methane	154.33	2000	0.0049
0004	Nitrous oxide	0.64	100	0.0094
0005	Carbon monoxide	2018.39	1000	0.0099
0006	Hydrogen fluoride	0.16	50	0.0009
0008	Hydrogen cyanide	7.02	100	0.0019
0009	Dimethyl carbonate (DCM)	123.75	200	0.0232
0010	Ethyl methyl carbonate (EMC)	8.89	200	0.0232
0011	Ethylene carbonate (EC)	1.73	100	0.0101
0014	Formaldehyde	17.31	50	0.0008
0016	Hexane	5.18	50	0.0046
0017	Benzene	22.36	50	0.0047
0018	Ammonia	0.00	100	0.0067
0019	Acetaldehyde	6.12	200	0.0008
0020	Ethanol	7.84	200	0.0110
0021	Acetic acid	3.15	100	0.0103
0022	Methanol	17.71	200	0.0105
0023	Acetylene	35.16	200	0.0025
0024	Ethylene	98.44	200	0.0149
0025	Propene	23.11	200	0.0111
0026	Isopentane	7.26	200	0.0046
0027	Methyl acetate	0.65	100	0.0101
0028	Styrene	17.74	100	0.0046

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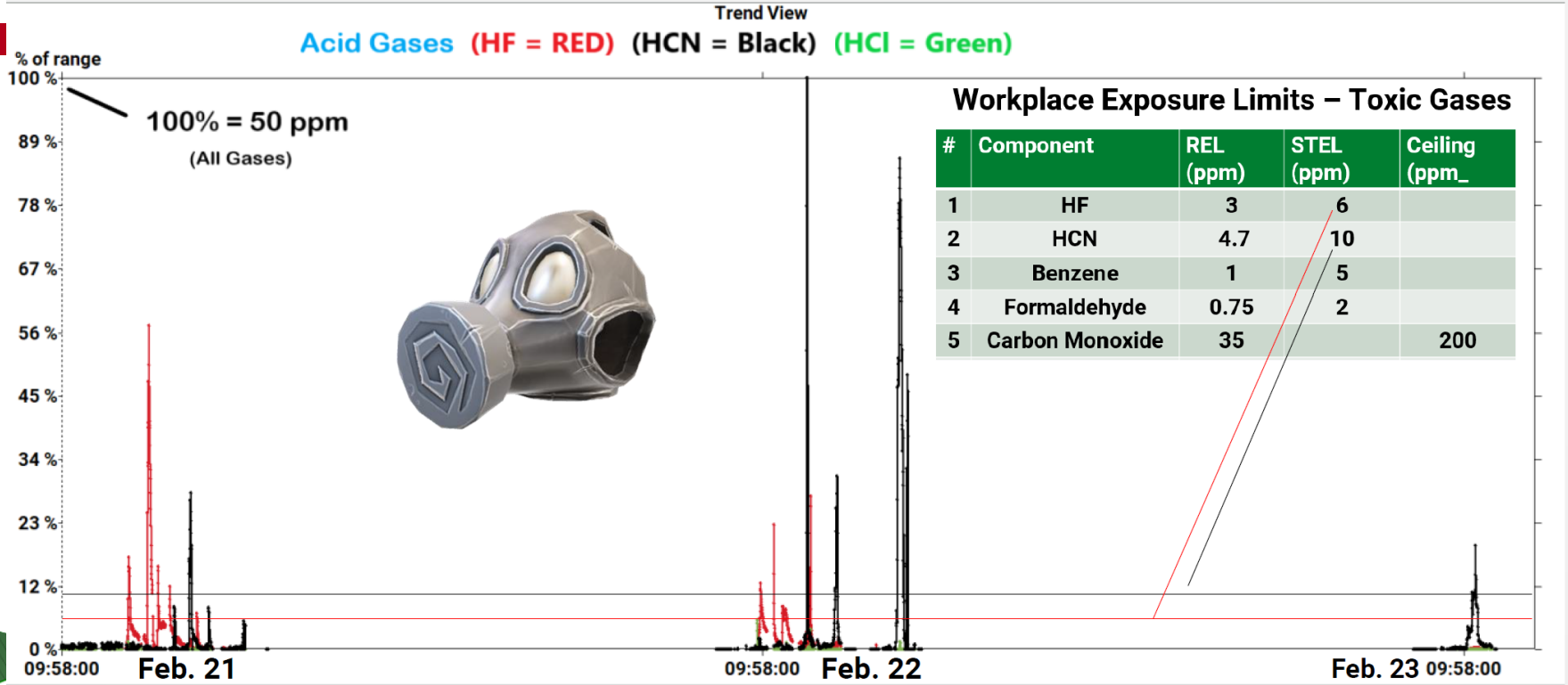
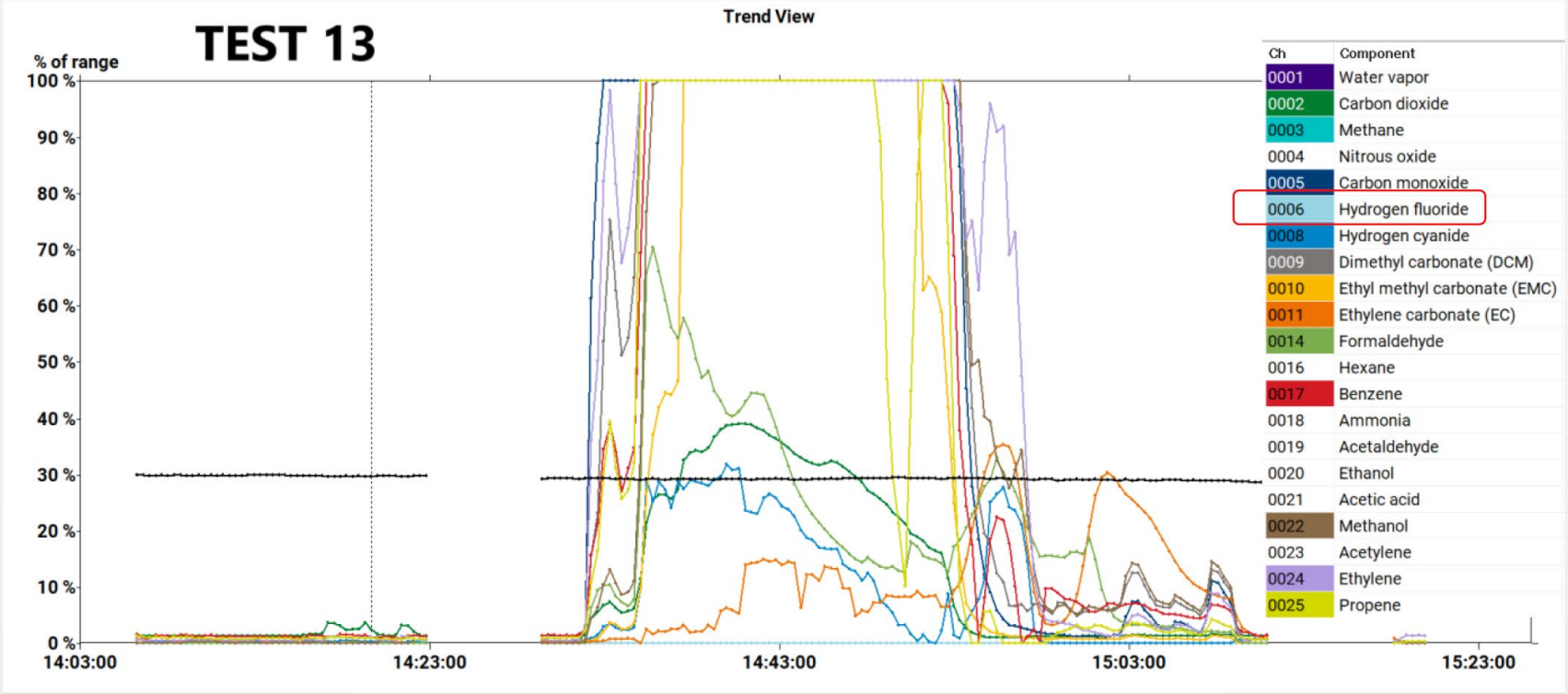
GT5000 gas analysis results



Workplace Exposure Limits – Toxic Gases

#	Component	REL (ppm)	STEL (ppm)	Ceiling (ppm_
1	HF	3	6	
2	HCN	4.7	10	
3	Benzene	1	5	
4	Formaldehyde	0.75	2	
5	Carbon Monoxide	35		200

GT5000 gas analysis results



Day 1

Test # 1: Before T1: 72 F, 58 RH, approx. 10:40

Eagle HF, 2.40ppm, in alarm
Eagle 2 CH4 IR, 1% LEL
Instruments with zero reading: GX-6000 LEL, O2 (20.9%), H2S, CO, VOC (PID) / GD-70D, H2 Specific (Fixed System) 0-2,000ppm / Eagle 2 H2 Specific 0-100% LEL, VOC (PID) 0-2,000ppm.

Test # 2: After T2: 69 F, 63 RH, approx. 11:45

Eagle HF 4.10ppm to 9.00ppm / Eagle 2 VOC (PID) 0.2ppm / GX-6000 VOC (PID) 0.2ppm. All other instruments and sensors were reading zero.

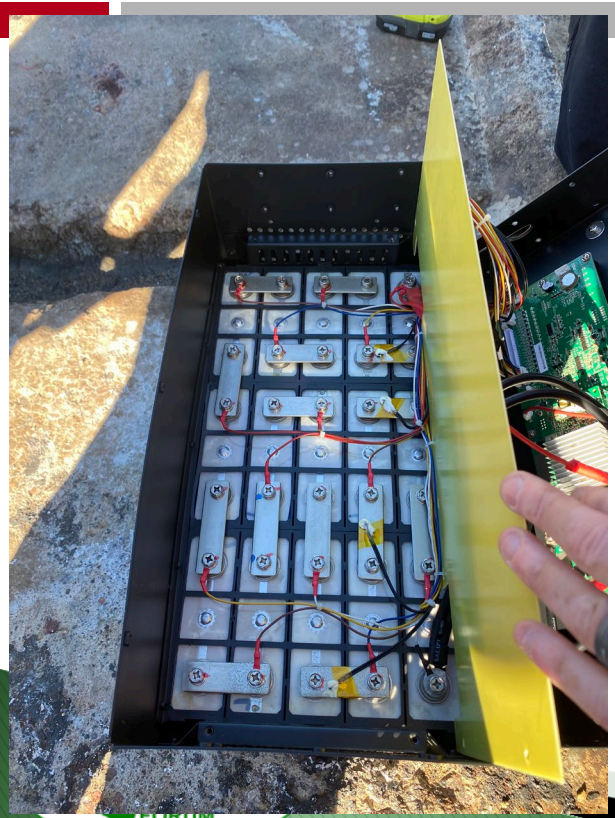
Test # 3: Temp, RH & Time, not recorded.

Eagle HF 7.00ppm / Eagle 2 IR, 2% LEL, Eagle 2 VOC 3.00ppm / GX-6000, VOC, 12.9ppm, CO 27pm. All other sensors were reading zero or O2 at 20.9%.

Test # 4: Temp, RH & Time, not recorded.

Eagle HF 9.00ppm Over (Over Range) / Eagle 2 VOC (PID) 1.0ppm / GX-6000, O2 22.3%, CO 3ppm, VOC (PID) 5.2ppm. All other sensors were reading zero or O2 at 20.9%.

Toxic/Flammable Smoke from 1/15th of an ESS Batt



fied Program
Conference
, 2025

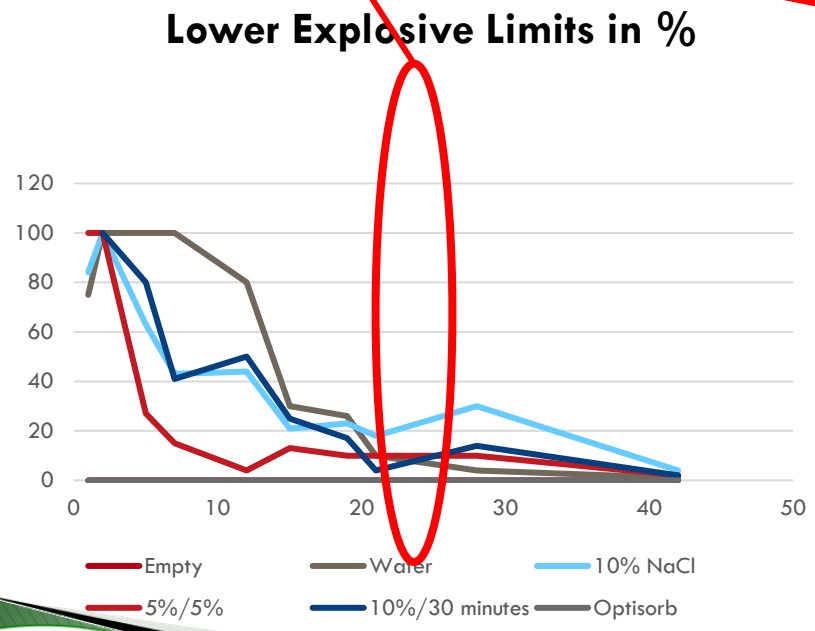
Mitigation Study Design

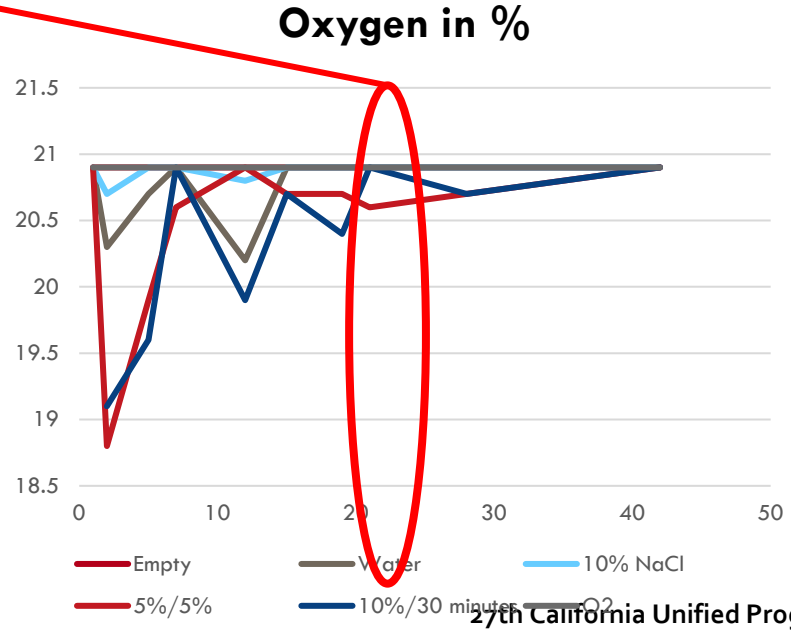
- Three burned batteries and three intact batteries at 100% state of charge were used to simulate a partially burned battery
- Five mitigation techniques used
  1. Empty metal container
  2. Water
  3. 10% NaCl in water
  4. 5% NaCl and 5% Sodium Bicarbonate in water
  5. 10% NaCl in water for 30 minutes then empty container
  6. Optisorb absorbent
- Each solution was made to two gallons and placed in a sealed container to capture reaction gasses.
- Containers were monitored periodically over 42 days using CGI, PID and MultiRae with CL2, NH3, PH3, CO and HCN

21 days to start monitoring or send for disposal?

Mitigation Solutions

Reaction Data





Brine solution and Batteries = H2

Waste Determination: Liquid

Each mitigation solution was tested using STLC for heavy metals listed as hazardous waste in California under Health and Safety Code 66261.24. No solution failed.

Heavy Metal Concentration in Solution in mg/L								
	Antimony	Barium	Cobalt	Copper	Nickel	Thallium	Zinc	Mercury
Water	ND	0.112	0.789	2.08	6.93	ND	75.6	0.0259
10% NaCl in Water	0.214	0.182	1.85	2.71	16.2	ND	134	0.0139
5% NaCl and 5% Sodium Bicarbonate in Water	0.440	0.182	1.60	3.94	14.4	ND	14.5	ND
10% NaCl in water for 30 minutes	0.243	0.247	0.340	1.51	3.26	0.336	12.4	ND
Hazardous Waste Limits	15	100	80	25	20	7	250	0.2

Waste Determination: Solid

The Molicel 2170 batteries were tested using TTLC. The batteries failed for Antimony, Copper and Nickel making the burned batteries a hazardous waste.

Table 1: Metal Composition of Solid Waste Molicel Lithium-Ion Batteries in mg/kg							
	Antimony	Barium	Cobalt	Copper	Nickel	Thallium	Zinc
Molicel	822	ND	1140	428000	9680	ND	4000
Hazardous Waste Limits	500	10000	8000	2500	2000	700	5000

Cobalt can exceed TTLC in some tests

Waste Determination Results

- Aquatic Toxicity tests passed for 10% NaCl in water for both Lithium Iron Phosphate and Nickel Manganese Cobalt batteries
- All mitigation solutions are non-hazardous based on this study
  - Will require additional testing to determine if mitigation solutions are able to be discharged to the sewer
- Solid materials are a hazardous waste
  - Antimony, Copper and Nickel above threshold
  - Solid materials may not be classified at D003 for reactivity even if discharged below 1V or if batteries have suffered enough physical damage that they are no longer considered to be a battery

Outdoor Air Monitoring

Area Raes:
6 deployed around structure

Day 2, all readings normal

Day 3 Structure Burn.
East Unit:
102ppm CO,
4.7ppm HCN

EPA Metals in Air Data- Indoor

NIOSH 7303: Inductively couple plasma (ICP) mass spectrometry sample taken using SKC pump and sampling media to determine an assortment of metals concentrations by volume. Metals screened for were: silver (Ag), aluminum (Al), arsenic (As), barium (Ba), beryllium (Be), cadmium (Cd), cobalt (Co), chromium (Cr), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo), nickel (Ni), lead (Pb), antimony (Sb), selenium (Se), tin (Sn),

Sample Number	Lab Number	Volume	Analyte	Result	Result Units	Reporting Limit*	Method Reference
SDFE-022224-7303-D	LM267279	87 L	Ag	< 4	ug/m3	4	NIOSH 7303
	LM267279	87 L	As	< 7	ug/m3	7	NIOSH 7303
	LM267279	87 L	Ba	< 6	ug/m3	6	NIOSH 7303
	LM267279	87 L	Be	< 0.9	ug/m3	0.9	NIOSH 7303
	LM267279	87 L	Cd	< 7	ug/m3	7	NIOSH 7303
	LM267279	87 L	Co	210	ug/m3	4	NIOSH 7303
	LM267279	87 L	Cr	< 20	ug/m3	20	NIOSH 7303
	LM267279	87 L	Cu	30	ug/m3	6	NIOSH 7303
	LM267279	87 L	Mo	< 20	ug/m3	20	NIOSH 7303
	LM267279	87 L	Ni	1800	ug/m3	4	NIOSH 7303
	LM267279	87 L	Pb	< 9	ug/m3	9	NIOSH 7303
	LM267279	87 L	Sb	100	ug/m3	6	NIOSH 7303
	LM267279	87 L	Se	< 20	ug/m3	20	NIOSH 7303
	LM267279	87 L	Tl	< 40	ug/m3	40	NIOSH 7303
	LM267279	87 L	V	< 6	ug/m3	6	NIOSH 7303
	LM267279	87 L	Zn	70	ug/m3	9	NIOSH 7303

gram
nce

Indoor Environment Air Sampling (EPA)

- ASTM-D-1945 Tedlar Bag- SKC pump and vacuum chamber
  - Hydrogen, CO, O2
- NIOSH 6010
  - Colorimetric Sample for HCN
- NIOSH 7902- Ion Concentration
  - HF and Soluble Fluoride particulate
- NIOSH 7303 ICP using SKC Pump
  - Various metals and toxic heavy metals

RUN 9							
Date: 2/22/24	**Official Run Time: 0940 - 0950 (10 mins)**				**Test Media:**		
	5-Gas Meter Run Time: 0940 - 0944 (4 mins)				**18 NMC Mollicel ISS 21700**		
	HF/Particulate Run Time: 0940 - 1010 (30 mins)				**100% SOC**		
Time to 1st Rxn: 4:30	**Sample Run Time: 0905 - 0955 (50 mins)**						
	***26 mins missing from 5-Gas 9:44:20 - 10:10:00**						

Field Measured Data	**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**
Sensor Peak Time	--	9:40:38	9:44:00	--	9:40:38	--	9:45:19

ASTM-D-1945 - Tedlar Bag Samples

Property:	Units:	SDFE-02224-1945-**03A**	SDFE-02224-1945-**03B**
Hydrogen	ppm (v/v)	19370	350
Carbon Monoxide	ppm (v/v)	160	3910
Oxygen	ppm (v/v)	239220 #	263890 #
Hydrogen	ppm (m/m)	<100	<100
Carbon Monoxide	ppm (m/m)	150	8210
Oxygen	ppm (m/m)	312820 #	336680 #

- Result is outside of test method limits and/or analytical range used in method precision study

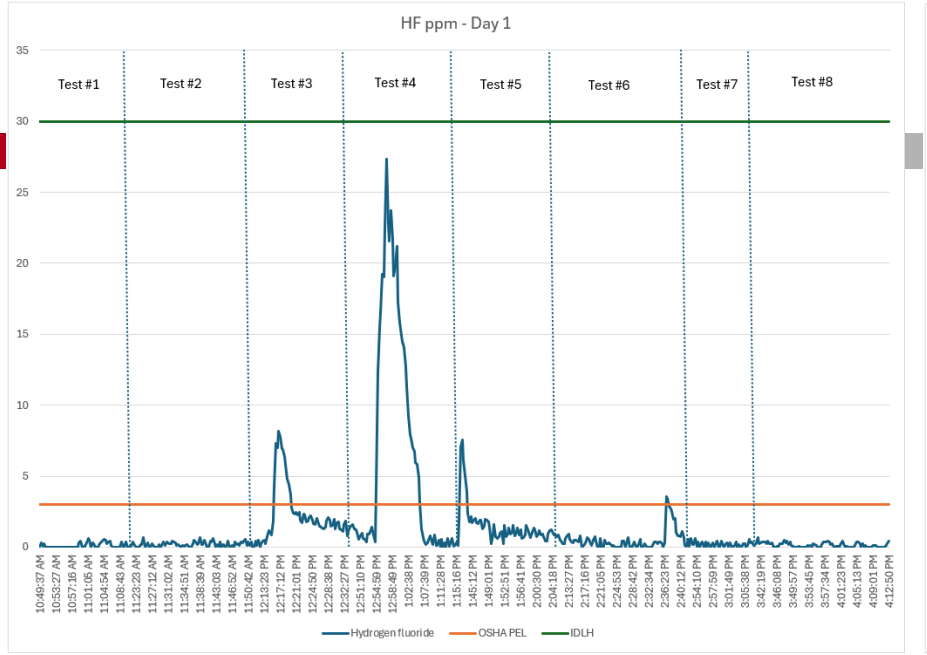
*Note that two Tedlar Bag samples were taken per run to ensure sufficient volume for analysis

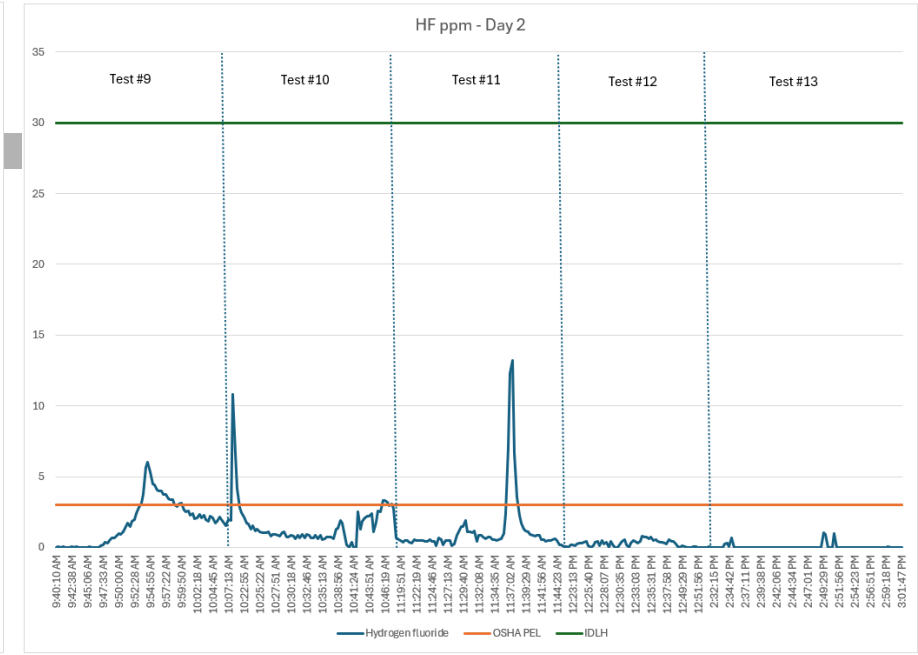
HCN - NIOSH 6010 - Colorimetric

Sample ID	Lab ID	Air Vol liter	Front ug	Back ug	Total ug	Conc mg/m3	ppm
SDFE-022224-6010-03	L618635-5	10	<2.6 ND	<2.6 ND	<2.6 ND	<0.26 ND	<0.23 ND

HF - Fluoride Vapor - NIOSH 7902 (Plus Duplicate)

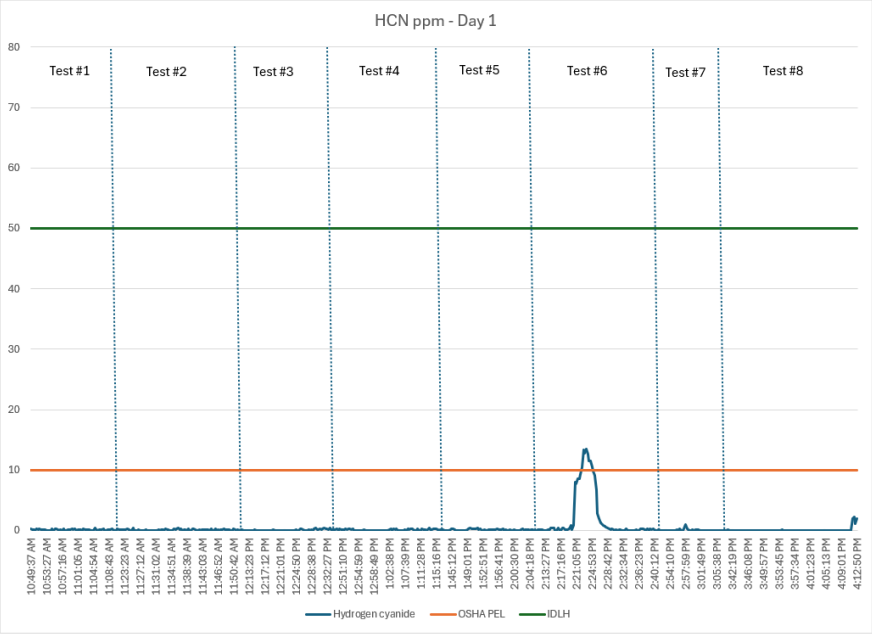
Hydrogen Fluoride - ppm

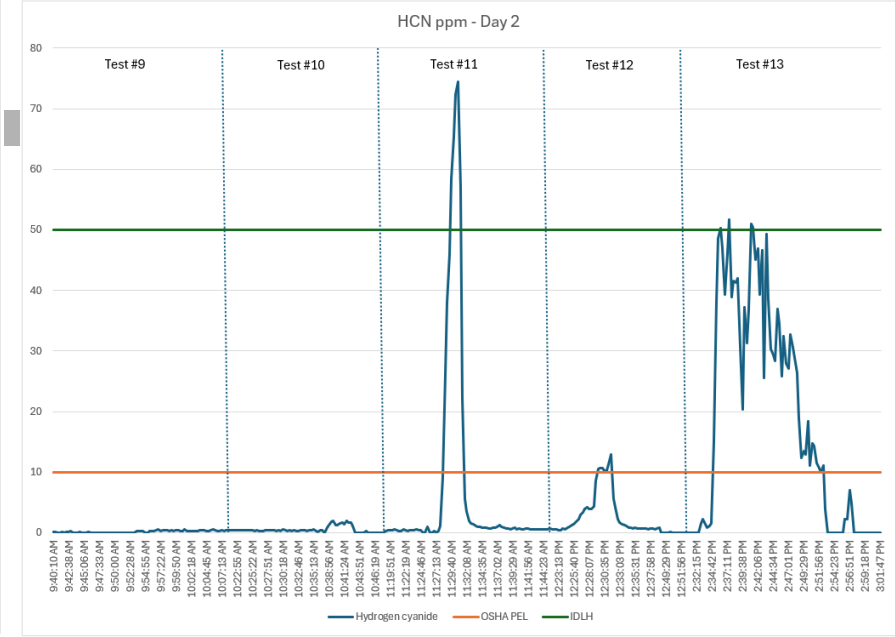




Test #	Description	Test #	Description
1	4 LiFePO4 18500 Solar - 100% SOC	8	65 NMC KULR Ebike & Amazon 18650
2	4 LiFePO4 18500 Solar	9	18 NMC Mollicel ISS 21700 - 100% SOC
3	8 LiFePO4 18500 Solar - Low SOC	10	2 LiFePO4 ESS (Prismatic) - 1 charged, 1 uncharged
4	8 LiFePO4 18500 Solar - 100% SOC	11	48 NMC Zhejang skateboard 21700, <40V
5	12 NMC (Nuon) 18650 - 100% SOC	12	48 NMC Zhejang skateboard 21700 - 100% SOC, 49.6V
6	44 NMC 21700 Zhejang Skateboard - 100% SOC plus some reacted cells	13	3 x NMC Zhejang Skateboard in Akkudan Box - 100% SOC, 144 cells total
7	8 N[illegible]ollicel ISS 21700 - <100% SOC		

Hydrogen Cyanide - ppm





Test #	Description
1	4 LiFePO4 18500 Solar - 100% SOC
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6	44 NMC 21700 Zhejang Skateboard - 100% SOC plus some reacted cells
7	8 [illegible] Mollicel ISS 21700 - <100% SOC

Test #	Description
8	65 NMC KULR Ebike & Amazon 18650
9	18 NMC Mollicel ISS 21700 - 100% SOC
10	2 LiFePO4 ESS (Prismatic) - 1 charged, 1 uncharged
11	48 NMC Zhejang skateboard 21700, <40V
12	48 NMC Zhejang skateboard 21700 - 100% SOC, 49.6V
13	3 x NMC Zhejang Skateboard in Akkuginal Box - 100% SOC, 144 cells total

Notes/Lessons Learned

- We confirmed the presence of HF. More analysis of the data needed to see when it is higher concentrations i.e. smoking, on fire, exploding…and how long present
- Confirmed H2 present in room and in waste container
- HF and H2 can exceed IDLH
- Full SOC more hazardous/reactive.
- Batteries don't need a heat source (heating element) to go through thermal runaway:
- Can be more projectile than expected
- Some types like LiFePO4 took longer for thermal runaway, could present more vapors if they are not consumed with higher temperatures.
- Water works to discharge batteries with intact terminals
- Turnouts can get metals in them. Waiting on UCLA data. Other data from Texas A&M here: https://teex.org/ev-ess-current-practices/

Further Review/ Further Study

- LiPO4 vs Metal Oxide types. HF readings appeared slightly higher for LiPO4 vs NMC for the quantity tested.
- Outdoor monitoring for heavy metals/particulates
- Weather conditions for HF dispersion, lighter than air but water soluble
- Suppressant agent testing
- Wood crates for DDRs
- Much more…

Any Questions?

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