NHTSA

NATIONAL HIGHWAY TRAFFIC SAFETY ADMINISTRATION

Overview of NHTSA EV Safety Activities

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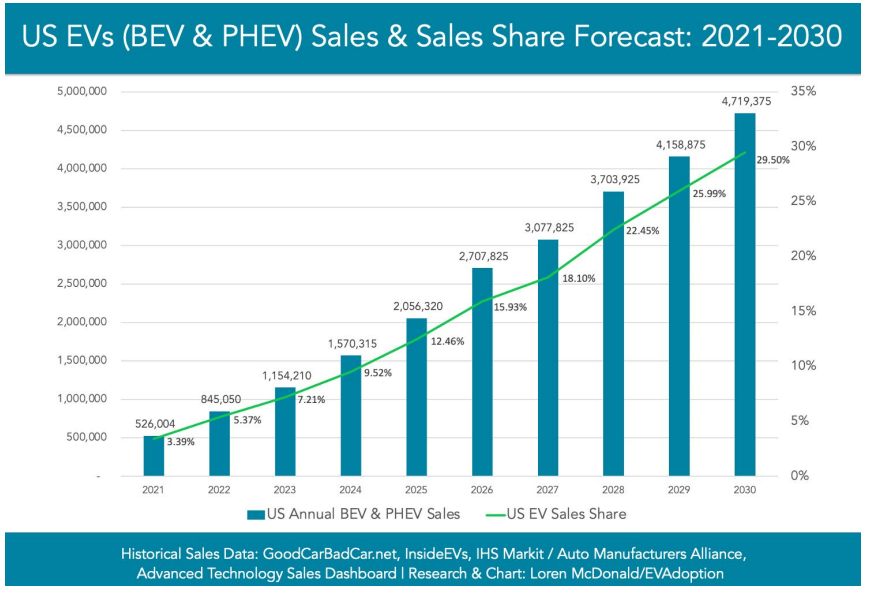
Agenda

- Overview of NHTSA R&D activities to support greater EV adoption
  - Prevention, Mitigation and Response to EV Battery safety incidents
- Flooded EV Safety (In progress study)
  - Mitigate EV fires due to catastrophic Hurricane Ian flooding
- Multiple partners support NHTSA R&D:



https://evadoption.com/ev-sales/ev-sales-forecasts/, on 1/4/23

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

SwRI SOUTHWEST RESEARCH INSTITUTE

Argonne NATIONAL LABORATORY

mga

INL Idaho National Laboratory

SAE INTERNATIONAL

VIRGINIA TECH TRANSPORTATION INSTITUTE VIRGINIA TECH

FEMA | U.S. Fire Administration

+ Others …

Overview of NHTSA R&D Activities to Support Greater EV Adoption

NHTSA Advancing EV Systems Safety

NHTSA + partners have developed test procedures to characterize the failure modes and mitigation methods associated with Lithium-ion battery EVs

Battery Pack Failure scenarios include:

Mechanical

- Crush
- Penetration
- Shock
- Vibration
- External thermal exposure
- **Immersion** (Hurricanes Ian, Sandy)
- Chemical Exposure

Control

- External Short Circuit
- Over Charge
- Under Charge
- Loss of isolation (internal)
- Internal Thermal Control
- Cell properties (balance)

Manufacturing Defects

Propriety, complex manufacturing process with multiple failure points

THERMAL RUNWAY & PROPAGATION → **FIRE / TOXIC GAS**

NHTSA Efforts

Prevention
On-board early warning battery diagnostics

Mitigation
Battery Pack Thermal runway response

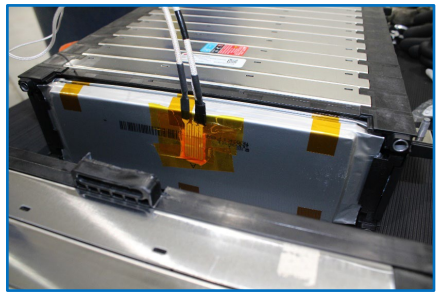
Response
Improved fire fighting techniques

Mitigation: EV Battery Pack Thermal Propagation

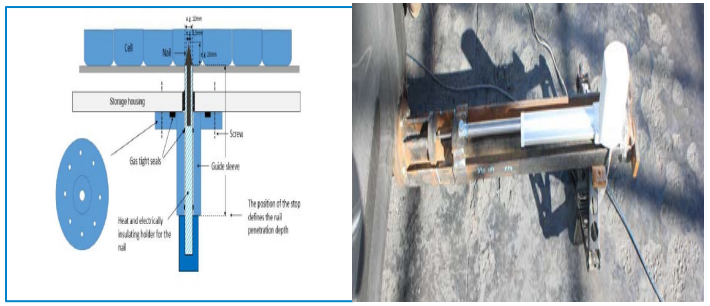
- Battery pack mitigates single cell failure
- Characterize EV pack abuse test method:
  - Objective & Reproducible

(1) Localized rapid heating (2) Nail penetration

Heater: -TRIM NRC

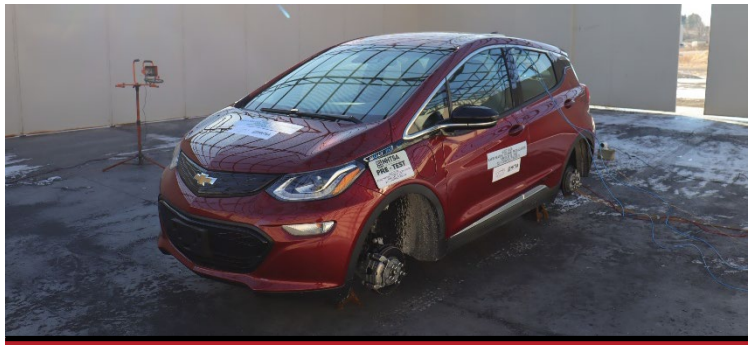


Heater located at cell



Nail Penetration – ISO 6469:1

T/Cs distributed



Test Setup Information	
Vehicle Ignition	On – in Park
Ambient Temperature (°C)	5
Ambient Wind Speed (m/s)	8.0 SSW
TRIM Target Temp (°C)	700
TRIM Ramp Time (s)	10

Mitigation: EV Battery Pack Thermal Propagation

Method	Vehicle	External Smoke (min:sec)	Smoke - In Cabin (min:sec)	External Flame (min:sec)	Warning Observed	Venting Observed	CO in ppm (min:sec)
TRIM	2019 Chevrolet Bolt	00:15	00:38	22:29	No	Yes	N/A
TRIM	2021 Chevrolet Bolt	00:17	01:10	08:17	Yes (00:51)	Yes	> 100 ppm (02:20) > 1500 ppm (3:30)
NP	2021 Chevrolet Bolt	00:07	03:10	11:58	Yes (00:27)	Yes	> 100 ppm (07:30) > 1200 ppm (08:58)
TRIM	2020 Nissan Leaf	00:25	04:45	31:09	Yes (00:45)	Yes	N/A
NP	2021 Nissan Leaf	00:05	01:10	24:48	Yes (00:34)	Yes	> 100 ppm (10:10) > 800 ppm (21:30)
TRIM	2020 Tesla Model 3	N/A	N/A	N/A	No	No	N/A
TRIM	2021 Tesla Model 3	00:28	N/A	N/A	No	Yes	N/A
TRIM	2022 Kia Niro EV	01:01	03:57	177:03	No	Yes	25 ppm (5:25)
NP	2022 Kia Niro EV	07:16	14:40	59:31	No	Yes	> 100 ppm (14:20)

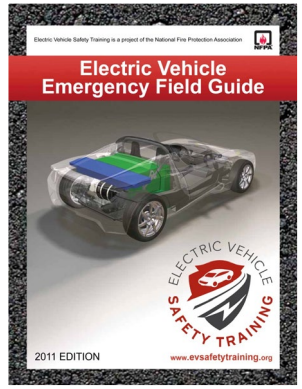
- Results at UN GTR No. 20 – EVS25, Nov 2022
- Large deviation in vehicle results based on cell method

Post Test Observation	Value
TRIM Operation Time (s)	14
Minimum Voltage of Initiation Cell (V)	Not measured
Maximum Temperature of Initiation Cell (°C)	802
dT/dt ≥ 1K/s	Yes
Propagation	Yes
Venting Observed	Yes
Fire/Flames Observed	Yes
Time Observed (min)	8
Warning to Driver/Occupants Observed	No

Post Test Observation	Value
TRIM Operation Time (s)	25
Minimum Voltage of Initiation Cell (V)	Not measured
Maximum Temperature of Initiation Cell (°C)	324
dT/dt ≥ 1K/s	Yes
Propagation	No
Venting Observed	No
Fire/Flames Observed	No
Time Observed (min)	N/A
Warning to Driver/Occupants Observed	No

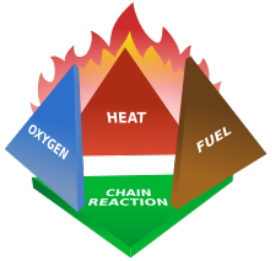
Response: Battery Electric Vehicle Fire Safety

- EV Fire Guidance 16 OEMS + Stake holders
- SAE J2990 Hybrid and EV First & Second Responder Recommended Practice

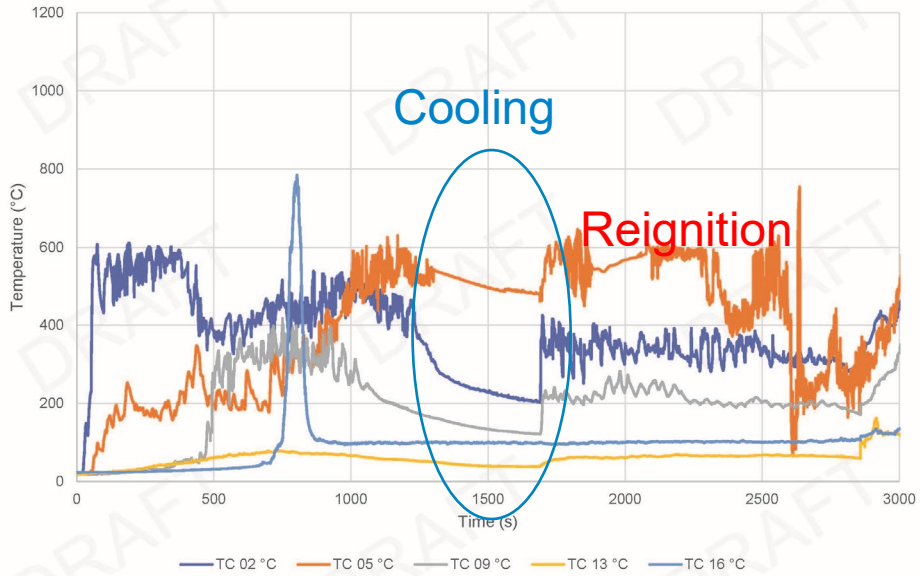


First responders' EV issues persist

- Defensive Fire Response
- Reignition due to Stranded Energy



*NFPA updated in 2018



- Study with US Fire Administration

Best tactics for EV fires

- Stranded Energy

Identify best strategies to mitigate

Flooded EV Safety

Flooded EV Safety Study (In Progress)

- Hurricane Ian storm surge 6-15 ft (< 12 hrs)
  - 3000~5000 EVs impacted (~600 total loss)
  - 17 EV fires
  - Multiple Li ion fires (golf carts, power tools)
- Rescue / Clean up, EV fire concerns:
  - BEV vs ICE fire: Increased time & cooling
  - Reignition during transport & storage
  - EV Hazard status unclear

    Fire ~ 4 weeks after submersion

FLORIDA · Published October 6, 2022 4:30pm EDT

Electric vehicles are exploding from water damage after Hurricane Ian, top Florida official warns

Florida's chief fire marshal and financial officer said there are a 'ton of EVs disabled' from Hurricane Ian

By Thomas Catenacci | Fox News

Responders requested improved guidance, tools & strategies for EV Fires

Previous Flooded EV Event: Superstorm Sandy (2012)

- At Port Newark, fire destroyed/damaged 16 of 338 PHEVs Fiskers Karmas
- Fire incident:
  - Single vehicle 12V shorting and subsequent fire
  - HV battery pack damage internal to steel case

16 PHEV vehicles destroyed, 338 water damaged

- EV Immersion Study:
  - 12 xEVs evaluated to ISO 6469 & SAE J2464
  - Hazards characterized (HV, Toxic gas, Fire)

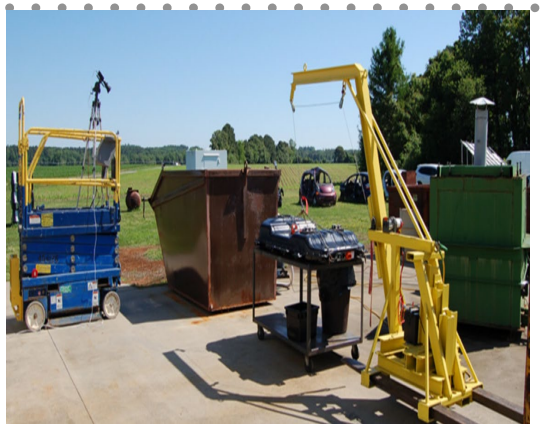
Safety Performance of Rechargeable Energy Storage Systems – DOT HS 812 717, May 2019

20 kWh High Voltage Li ion battery back and cell damage

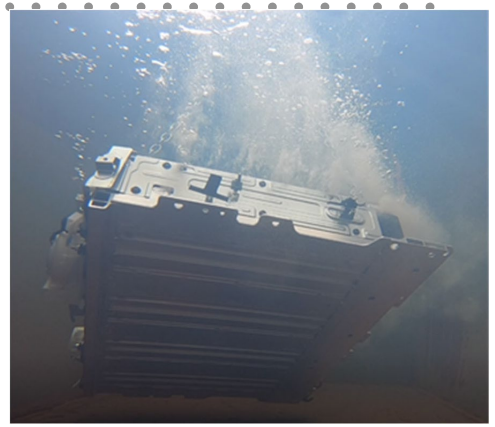
Battery Pack Immersion Study Summary

- Li-Ion Battery Pack Immersion Exploratory Investigation DOT HS 812 717, May 2019

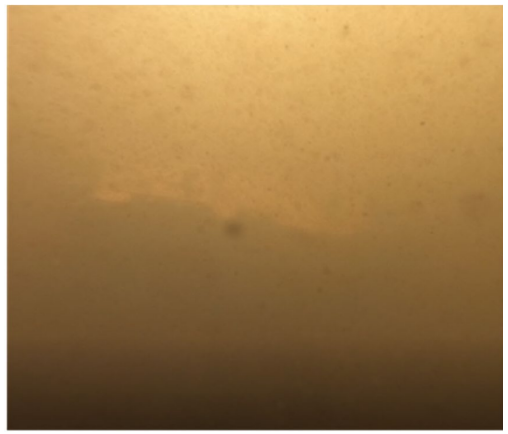
- No fires with any batteries while immersed
- Post-immersion batteries were under 50 V
- Larger capacity batteries took longer
- Post immersion, 2 batteries had smoke/venting
  - Battery 1 was immersed for 20 min. (3.5% salinity)
  - Battery 2 was immersed for 15 min (0.1% salinity)
- Battery passivation occurred quicker in 3.5% salinity



Full EV battery pack immersion



Water ingress and reaction



Byproducts contamination

Incomplete passivation

Immersion in lower salinity & shorter duration increased hazard vs. 2 hr. immersion duration

Conclusion

- Immersion study is ongoing to update guidance for future catastrophic EV flood events
- NHTSA EV Safety Publications at *https://rosap.ntl.bts.gov/*

- *Propagation Mitigation Testing Procedures, Modeling, and Analysis – DOT HS 813 230, March 2022*
- *Failure Modes and Effects Analysis for Wireless and Extreme Fast Charging – DOT HS 813 137, July 2021*
- *Li-Ion Battery Pack Immersion Exploratory Investigation – DOT HS 813 136, July 2021*
- *Electric Vehicle GTR No. 20 Test development, Validation, and Testing – DOT HS 812 092, April 2021*
- *Li-Ion Battery Propagation Trigger Technique Development/ Igniter Development – DOT HS 812 786, February 2020*
- *Stranded Energy Assessment Techniques and Tools – DOT HS 812 789, February 2020*
- *Battery State of Health and Stability Diagnostic Tool Set Development – DOT HS 812 810, January 2020*
- *System-Level RESS Safety and Protection Test Procedure Development, Validation, and Assessment–Final Report – DOT HS 812 782, October 2019*
- *DC Charging Safety Evaluation Procedure Development, Validation, And Assessment, and Preliminary Draft AC Charging Evaluation Procedure – DOT HS 812 754, July 2019.*
- *Safety Performance of Rechargeable Energy Storage Systems – DOT HS 812 717, May 2019*

Thank You! / Questions & Comments ?