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:
  
  ![Partners Logos]

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

**NHTSA Efforts**

**Prevention**
On-board early warning battery diagnostics

**Mitigation**
Battery Pack Thermal runway response

**Response**
Improved fire fighting techniques

THERMAL RUNWAY & PROPAGATION

FIRE / TOXIC GAS
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

<table>
<thead>
<tr>
<th>Test Setup Information</th>
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<tbody>
<tr>
<td>Vehicle Ignition</td>
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<tr>
<td>Ambient Temperature (°C)</td>
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<tr>
<td>Ambient Wind Speed (m/s)</td>
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<tr>
<td>TRIM Target Temp (°C)</td>
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<td>TRIM Ramp Time (s)</td>
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</table>
Mitigation: EV Battery Pack Thermal Propagation

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

- Study with US Fire Administration
  Best tactics for EV fires

- Stranded Energy
  Identify best strategies to mitigate

*NFPA updated in 2018*
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

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

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

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
  - 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

Thank You! / Questions & Comments?