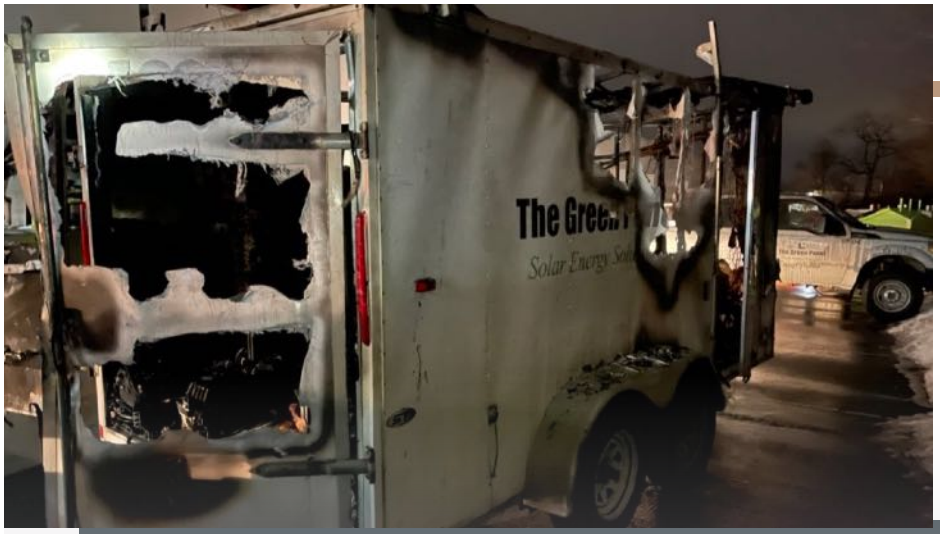


# UNDERSTANDING & MANAGING HAZARDS OF LITHIUM-ION BATTERY SYSTEMS

**MICHAEL O'BRIAN,** MANAGING PARTNER - CODE CONCEPTS GROUP

**MICHAEL SNYDER,** VP OPERATIONAL RISK MANAGEMENT – DEKRA

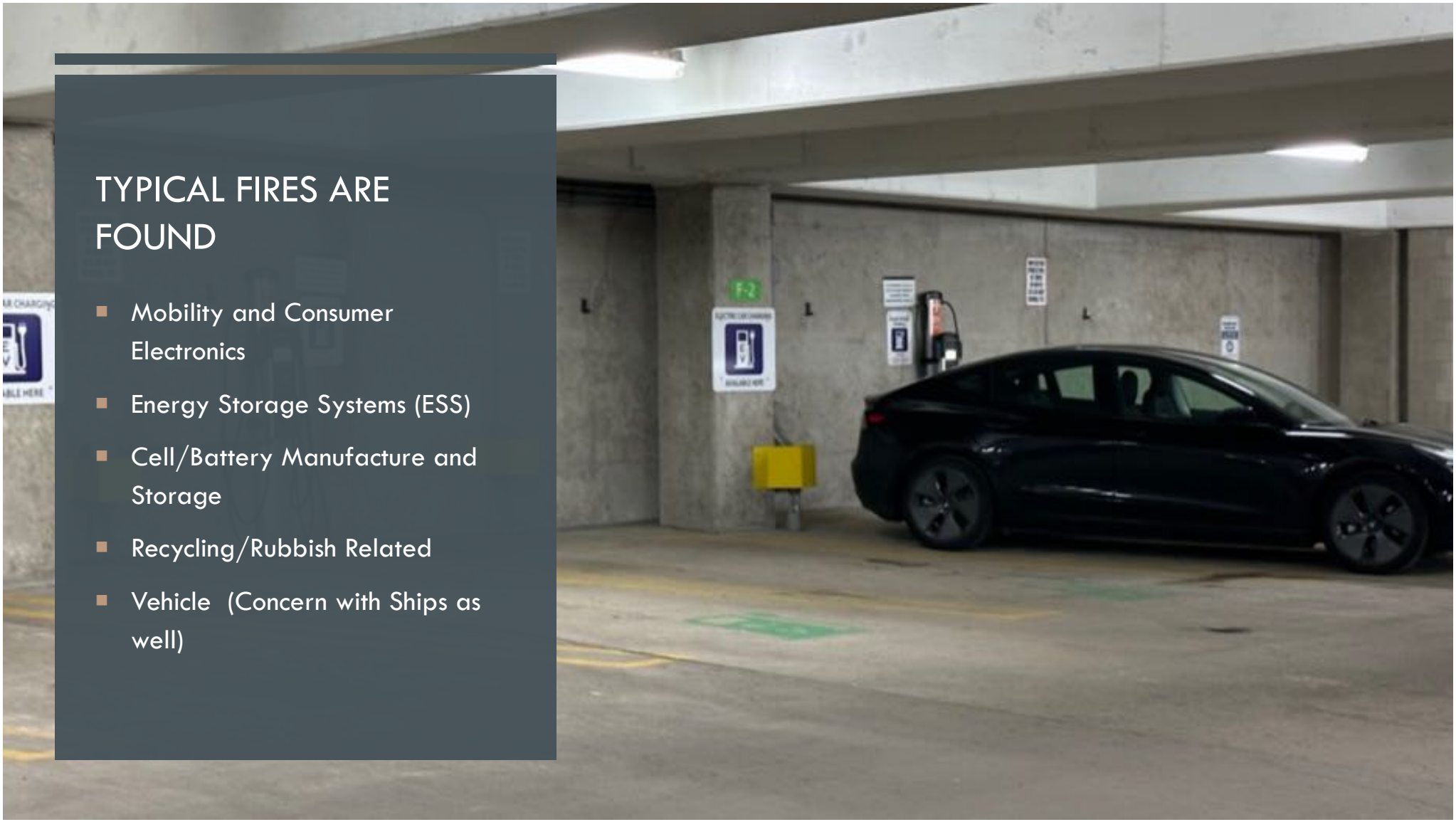
MICHIGAN SAFETY CONFERENCE

APRIL 16, 2024

# TOPICS FOR TODAYS DISCUSSION

- Overview of Li-ion Battery Utilization & Challenges
- Li-ion Battery Basics
- Anatomy of a Li-ion Battery Thermal Runaway
- Prevention, Preparedness, & Response
  - Fire & Building Codes, Emerging Best Practices, & Continued Opportunities
- Summary & References

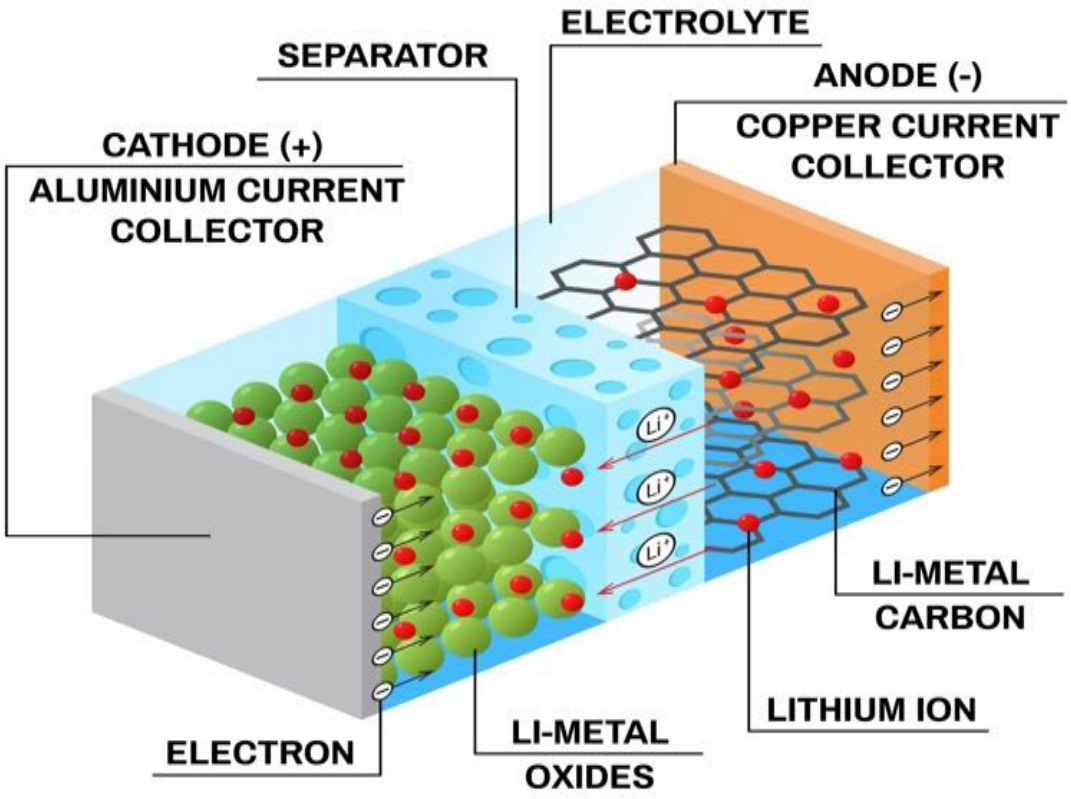

# WHERE ARE FIRES OCCURRING



# TYPICAL FIRES ARE FOUND

- Mobility and Consumer Electronics
- Energy Storage Systems (ESS)
- Cell/Battery Manufacture and Storage
- Recycling/Rubbish Related
- Vehicle  (Concern with Ships as well)

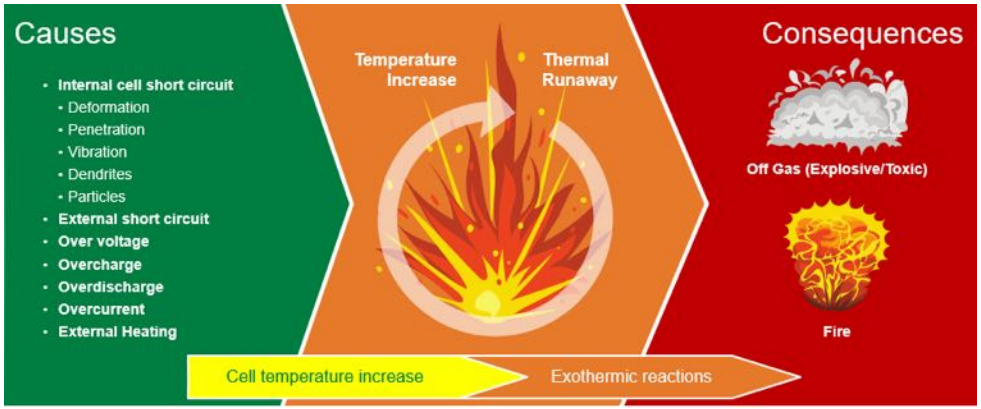
# LI-ION BATTERY NOMENCLATURE (DISCHARGE)



# LI-ION BATTERY NOMENCLATURE

- **Building Blocks**
  - Cells (Cylindrical, Prismatic, Pouch)
  - Modules
  - Packs
- **Battery Management Systems**
- **Thermal Management Systems**
- **Primary versus Secondary Cells**
- **Capacity (Wh) and State of Charge (SOC)**
  - Relationship of Capacity and SOC to Hazard
- **Solid Electrolyte Interphase (SEI)**
- **No "Free" Metallic Lithium in Battery**

# ANATOMY OF A LI-ION BATTERY THERMAL RUNAWAY




- **View through Abuse Mechanisms**
  - Mechanical
  - Electrical
  - Thermal
- **Manufacturing through Lifecycle Evaluation**
- **Each Mechanism results in "Short Circuit"**
- **Battery Components Have Specific Thermal Sensitivities**
  - Chemistry Dependent
- **Current Electrolytes Present Challenges**
  - Ignitable Liquids (Organic Carbonates)
  - Decomposition into HF (LiPF6)
- **Reignition & Stranded Energy Challenges**

# TODAY'S CODES AND EMERGING TECHNOLOGY

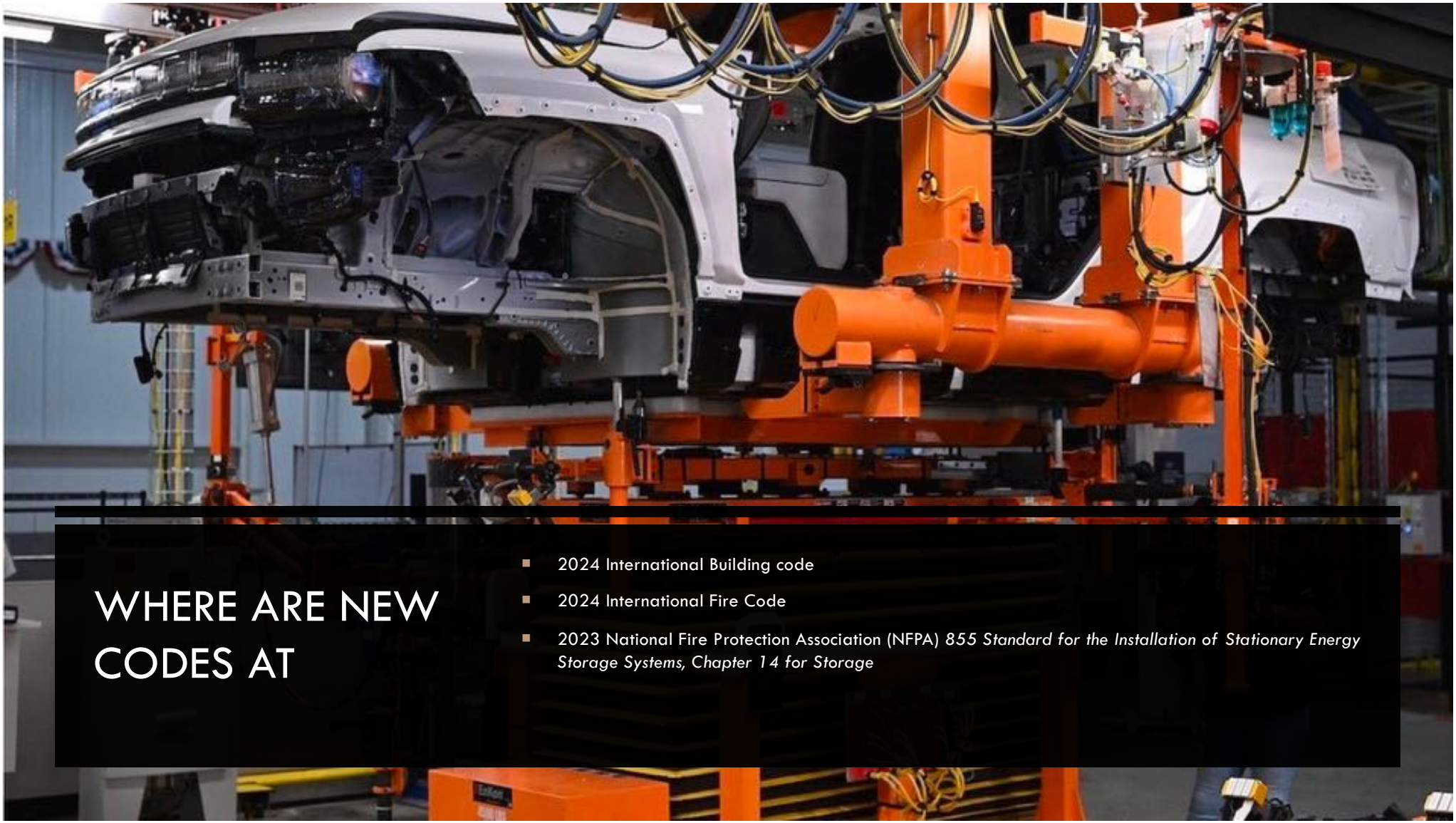
Most currently **adopted** fire and building codes do not have specific language for the storage, testing, manufacture and associated uses with lithium ion and other batteries types outside of legacy battery types

Code Development processes have specific provisions on what to do when technology moves faster then code development processes

Codes are Slow and Technology is Fast

# EMERGENCY RESPONSE PLANNING

- Staff Training
- Development of Overall Plans
- Evacuation Planning
- Business Continuity
- Post Incident Clean Up



# WHERE ARE NEW CODES AT

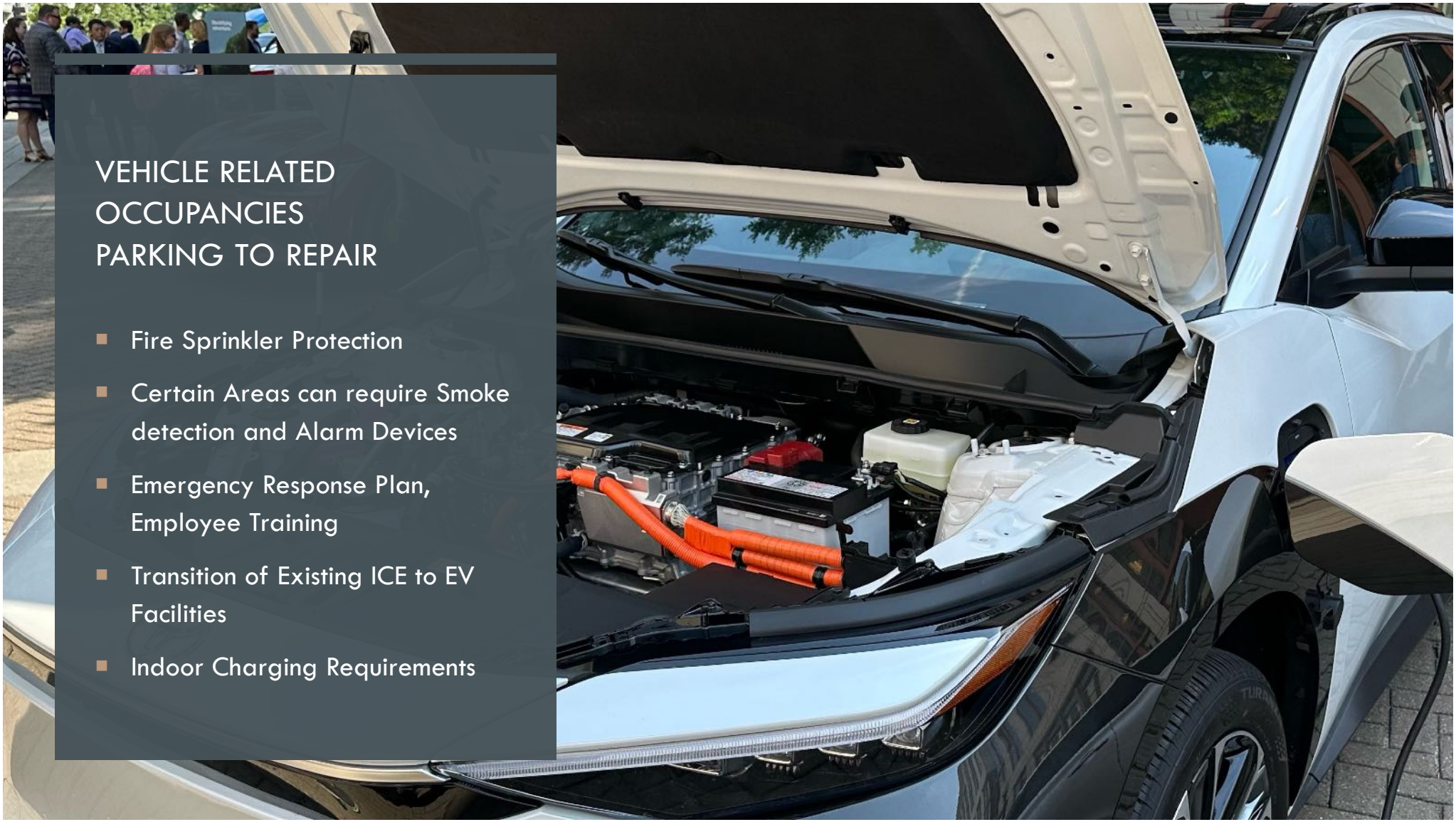
- 2024 International Building code
- 2024 International Fire Code
- 2023 National Fire Protection Association (NFPA) *855 Standard for the Installation of Stationary Energy Storage Systems, Chapter 14 for Storage*


# 2023-2024 PROVISIONS

- New Section IFC 320 specific for battery storage
- Updates for clarification on use group classifications in the built environment
- 1207 Updates for Energy Storage Systems (
- Newest NFPA 855 2023 edition for Energy Storage System
- Updates in Sprinkler Protection (when required)
- Updates on Mobile ESS

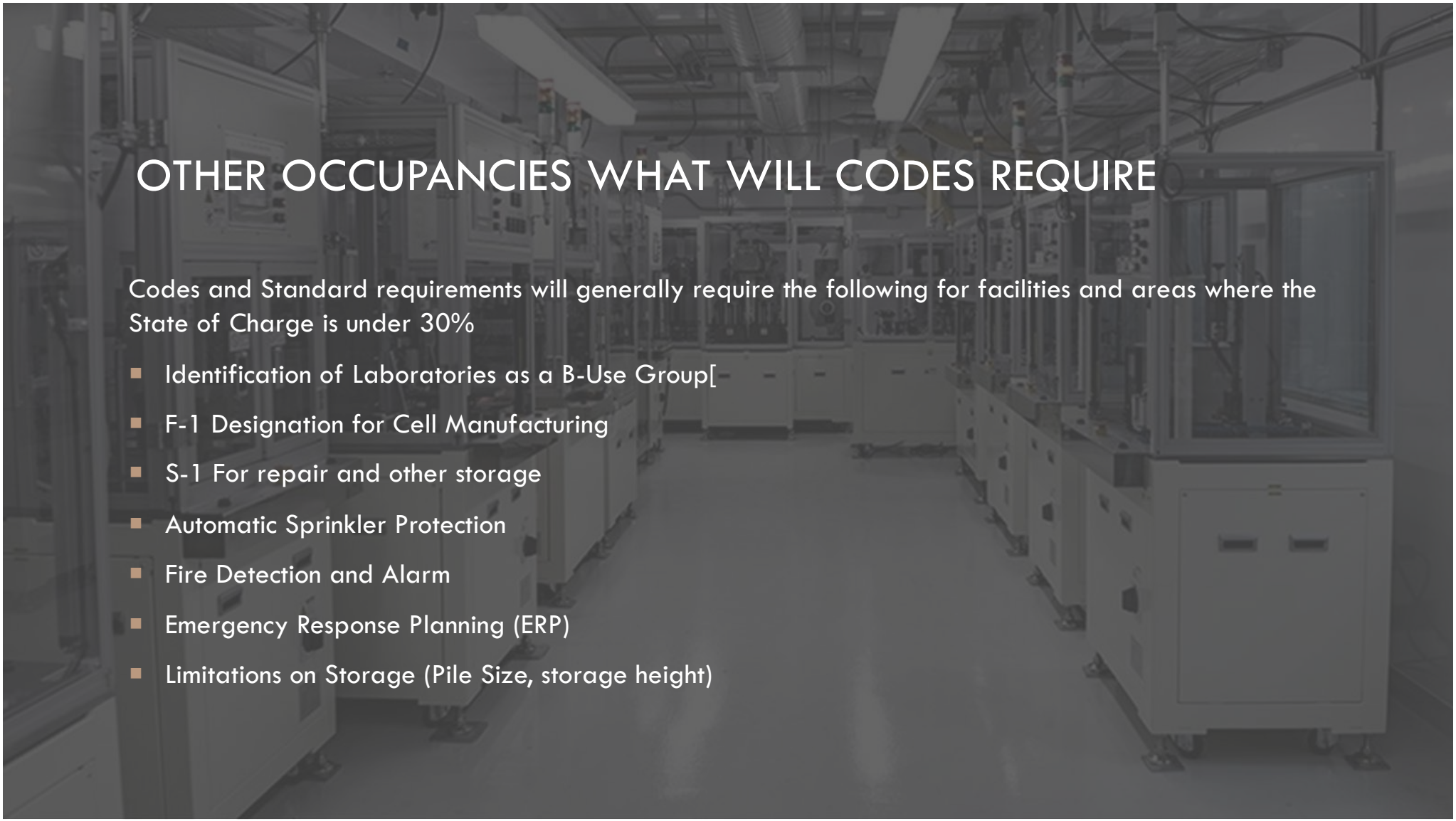
# PERSONAL MOBILITY IFC 322

- Where required
- Prohibited locations
- Charging Equipment
- Charging Areas
- Fire Safety Plan



## VEHICLE RELATED OCCUPANCIES PARKING TO REPAIR

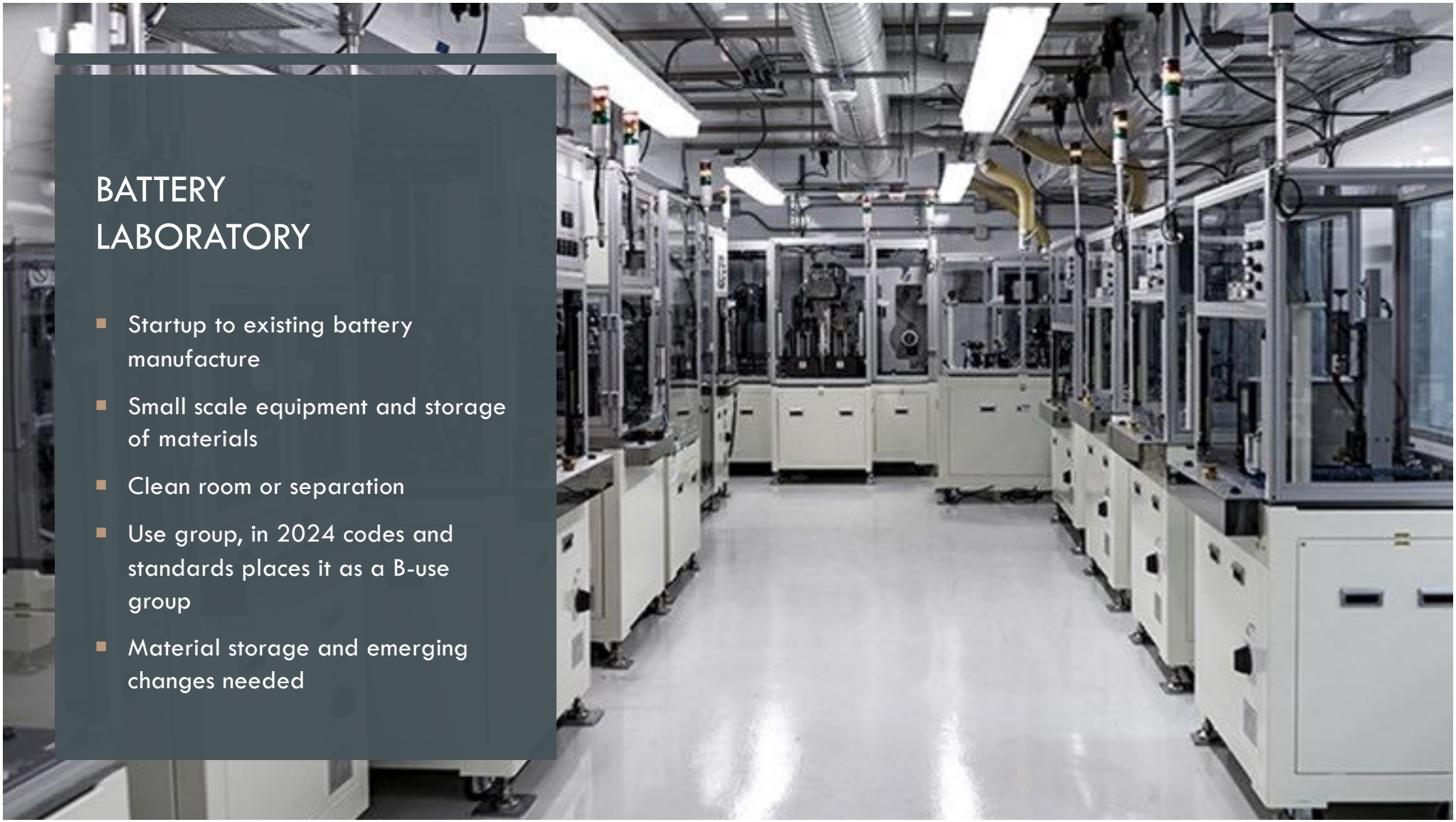
- Fire Sprinkler Protection
- Certain Areas can require Smoke detection and Alarm Devices
- Emergency Response Plan, Employee Training
- Transition of Existing ICE to EV Facilities
- Indoor Charging Requirements



# OTHER OCCUPANCIES WHAT WILL CODES REQUIRE

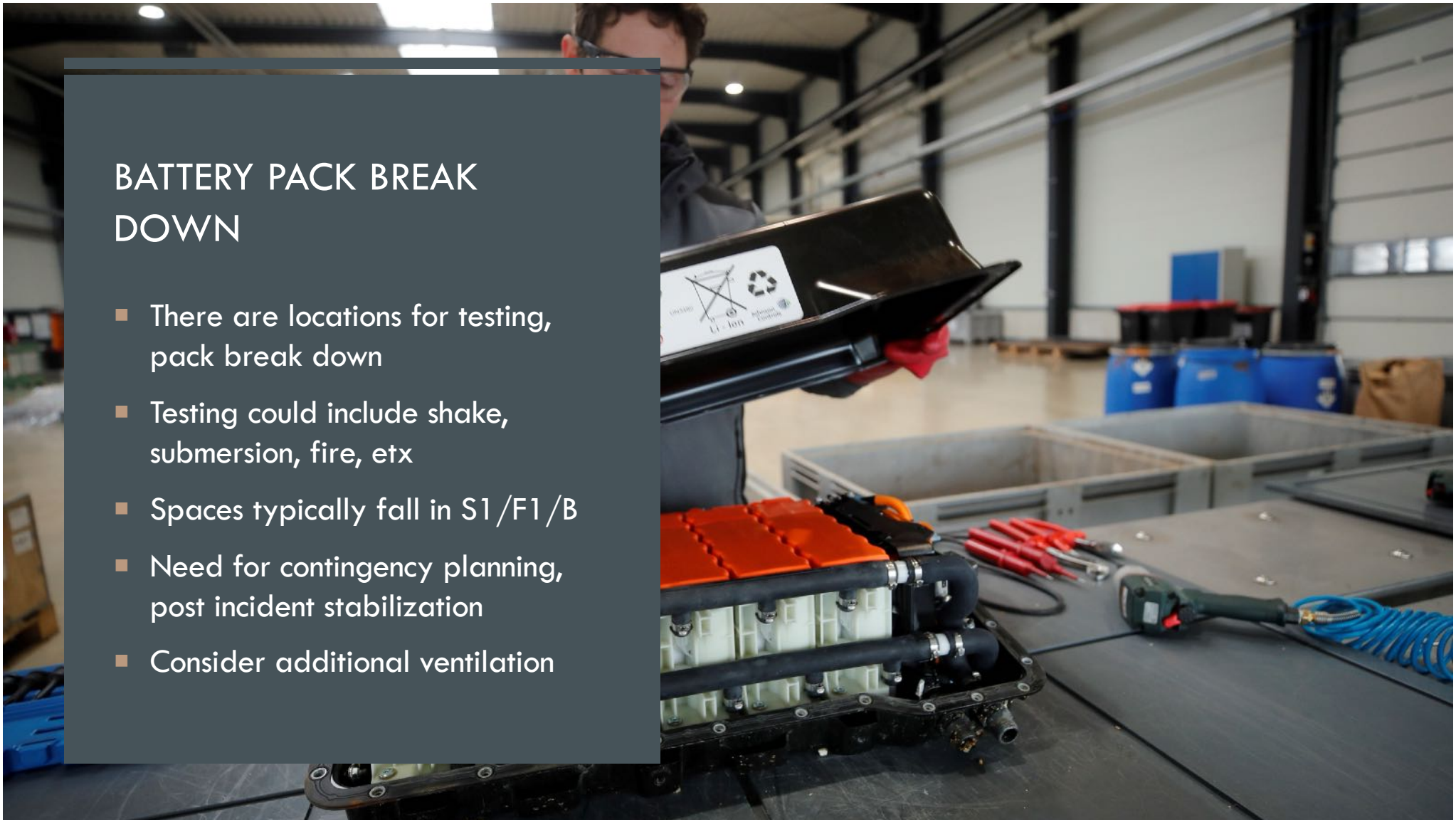
Codes and Standard requirements will generally require the following for facilities and areas where the State of Charge is under 30%

- Identification of Laboratories as a B-Use Group[
- F-1 Designation for Cell Manufacturing
- S-1 For repair and other storage
- Automatic Sprinkler Protection
- Fire Detection and Alarm
- Emergency Response Planning (ERP)
- Limitations on Storage (Pile Size, storage height)



# BATTERY LABORATORY

- Startup to existing battery manufacture
- Small scale equipment and storage of materials
- Clean room or separation
- Use group, in 2024 codes and standards places it as a B-use group
- Material storage and emerging changes needed

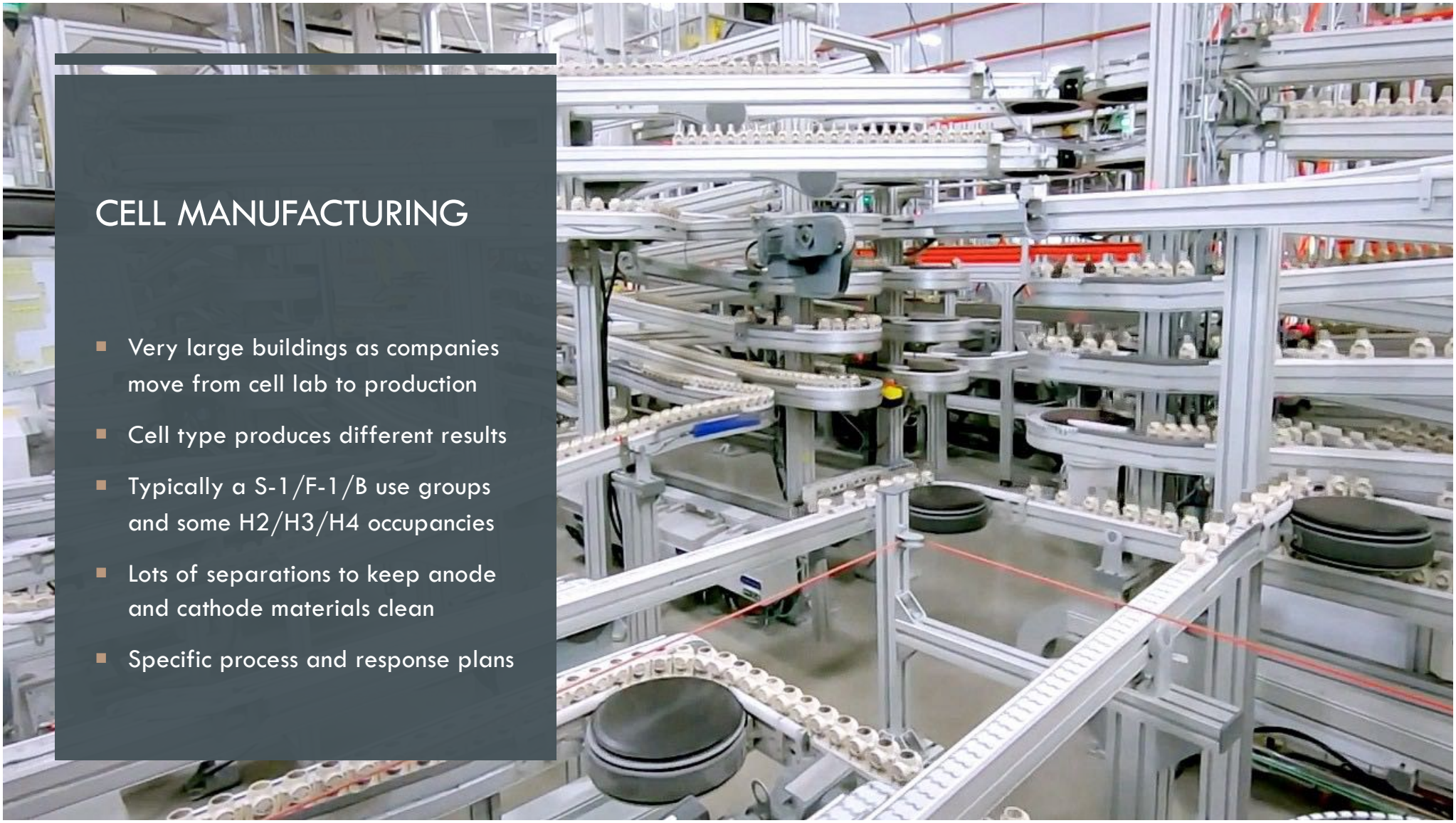


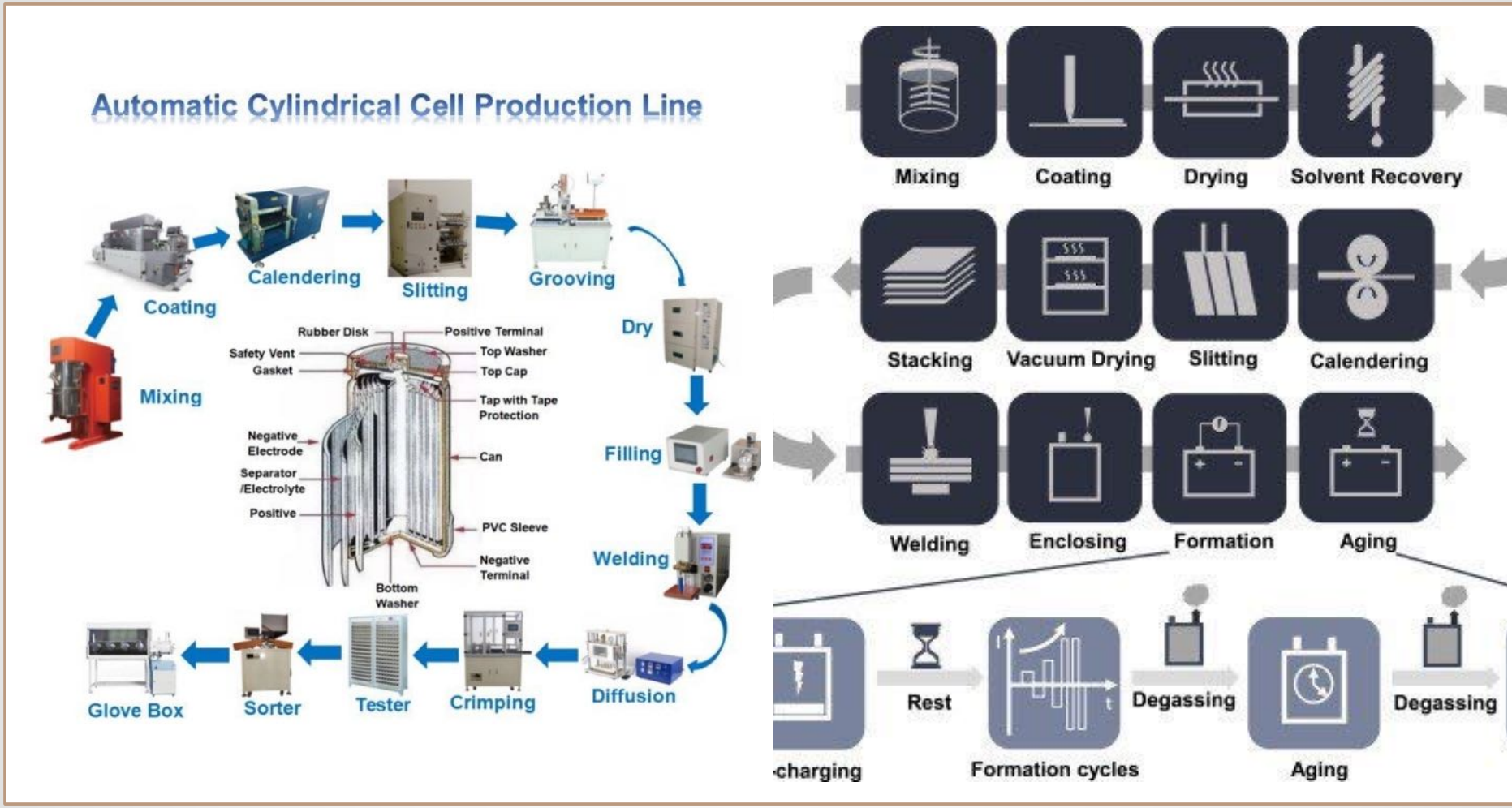
# BATTERY PACK BREAK DOWN

- There are locations for testing, pack break down
- Testing could include shake, submersion, fire, etx
- Spaces typically fall in S1/F1/B
- Need for contingency planning, post incident stabilization
- Consider additional ventilation

# CELL MANUFACTURING

- Very large buildings as companies move from cell lab to production
- Cell type produces different results
- Typically a S-1/F-1/B use groups and some H2/H3/H4 occupancies
- Lots of separations to keep anode and cathode materials clean
- Specific process and response plans



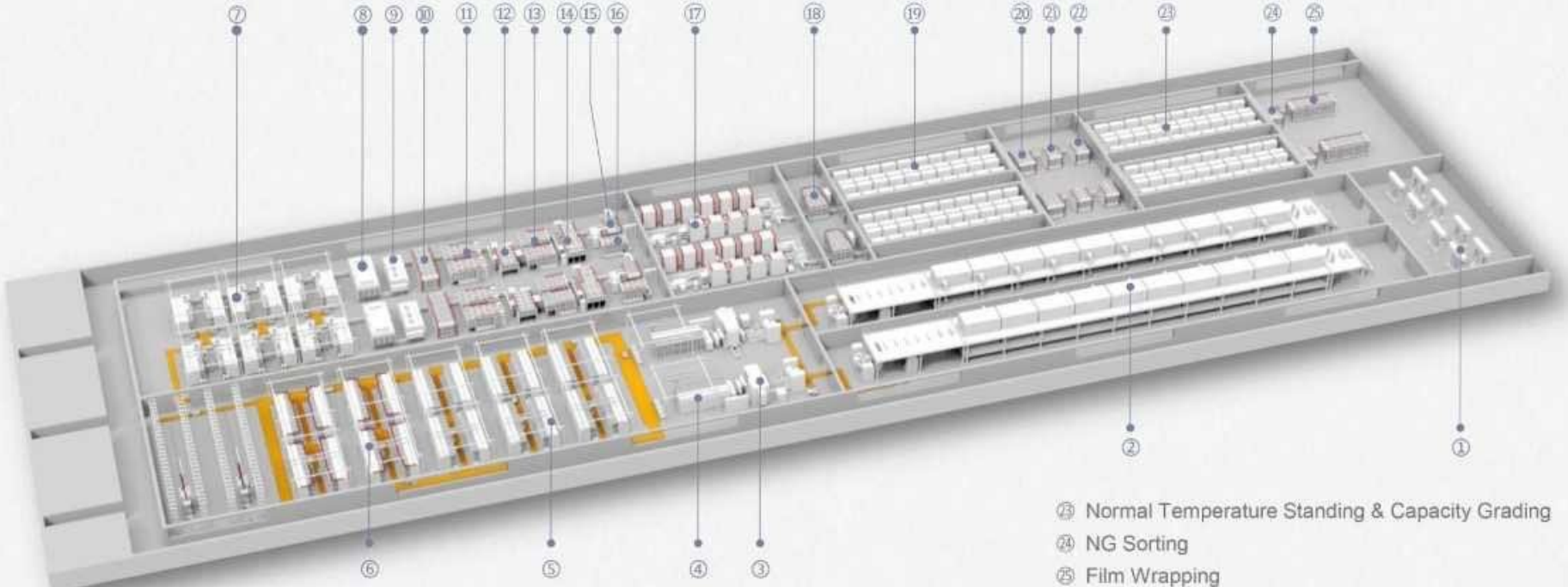

Automatic Cylindrical Cell Production Line
Coating
Calendering
Slitting
Grooving
Dry
Filling
Welding
Diffusion
Crimping
Tester
Sorter
Glove Box
Mixing
Rubber Disk
Positive Terminal
Safety Vent
Top Washer
Gasket
Top Cap
Tap with Tape Protection
Negative Electrode
Can
Separator /Electrolyte
Positive
PVC Sleeve
Negative Terminal
Bottom Washer
Mixing
Coating
Drying
Solvent Recovery
Stacking
Vacuum Drying
Slitting
Calendering
Welding
Enclosing
Formation
Aging
-charging
Rest
Formation cycles
Degassing
Aging
Degassing

# Business Scope

Lead turnkey automation @ LIB Prismatic

① Mixing
② Coating
③ Roll Pressing
④ Striping
⑤ Tab Forming
⑥ Slitting
⑦ Winding
⑧ Preheating
⑨ Heat Pressing
⑩ Matching
⑪ Tab Welding
⑫ Adapter Welding
⑬ Film Wrapping
⑭ Shell Inserting
⑮ Top Sealing
⑯ Leakage Testing
⑰ Backing
⑱ 1st Filling
⑲ High Temperature Standing & Formation
⑳ 2nd Filling
㉑ Seal Nail Welding
㉒ Leakage Testing

- prismatic LIB: 28 ppm x 2
- 5.6 GWh
- 48 operators per shift
- 405 x 108 x 18/10 m
- 20,000 kW




㉓ Normal Temperature Standing & Capacity Grading
㉔ NG Sorting
㉕ Film Wrapping

# STORAGE

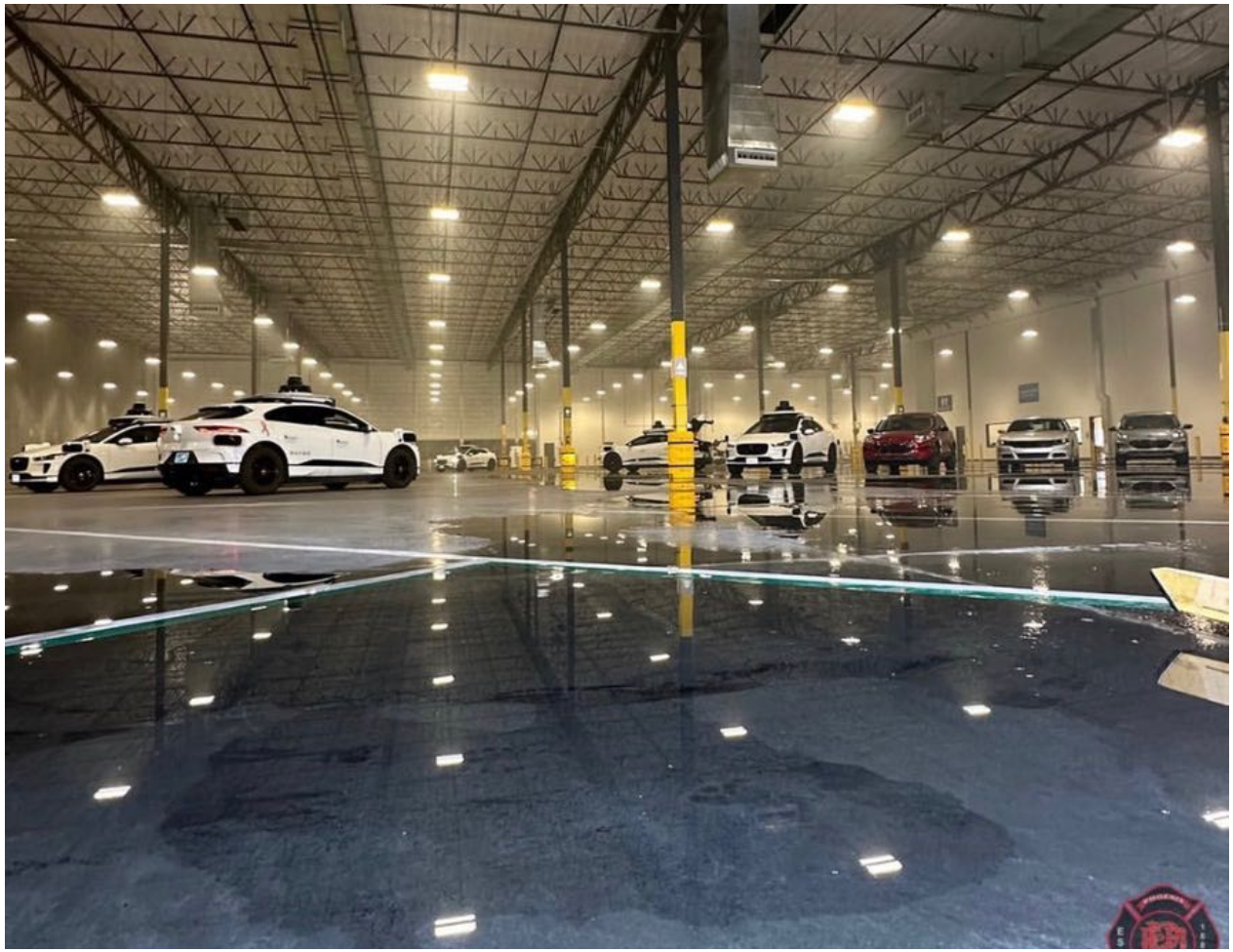
- Cells to modules, complete battery packs
- Damaged, Defective, Recalled batteries
- Difficulty on fire sprinkler requirements because of changes in what is used
- State of Charge (SOC), under 30%

# VEHICLE ASSEMBLY

- Typical automotive facility,
- Automation
- Paint Spray
- Battery pack storage
- Connection to equipment

# SPRINKLER PROTECTION

- What do we do with NFPA 13 stating Lithium Ion Batteries are outside the scope of the Standard
- Design Criteria with FM Global
- Large Scale Testing
- Processes may require alternatives



# CONTEXT OF LI-ION THERMAL RUNAWAY IN A STRUCTURE: FIRE & ROOM EXPLOSION HAZARDS

**COURTESY: FIRE SAFETY RESEARCH INSTITUTE (11/2022)**


Makita
18V
HYD
Diablo
3/8" x 25 Ft
Rubber Air Hose


BATTERY RECYCLING
01 COLLECTION
02 STORAGE
03 PACKAGING
04 TRANSPORT
05 RECYLCING FACILITY


SUNVIEW
LOGISTICS, Inc
STOCKTON, CA


CloudTrucks
ion
ion
ion

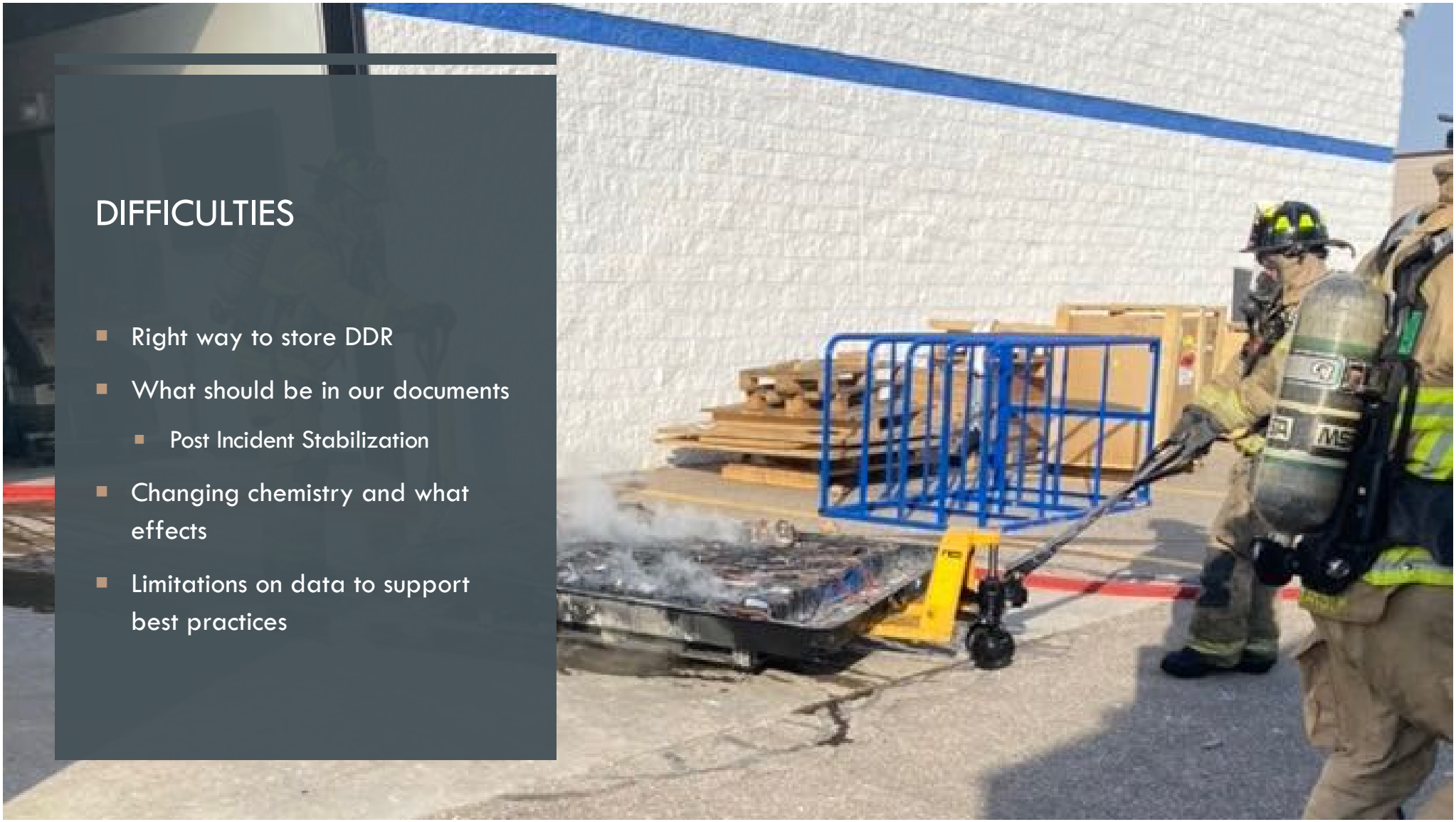

UNIVERSAL WASTE
UN3480
LITHIUM ION BATTERIES 9
7-28-22
HANDLE WITH CARE
9

# OUTDOOR REQUIREMENTS AS WELL

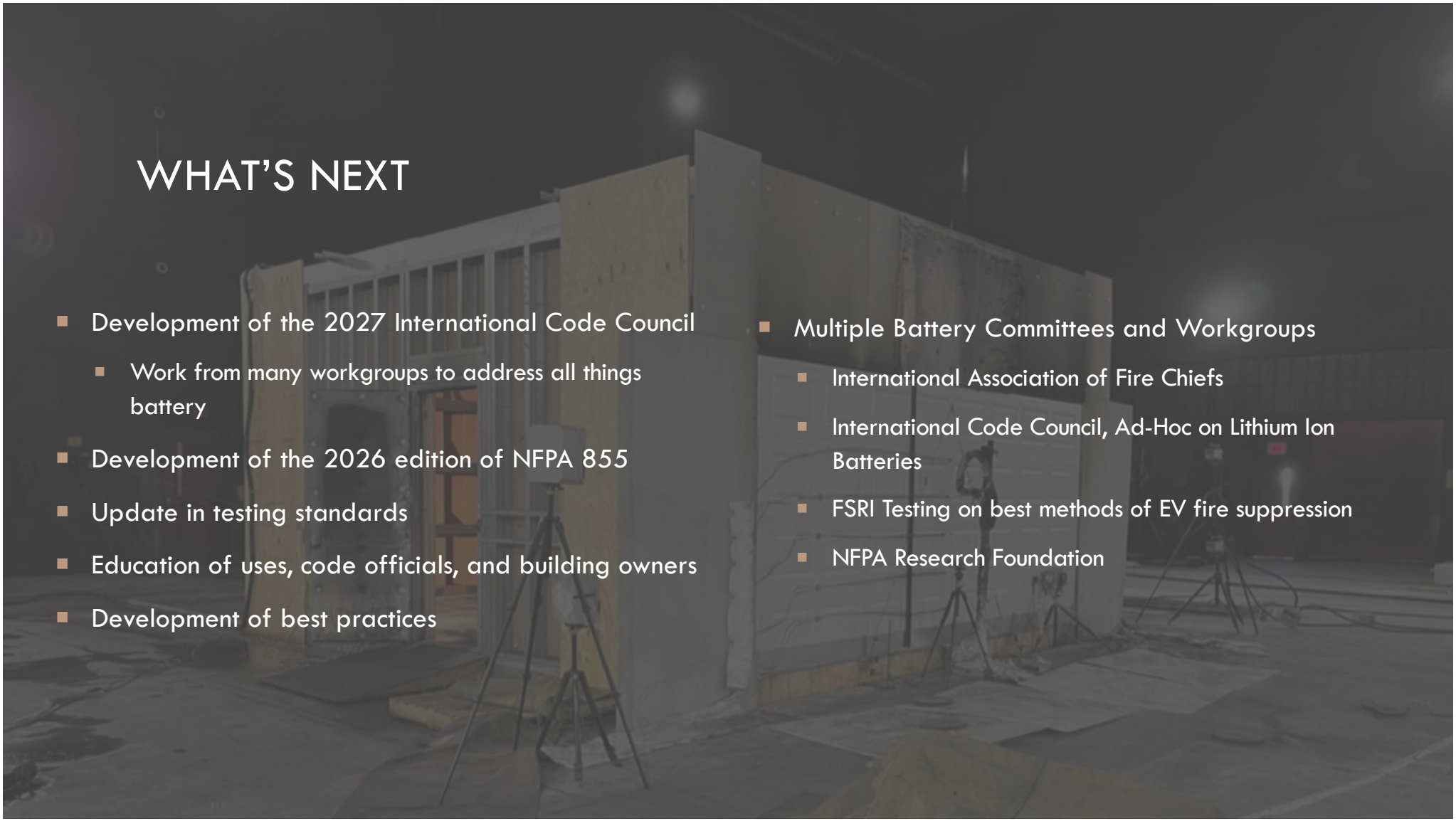
- Site Access
- Fire Fighting Water
- Pile Size and Dimension
- Weather Protection Requirements when provided
- More then a container outside

# DIFFICULTIES

- Right way to store DDR
- What should be in our documents
  - Post Incident Stabilization
- Changing chemistry and what effects
- Limitations on data to support best practices




DIY MARKET



# WHAT'S NEXT

- Development of the 2027 International Code Council
  - Work from many workgroups to address all things battery
- Development of the 2026 edition of NFPA 855
- Update in testing standards
- Education of uses, code officials, and building owners
- Development of best practices

- Multiple Battery Committees and Workgroups
  - International Association of Fire Chiefs
  - International Code Council, Ad-Hoc on Lithium Ion Batteries
  - FSRI Testing on best methods of EV fire suppression
  - NFPA Research Foundation

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- NFPA 855 (2023), Standard for the Installation of Stationary Energy Storage Systems
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- Fire Department City of New York; Lithium-Ion Battery Safety
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# THANKS FOR ATTENDING!

**Michael O'Brian**
810-337-8788
mobrian@concepts.codes

**Mike Snyder, PE**
609-578-8441
Mike.Snyder@dekra.com