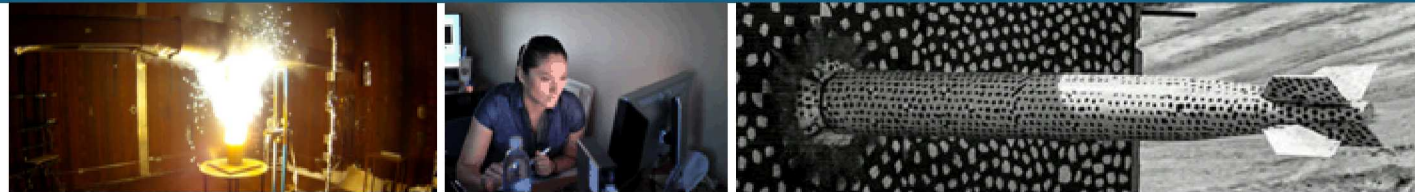


# Energy Storage Standard UL9540



*TechAdvantage March 30, 2020*

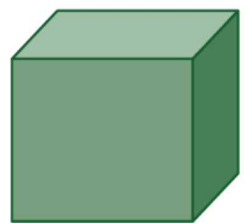
Benjamin Schenkman



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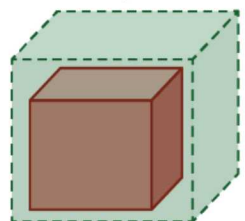
## Energy Storage Installation Standards (Not All)

Standard	Title
NFPA 70	National Electrical Code
NFPA 791	Recommended Practice and Procedures for Unlabeled Electrical Equipment Evaluation
NFPA 855	Standard for the Installation of Stationary Energy Storage Systems
UL 1741	Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources
UL 1973	Standard for Batteries for Use in Stationary, Vehicle Auxiliary Power and Light Electric Rail (LER) Applications
UL 1974	Standard for Evaluation for Repurposing Batteries
UL 810A	Standard for Electrochemical Capacitors
UL 9540	Standard for Energy Storage Systems and Equipment
UL 9540A	Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems



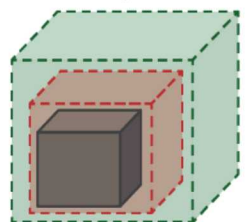
## BUILT ENVIRONMENT

- ICC IFC, ICC IRC, ICC IBC
- NFPA 5000
- NFPA 1



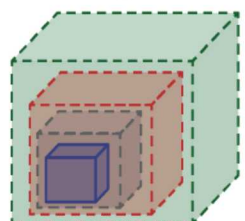
## INSTALLATION / APPLICATION

- **NFPA 855**
- NFPA 70
- UL 9540 A
- IEEE C2
- IEEE 1635/ASHRAE 21
- IEEE P1578
- DNVGL GRIDSTOR
- FM GLOBAL 5-33
- NECA 416 & 416



## ENERGY STORAGE SYSTEMS

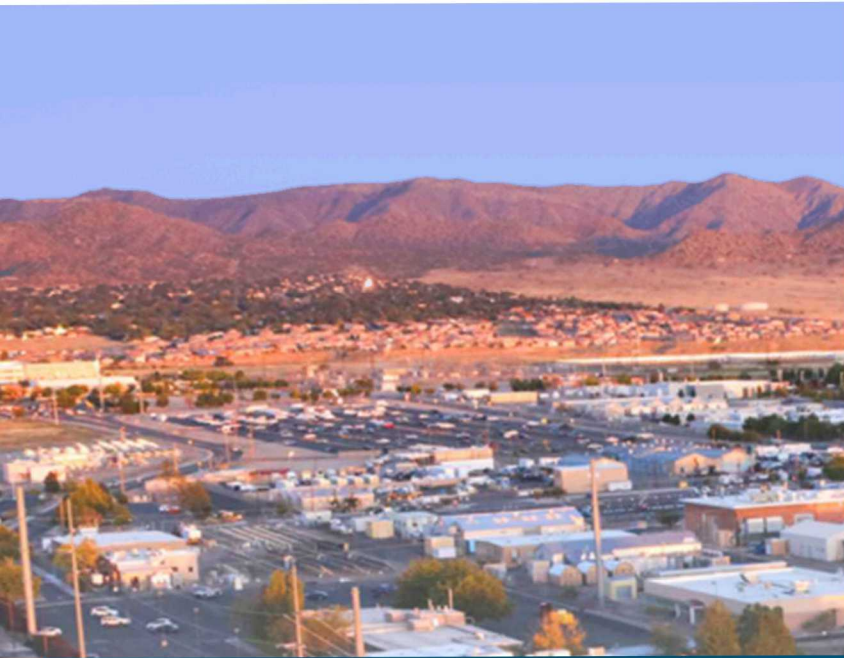
- **UL 9540**
- ASME TES-1
- NFPA 791



## SYSTEM COMPONENTS

- **UL 1973**
- UL 1974
- UL 810A
- UL1741
- CSA 22.2 No. 340-201
- IEEE 1547
- IEEE 1679 Series





# UL 1973

Standard for Batteries for Use in Stationary, Vehicle Auxiliary  
Power and Light Electric Rail (LER) Applications

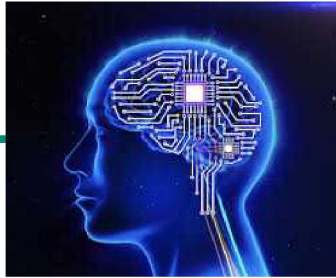


# What is UL 1973?

## Scope:

Safety standard for Cells, Modules and Battery Systems.

### Site Controller



## What Technologies are covered?

Non Technology specific and includes specific criteria for

- Lithium Ion
- Nickel
- Lead Acid
- Sodium Beta
- Flow Batteries
- Electrochemical Capacitors (ultracaps or double layer)

# Tests Performed



## Construction

- Materials
- Enclosures
- Electrical Spacings, Insulation and Grounding
- Wiring and Electrical Components
- Safety Analysis/FMEA
- Controls and Functional Safety
- Cells/Stack Technology Specific Criteria



## Electrical Tests

- Overcharge
- Short Circuit
- Over-discharge
- Imbalanced Charging
- Temperature
- Failure of Cooling/Thermal Stability System



## Mechanical Tests

- Impact
- Drop
- Static Force
- Mold Stress



## Environmental Tests

- IP Enclosure
- Salt Fog
- External Fire Exposure
- Internal Fire Exposure



## Single Cell Failure Design Tolerance

- Lithium Ion and other Technologies

## Safety Analysis/Failure Mode and Effects Analysis (FMEA)

- BMS
- Cells Maintained
- External Fire Exposure
- Internal Fire Exposure

## Reliability Protection Number (RPN)

$$RPN = S \times O \times D$$

Where:

S - Severity of failure

O - Probability of occurrence

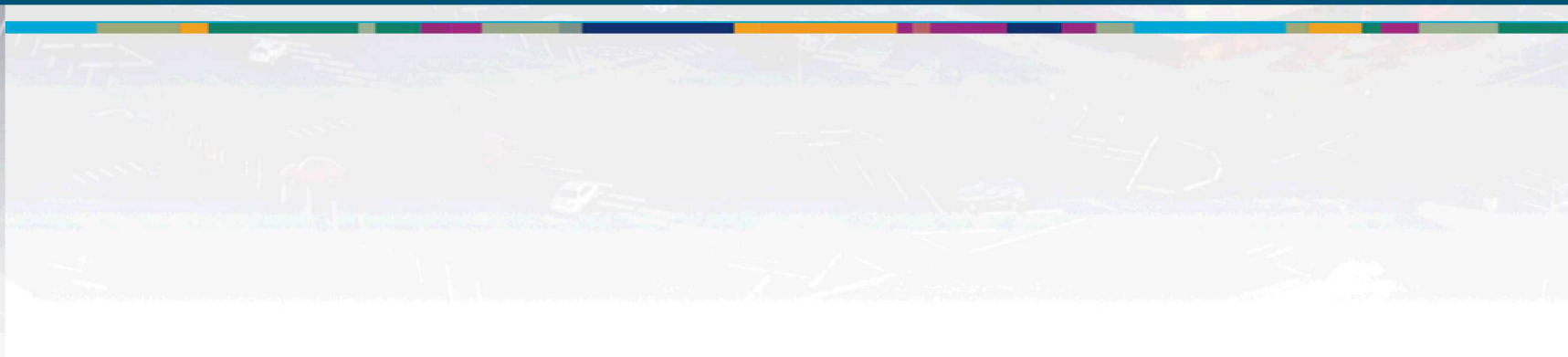
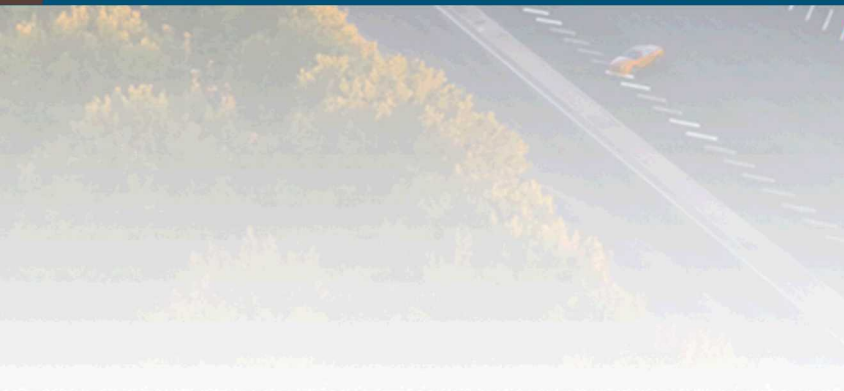
D - Reliability of detection





# UL 9540

Standard for Energy Storage Systems and Equipment





## What is UL 9540?

### SCOPE:

Safety Standard for Energy Storage systems that are:

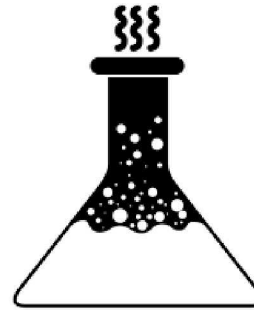
- Standalone to provide energy for local loads
- Parallel with an electric power system/electric utility grid
- Able to perform multiple operation modes
- For use in utility-interactive applications in compliance with IEEE 1547 and IEEE 1547.1
- Other applications intended to provide grid support functionality  
(May include Balance of Plant)

# What Technologies are covered?



## Electrochemical

Example: Batteries



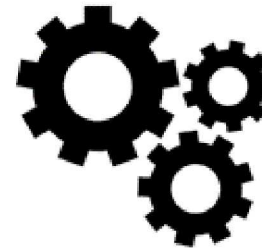
## Chemical

Example: Hydrogen



## Thermal

Example: Ice Storage



## Mechanical

Example: Flywheel

## CONSTRUCTION ITEMS

Non-Metallic Materials

Metallic Parts Resistance to Corrosion

Enclosures and Guarding of Hazardous Parts

**General Electrical Safety and Walk-in Systems**

Wiring and Electrical Supply Connections

General Electrical Service Equipment

Electrical Spacings and Separation of Circuits

Insulation Levels and Protective Grounding

Communication Systems

Remote Controls

Heating and Cooling Systems

Piping Systems, Pressure Vessels, Fuel and Other

Fluid Supply Connections and Controls

Containment of Moving Parts

Hazardous Fluid Containment

Combustible Concentrations

**Fire Detection and Suppression**

**Utility Grid Interaction**

**Energy Storage System Technologies**

## General Electric Safety and Walk-in Systems

- Safe egress and exit signs
- Sufficient work space per NFPA 70
- Use of guarding, etc. to prevent access to hazardous voltage parts
- Ventilation per ASHRAE 62.1
- Lighting provided within enclosed spaces and per NEC
- Arc Flash Criteria per NFA 70E





# Safety Analysis

- Requires a Safety analysis (e.g. FMEA) of system
  - Safety Components comply with associated standards
- Remote controls
  - Remote controls cannot override local controls
  - System has means to disconnect from remote control

## Reliability Protection Number (RPN)

$$RPN = S \times O \times D$$

Where:

S - Severity of failure

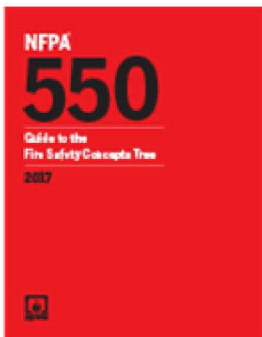
O - Probability of occurrence

D - Reliability of detection

RISK (P,S) ↑	Low	Medium	High	Critical
	Medium	Low	Medium	High
	High	Low	Low	Medium
		Low	Medium	High
		DETECTABILITY →		

# Fire Detection and Suppression

- The level and type of fire detection and suppression dependent upon
  - Size (Containment and Power/Energy)
  - Technology (Li-Ion, Lead Acid, Zinc, Sodium)
  - Location of installation (Next to Substation, Humid)
  - Local building and fire codes or utility requirements
- Fire Risk Assessment
  - NFPA 550 & NFPA 551 guidelines



## What is being updated?

- Clarification of scope
- Clarification of mechanical test methods
- Modification of ISO containers/impact on strength
- Addition of grounding connections details
- Reference to new fire code criteria with regard to fire detection and suppression
- Global revisions to ensure more enforceable language

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