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EV and Lithium-Ion battery hazards & Emerging Code Requirements

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EFCOG 2023 – August 1, 2023

SRNS-TR-2023-00418

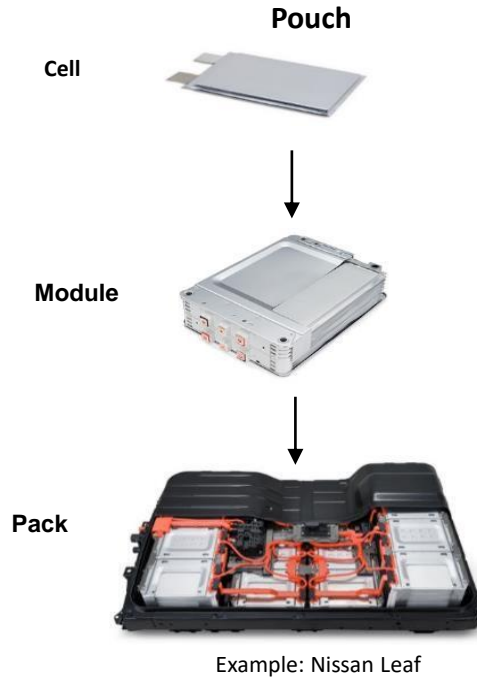
Michael J. Davenport

- Savannah River Nuclear Solutions Contractor Authority Having Jurisdiction (CAHJ)
- ICC Certified Fire Marshal and Building Official
- Savannah River Site Qualified Fire Protection Engineer
- 42 Years experience in fire protection engineering and fire fighting

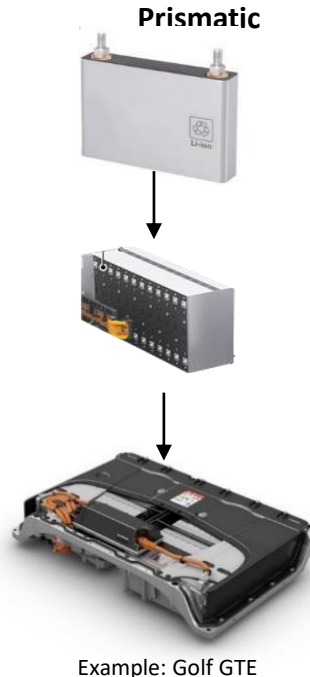
Craig S. Burgess

- Savannah River Site Qualified Fire Protection Engineer
- Senior FPE liaison to the SRS Fire Department
- Retired Captain from Aiken City Fire Department – 30 years of service

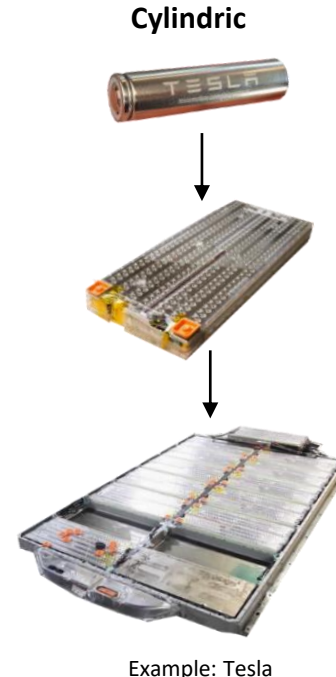
Basics – Structure of Rechargeable Batteries



Source: Nissan



Source: Volkswagen AG



Source: Tesla

Info:

A Nissan Leaf contains ~192 pouch cells

A VW ID.4 has > 300 prismatic cells in the battery pack

A Tesla Model S has > 7,000 cylindrical cells in the battery pack.

With the “new” technology comes new challenges

- **Fire Stats**

- 50% of all verified EV battery fires the vehicle were connected to energized charging stations
- 63% occurred in underground / enclosed space
- 35.7% occurred while parked or driving in open air

- **Full Scale Fire Testing of Li-Ion Electric Vehicles Highlights**

- Characteristics of EV fire is comparable with those of conventional ICE vehicles
- The new combustibles in the battery pack make a minor contribution to the whole magnitude of EV fires
- The jet flame, caused by thermal runaway, accelerates the fire spread to other combustibles
- The uncertainties, induced from unforeseen thermal runaway and reignition, make a major risk to first responders.

Source: Applied Energy 332 (2023) 120497

- **Fire Hazards**

- Irreversible thermal event
- Electrolyte in Li-Ion battery is flammable
- Intense heat with possible flame jets
- Thermal runaway produces large amounts of dangerous gasses and heavy metals
- Lithium salts in the battery are self-oxidizing

*** Initial Solution to EV Fires is up to 15,000 gallons of water, ~ 6 hours**





- **Explosion Hazards**
 - Electrolyte overheats causing evaporation
 - Vented gases may or may not be ignited immediately
 - Vented gases that do not ignite immediately pose an explosion hazard



EV FireSafe

Electric Vehicle Battery Fire Deep Dive

*Jeep Hybrid garage explosion
Colorado, USA, 11 April 2023*



- **Vapor / Explosive Hazards**

- Vapors can be trapped or vented

- Trapped Vapors – Explosion (High probability)

- *Cause over-pressurization to the battery compartment*

- *Increase the heat being trapped in the battery compartment*

- *Cause thermal-runaway*

- Vented Vapors – Fire, Explosion unlikely

- *Ignites quickly and intensely*

- *Vapors are toxic especially HF (Hydrofluoric Acid)*

- CO, CO₂, HF, PF₅, POF₃

- **Contamination Hazards**

- Heavy metals
- Hydrocarbons

- **Poisonous Gasses**

- Lithium Dioxide
- Lithium Hydroxide



- **Current best practices**

- Li-Ion batteries, Chargers, and Devices shall be UL Listed
- Restrict charging of *personal* Li-Ion technology to cell phones only
- Storage locations when technology is not in use shall be evaluated
- Restrict indoor usage to handheld devices such as laptops, cellphones, handheld power tools and handheld charging banks (Use FAA guidance on size)
- MAQ of storage and waste streams needs to be evaluated for Li-Ion hazard
- Consider adoption of 2024 IFC draft language on Li-Ion requirements



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Current Code Requirements referencing Lithium/Li-Ion & EV systems



2021 IBC

— No requirements



- NFPA 70 – 2023 (National Electric Code)
- NFPA 484 – 2022 (Combustible metals)
- NFPA 855 – 2023 (Standard for ESS Installation)

2021 IFC



- 406.2.7 - Electric vehicle charging stations and system
- 903.2.10 - Group S-2 parking garages
- 1107 – Motor-Vehicle-Related Facilities
- 1207 – Electrical Energy Storage Systems (ESS)
- 3203 – Commodity Classifications
- Chapter 59 (Flammable Solid)
- Generally silent on storage requirement associated with Li batteries
- Li-Ion batteries currently listed as "high hazard commodity"

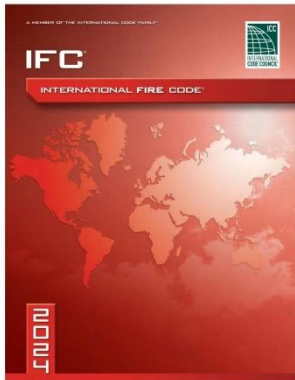
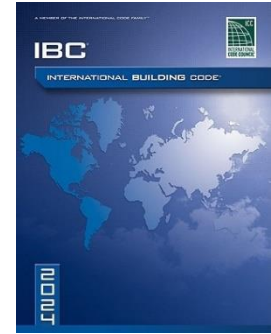
- **ICC A117.1 Section 502.11**
 - **EV Charging Stations**
 - *Operable parts – comply with section 309 (accessibility)*
 - *Accessible route -*
 - *Obstructions – Bollards curbs and wheel stops shall not obstruct access route*
- **NFPA 70**
 - **Requires emergency power shutdown device**
- **EV charging stations are being provided with Energy Storage Systems**

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Emerging code requirements – Draft 2024



- **Draft 2024 IBC changes (language is being finalized for publication)**
 - Occupancy Classification changes coming
 - Automatic Sprinkler systems
 - Fire Alarm and Detection systems



- **Draft 2024 IFC changes (language is being finalized for publication)**
 - 105.6.25 Permits- Lithium Batteries
 - 301.2 Permits
 - 321.3 Fire safety plans
 - 321.4 Storage Requirements
 - 403.10.6 Buildings with lithium-ion or lithium metal battery storage

- **New section 321 (chapter 3) on Storage Requirements**
 - **Storage requirement exceptions 321.1**
 - **Indoor storage in containers**
 - Depending on quantities and packaging may require:
 - *Permit*
 - *fire safety plan*
 - *Technical Opinion and Report to evaluate the level of hazard and protection measures.*
 - *Construction Requirements to include 2-hr barrier separation.*
 - *Fire Protection System*
 - *Fire Alarm System*
 - *Explosion Control*
 - *If batteries are stored at no more than 30% charge some of the above requirements are waived*

- **New section 321 (chapter 3) on Storage Requirements (cont.)**
 - **Outdoor storage areas**
 - Separation distances from structures, property lines and streets dependent on FP features
 - Fire Detection System required
 - Area and Size Limits

See previously emailed handout for detailed 2024 IFC draft language

Developing code requirements – 2027 IFC

- **2027 IFC Proposals**
 - **Section 309 Powered Industrial Trucks and Equipment**
 - *NFPA 505*
 - **Section 1207 - ELECTRICAL ENERGY STORAGE SYSTEMS (ESS)**
 - Strip most of section and incorporate NFPA 855
 - **Section 322 – Micro-mobility Devices**
- * **2027 codes and standards are generally becoming more restrictive**

BREAKING NEWS



SPECTRUM
NEWS

0:00 / 3:16

HERNANDO COUNTY: THUNDERSTORMS ARE POSSIBLE. HERNANDO COUNTY: THUNDERSTORMS

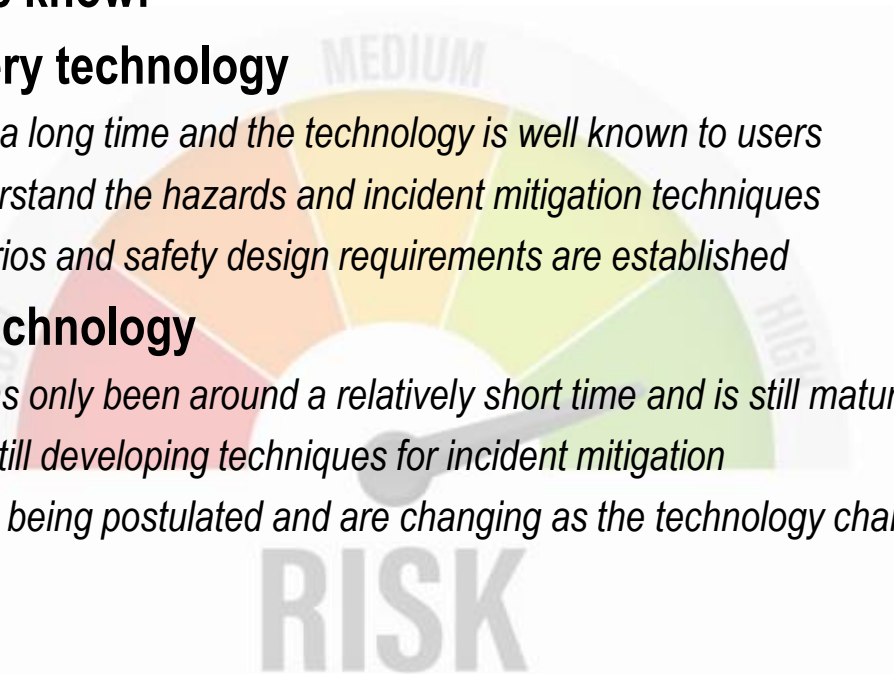
- **Stick with what we know:**

- **Lead-Acid battery technology**

- *Has been around a long time and the technology is well known to users*
 - *Responders understand the hazards and incident mitigation techniques*
 - *Postulated scenarios and safety design requirements are established*

- **Li-Ion battery technology**

- *By comparison has only been around a relatively short time and is still maturing*
 - *Responders are still developing techniques for incident mitigation*
 - *Scenarios are still being postulated and are changing as the technology changes and eventually stabilizes.*



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SRNS

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We make the world **safer.**





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