SA Energy Storage 2018

New Energy In The Battery Infrastructure

by Maurice Johnson - Business Development Engineer, UL LLC

ee publishers

Introducing Maurice Johnson

Business Development, Energy Systems & e-Mobility at UL LLC

Maurice Johnson
Business Development
& Senior Engineer

Background

- Business Development & Senior Engineer for Battery & Energy Storage Systems as well as Fuel Cell Systems and Ultra-Capacitors.
- Over 20 years of experience in product advising, certifying evaluating, testing, and validating with the last 15 years devoted to batteries, fuel cells and land vehicle converters and inverters.
- Responsible for enabling the market of ESS & developing strategies to overcome technical challenges.
- UL's Regional Lead Reviewer for Fuel Cells and Land Vehicle Inverters/Converters.

UL LLC

22 BILLION UL MARKS APPEAR ON PRODUCTS ANNUALLY

1 BILLION CONSUMERS WERE REACHED BY UL SAFETY MESSAGES IN ASIA, EUROPE AND NORTH AMERICA

MORE THAN **567K** FOLLOW-UP INSPECTION VISITS WERE CONDUCTED BY UL

1,490	20,104	69,007	92,442
CURRENT STANDARDS FOR SAFETY PUBLISHED BY UL	TYPES OF PRODUCTS EVALUATED BY UL	MANUFACTURERS PRODUCED UL CERTIFIED PRODUCTS	PRODUCT EVALUATIONS CONDUCTED BY UL

We Provide Global Market Acceptance

Our marks are on nearly 22 billion products worldwide, per year, signaling peace of mind to consumers, customers, businesses, and governments.

Lithium ion Battery Incidents Over the Years

Since its commercialization, there have been well publicized safety incidents involving lithium ion batteries used in consumer products

- 2005-2006 Notebook Computer Fires
- 2013-2015 E-cigarette Fires
- 2014-2015 Power Bank Fires
- 2015-2016 Hoverboard Fires
- 2016 Samsung Galaxy Note 7 Cell Phone Fires

PROTECTING AGAINST FAILURE EVENTS

- Mitsubishi Materials Corporation (Japan 2011)
  - 2 MWh Sodium Sulfur system, thermal runaway
- Kahuku Wind farm (USA, 2012)
  - 15 MWh, Advanced lead acid battery
- The Landing Mall (USA, 2013)
  - 50 kWh Li-ion ESS system in a shopping mall, thermal runaway
- Engie Electrabel (Belgium, 2017)
  - 20 MWh Li-ion facility, thermal runaway

IMPORTANCE OF ENERGY STORAGE

- Enabling the Smart Grid
- Peak Demand & Economics
- Grid Reliability & Resiliency
- Grid Balancing & Load Leveling
- Supporting Renewables by Mitigating Intermittency

INSTALLATION OF ENERGY STORAGE SYSTEMS

Energy storage systems (ESS) utilized for these various applications, may be subject to the local installation codes depending upon where they are installed.

ESS may be located on commercial sites or other private property that are subject to Authorities Having Jurisdiction (AHJ) inspections.

The AHJs in these areas rely upon municipal building and fire codes based upon model codes developed by organizations such as National Fire Protection Agency (NFPA) and International Code Council (ICC).

CODES IMPACTING ENERGY STORAGE

NFPA 70 (NEC) 2017 Article 706 Energy Storage	NFPA 1 (2018)	NFPA 855 (2019)	ICC IFC (2018)
Equipment: Monitors, controls, switches, fuses, circuit breakers, power conversion systems, inverters and transformers, energy storage components, and other components of the energy storage system other than lead-acid batteries, shall be listed. **Alternatively, self-contained ESS shall be listed as a complete energy storage system. UL 9540 is referenced.**	**Mirrors proposals for ICC IFC with regard to Listing of systems to UL 9540.**	**Standard for Installation of Energy Storage Systems (under development).** **Includes reference to UL 9540 and identifies areas where equipment will need to be listed.**	**Listings. Storage batteries and battery storage systems shall comply with all of the following:** **Storage batteries shall be listed in accordance with UL 1973.** **Prepackaged and pre-engineered stationary storage battery systems shall be listed in accordance with UL 9540.**

UL STANDARDS

UL 9540

Energy Storage System and Equipment

UL 9540

Energy Storage Systems and Equipment

- Safety Standard
- Includes energy storage systems that are:
  - Standalone to provide energy for local loads
  - In parallel with an electric power system / electric utility grid
  - Able to perform multiple operational modes
  - For use in utility-interactive applications in compliance with IEEE 1547 and IEEE 1547.1
  - For use in other applications intended to provide grid support functionality

    (May include balance of plant and other ancillary equipment of the system)

UL 9540

Scope

- Safety Standard
- Energy Storage Systems intended for connection to a local or utility grid or for a standby application
- Electrochemical, Chemical, Mechanical, and Thermal
- ANSI/CAN UL 9540: Bi-national (USA & Canada)

Energy Storage System (ESS):

Stores energy in some form and provides electrical energy for use when needed

Technologies Covered

The scope of UL 9540 covers multiple technologies:

- Electrochemical,
- Chemical,
- Mechanical,
- Thermal

Technology	Input Energy Conversion Mechanism	Energy Storage Mechanism	Output Energy Conversion Mechanism
Electrochemical	Charger	Battery	Converter
Chemical	Water Electrolysis H2 Generator	Hydrogen Storage	Fuel Cell
Mechanical	Air Compressor	Flywheel	Motor Generator
Thermal	Heat Pump	Thermal Storage	Heat Generator

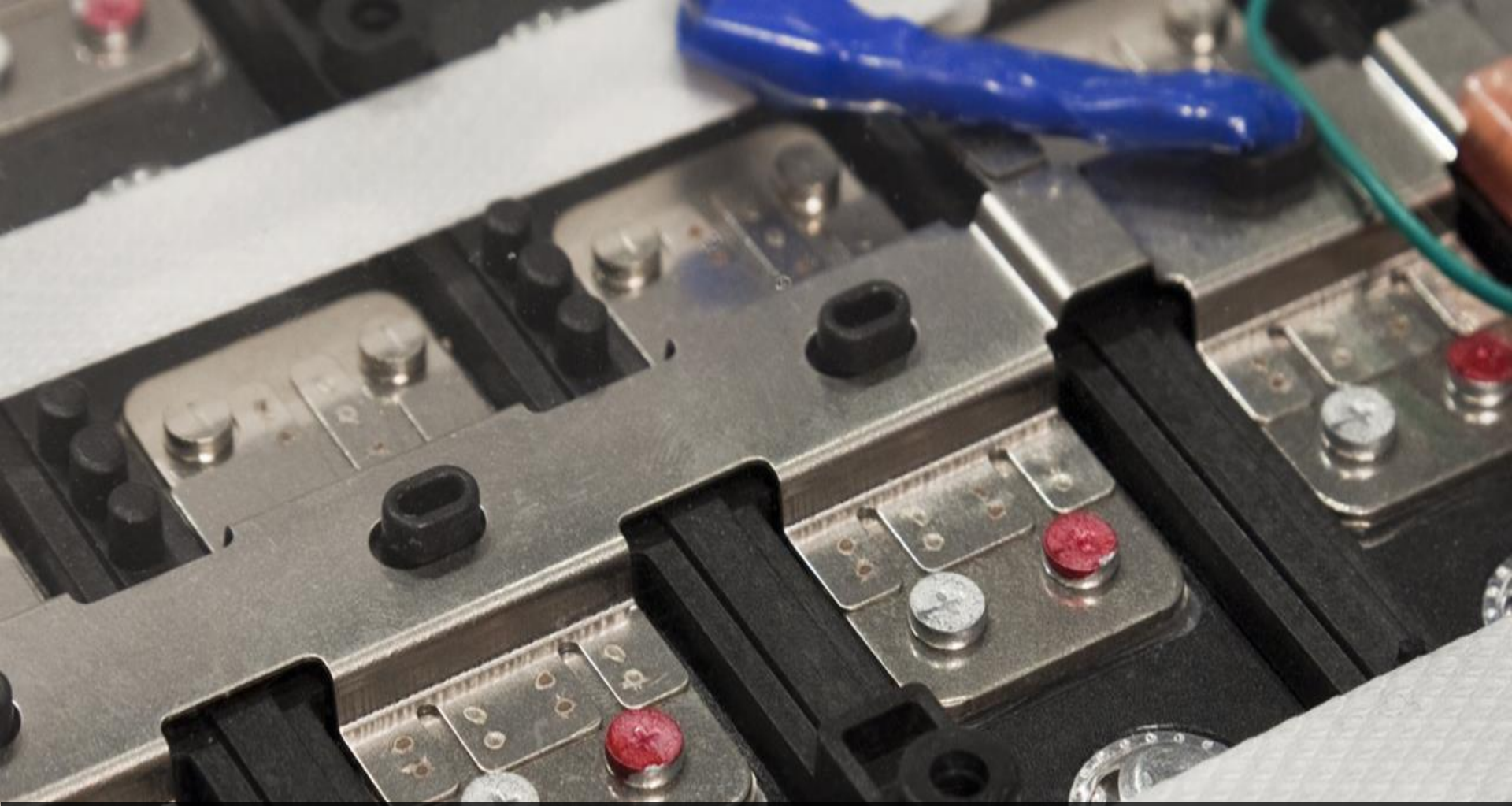
Typical Applications by Technology

Technology	Application
Lithium Ion	• Power quality • Frequency regulation
Compressed Air	• Energy management • Backup and seasonal reserves • Renewable integration
Flow Batteries	• Demand Charge Reduction • Peak Shaving • Time Shifting • Frequency regulation • Power quality
Sodium Beta	• Power quality • Renewables Support
Electrochemical Capacitors	• Power quality • Frequency regulation
Thermal Energy Storage	• Load leveling and regulation • Grid stabilization

UL 9540

Utility Grid Interaction

- UL 1741 including its Supplement SA
  or
  The Standard for General Use Power Supplies, C22.2 No. 107.1, including:
  - IEEE 1547, 1547.1, 1547A, 1547.1A
  - NERC PRC-024-1 as applicable



UL 1973

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

UL 1973

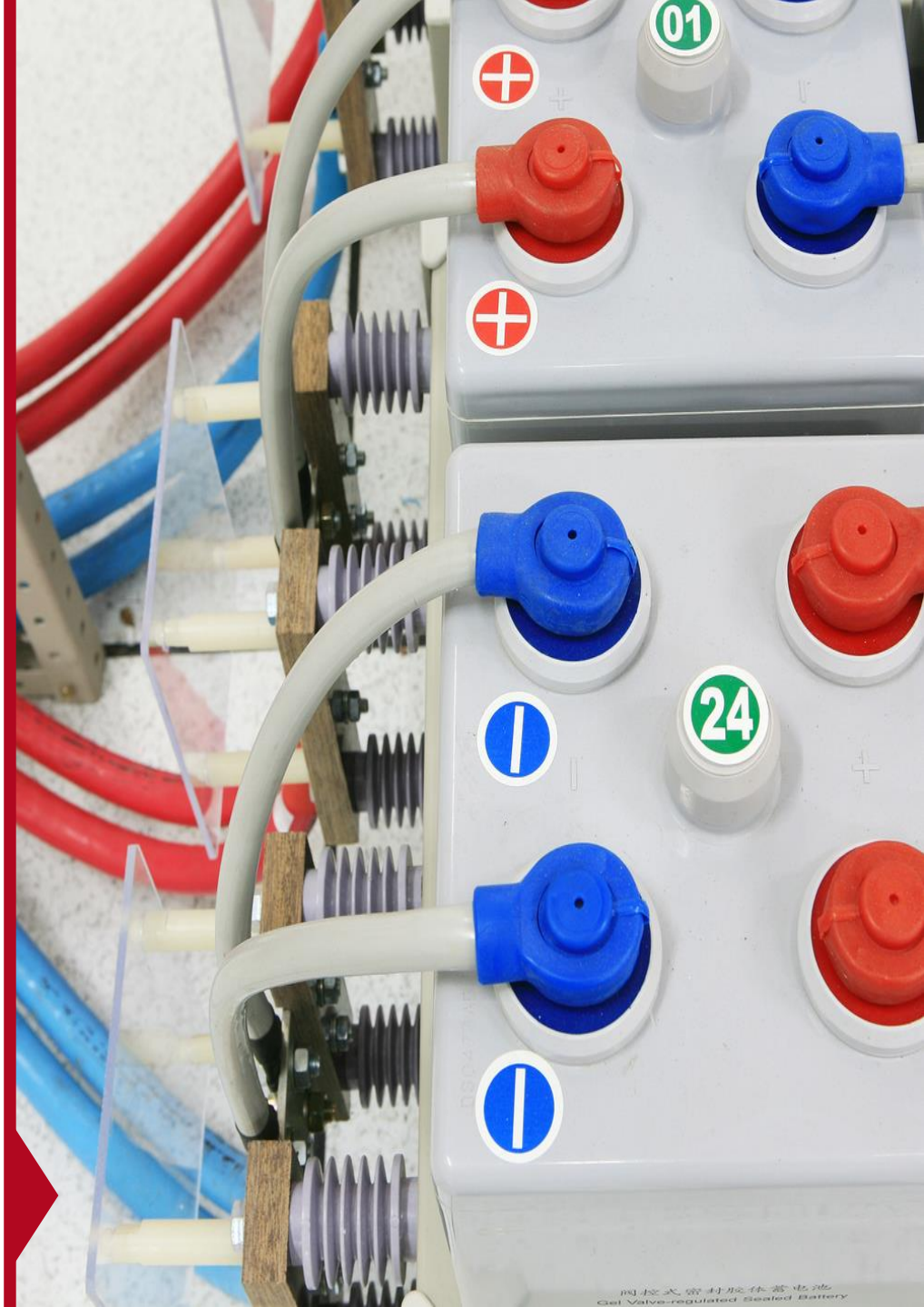
Scope

- Safety Standard for Cells, Modules and Battery Systems
- Non-technology specific and includes specific criteria for:
  - Lithium ion
  - Nickel
  - Lead Acid
  - Sodium Beta
  - Flow Batteries
  - Electrochemical Capacitors (ultracaps)
- Construction & testing (type and routine) criteria

UL 1973

UL 1973 Construction

- Materials
- Enclosures
- Electrical Spacings, Insulation and Grounding
- Wiring and Electrical Components
- Safety Analysis/FMEA
- Controls and Functional Safety
- Cells/Stack Technology Specific Criteria
    - Lithium ion, Nickel, Lead Acid, Sodium Beta, Flow Batteries, Ultracapcitors



UL 1973 TESTS

Electrical

- Overcharge
- Short Circuit
- Over discharge Protection
- Imbalanced Charging
- Temperature
- Dielectric Voltage Withstand
- Continuity
- Failure of Cooling/Thermal Stability System
- Strain Relief Tests

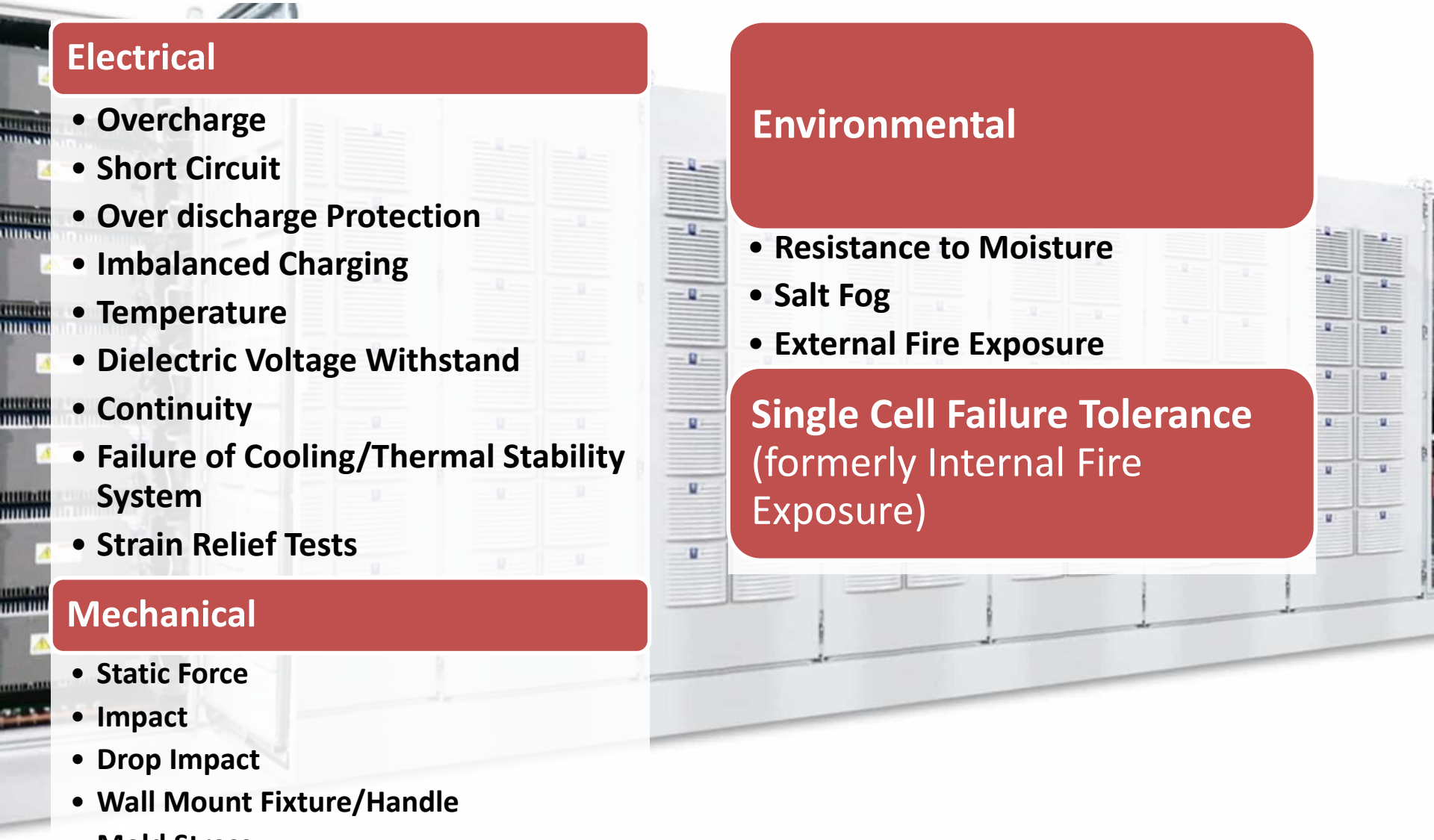
Mechanical

- Static Force
- Impact
- Drop Impact
- Wall Mount Fixture/Handle
- Mold Stress

Environmental

- Resistance to Moisture
- Salt Fog
- External Fire Exposure

Single Cell Failure Tolerance (formerly Internal Fire Exposure)



UL 9540A

Thermal Runaway Fire Propagation Within Battery Energy Storage Systems

UL 9540A

Scope

- Provide fire test data and acceptance thresholds to meet fire safety objectives included in the model fire and other codes (large scale fault and fire testing)

Status

- Outline of investigation standard
- Published in September 2017

After Publication of UL Subject 9540A

- Include as Appendix in UL 9540

UL 9540A ADDRESSES KEY FIRE SAFETY CONCERNS

BESS Installation Parameters

- Enables determination of separation distances between units to minimize unit-to-unit fire propagation
- Enables determination of separation distances between units and enclosure walls
- Enables determination of potential of fire spread to overhead cabling

Installation Ventilation Requirements

- Quantifies deflagration potential
- Quantifies heat generation

Fire Protection (Integral or External)

- Evaluates fire protection strategies

Fire Service Strategy and Tactics

- Characterizes magnitude of potential fire event
- Documents re-ignitions within a BESS unit under test
- Documents gases generated

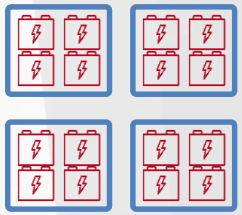
UL 9540A

Cell Level Test

- Whether cell can exhibit thermal runaway
- Thermal runaway characteristics
- Gas composition (flammability)

Module Level Test

- Propensity for propagation of thermal runaway
- Heat and gas release rates (severity/duration)
- Flaming/deflagration hazards



Unit Level Test

- Evaluation of fire spread
- Heat and gas release rates (severity/duration)
- Deflagration hazards
- Re-ignition hazards

Installation Level Test

- Effectiveness of fire protection system(s)
- Heat and gas release rates (severity/duration)
- Deflagration hazards
- Re-ignition hazards

UL 9540A – USE IN INDUSTRY

Energy Storage System

UL 9540A Test Method

Fire Test Report

Manufacturer/ Integrator/Sponsor

Fire Protection Consultant

Insurance Industry

Building Owner

Other AHJ

Fire Department

IEC STANDARDS ACTIVITY

IEC STANDARDS

Energy Storage System Standards - IEC 62933 series are either published or under development:

1. **IEC 62933-1**, Electrical Energy Storage (EES) systems - Part 1: Vocabulary
2. ∗**IEC 62933-2-1**, Electrical Energy Storage (EES) systems - Part 2-1: Unit parameters and testing methods - General specification
3. **IEC 62933-3-1**, Electrical Energy Storage (EES) systems - Part 3-1: Planning and installation- General specifications
4. ∗**IEC TS 62933-4-1**, Electrical energy storage (EES) systems - Part 4-1: Guidance on environmental issues - General specification
5. ∗**IEC TS 62933-5-1**, Electrical energy storage (EES) systems - Part 5-1: Safety considerations for grid-integrated EES systems - General specification
6. **IEC 62933-5-2,** Safety considerations related to the integrated electrical energy storage (EES) systems – Batteries

∗ - published

Key Energy Storage IEC Standards

Standard No.	Title	Scope Summary
IEC 62933-5-1	Electrical Energy Storage (ESS) Systems Part 5-1: Safety considerations for grid integrated EES systems	General safety TS for energy storage
IEC 62933-5-2	Electrical Energy Storage (ESS) Systems Part 5-2: Safety considerations related to grid integrated electrical energy storage (EES) systems - electrochemical based systems (under development)	Safety of battery energy storage systems

IEC 62933-5-1 & IEC 62933-5-2

Scope (IEC 62933-5-1)

- Technical specification that specifies safety considerations (e.g. hazards identification, risk assessment, risk mitigation) applicable to EES systems integrated with the electrical grid
- Provides criteria to foster the safe application and use of electric energy storage systems of any type or size intended for grid-integrated applications

Scope (IEC 672933-5-2)

- Safety standard for ESSs that use electrochemical storage technologies
- Provides technology specific safety criteria in addition to the general safety criteria of the Part 1 TS.

IEC 62933-5-2

- References IEC 62933-5-1 for general safety considerations
- Identifies hazards specific to battery energy storage systems (BESS)
  - e.g. potential hazards when working on energized electrical circuits & equipment
  - e.g. potential hazards associated with chemical systems such as electrolyte spills, off gassing, etc.
- Groups electrochemical technologies of BESS into categories
  - Identifies hazards specific to the groups that need to be addressed in the risk and hazard assessment

Battery Chemistry Categories	
Group A	BESS using non-aqueous electrolyte battery (e.g. Li-based)
Group B	BESS using aqueous electrolyte battery (e.g. Lead acid, Ni -based)
Group C	BESS using high temperature battery (e.g. NaS, NaNiCl)
Group D	BESS using flow battery
Group E	Others

Note 1: Chemical based supercapacitors are included in Group E.
Note 2: Combinations of two or more Groups of battery chemistry are included in Group E.

Pulling Them All Together - Global Adoption and Harmony of UL Standards That Address ESS

UL Standard to Address The Safety of Battery Storage

UL Standard to Address the Safety of Energy Storage Systems

International Fire Code References UL9540/ UL9540A

UL 1973 | UL 1741 | UL 9540 | UL 9540A | ICC/IFC/NFPA Performance

UL Standard to Address Safety of Equipment Used with Distributed Energy Resources

UL Standard to Address Fire Propagation of ESS

Due Diligence Activities

So not only does UL consider safety and sustainability of ESS, but also are interested in the performance over the life of the system

QUESTIONS?

CONTACT US

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More Information:

www.ul.com/bess

THANK YOU!

Icons made by Freepik, Geotatah, Good Ware, Kirill Kazachek, Pixel Perfect, Smartline, Smashicons, and Those Icons from www.flaticon.com.

APPENDIX - IEC STANDARDS

IEC STANDARDS

Lithium ion Batteries:

1. ∗IEC 62619, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries, for use in industrial applications
2. ∗IEC 62620, Secondary cells and batteries containing alkaline or other non-acid electrolytes for use in industrial applications
3. IEC 63056, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Safety requirements for secondary lithium cells and batteries for use in electrical energy storage systems
4. IEC 62485-5, Safety requirements for secondary batteries and battery installations - Part - 5 : Lithium-ion batteries for stationary applications

Sodium High Temperature Batteries

1. IEC 62984-1, High temperature secondary batteries - Part 1: General aspects, definitions and tests
2. IEC 62984-2, High Temperature secondary Batteries – Part 2: Safe operation of high temperature batteries
3. IEC 62984-3-1, High Temperature secondary Batteries – Part 3: Sodium-based batteries – Section 1: Safety requirements and tests of cells and batteries
4. IEC 62984-3-2, High Temperature secondary Batteries – Part 3: Sodium-based batteries – Section 2: Performance requirements and tests
5. ∗ - Published

IEC STANDARDS

Flow Batteries

1. IEC 62932-1Flow Battery Systems for Stationary applications - Part 1 General Aspects, Terminology and Definition
2. IEC 62932-2-1, Flow Battery Systems for Stationary applications - Part 2-1 Performance general requirement & method of test
3. IEC 62932-2-2, Flow Battery Systems for Stationary applications - Part 2-2 Safety requirements

Lead Acid

1. ∗IEC 60896-11, Stationary lead-acid batteries - Part 11: Vented types - General requirements and methods of test
2. ∗IEC 60896-21, Stationary lead-acid batteries - Part 21: Valve regulated types - Methods of test
3. ∗IEC 60896-22, Stationary lead-acid batteries - Part 22: Valve regulated types – Requirements
4. ∗IEC 62485-1, Safety requirements for secondary batteries and battery installations - Part 1: General safety information
5. ∗IEC 62485-2, Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries

∗ - Published

IEC STANDARDS

Nickel Batteries

1. ∗IEC 60622, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed nickel-cadmium prismatic rechargeable single cells
2. ∗IEC 60623, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Vented nickel-cadmium prismatic rechargeable single cells
3. ∗IEC 62675, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed nickel-metal hydride prismatic rechargeable single cells
4. IEC 63115-1, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed nickel-metal hydride rechargeable cells and modules for use in industrial applications - Part 1: Performance
5. IEC 63115-2, Secondary cells and batteries containing alkaline or other non-acid electrolytes - Sealed nickel-metal hydride rechargeable cells and modules for use in industrial applications - Part 2: Safety
6. ∗IEC 62485-1, Safety requirements for secondary batteries and battery installations - Part 1: General safety information
7. ∗IEC 62485-2, Safety requirements for secondary batteries and battery installations - Part 2: Stationary batteries

□∗ - Published