

DEMYSTIFYING THE TESTING, STANDARDS AND CERTIFICATIONS FOR BATTERY OPERATED ITEMS

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OUR SPEAKERS TODAY



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AGENDA

01

Introduction

02

Transportation regulations and tests

03

Product Safety Requirements

04

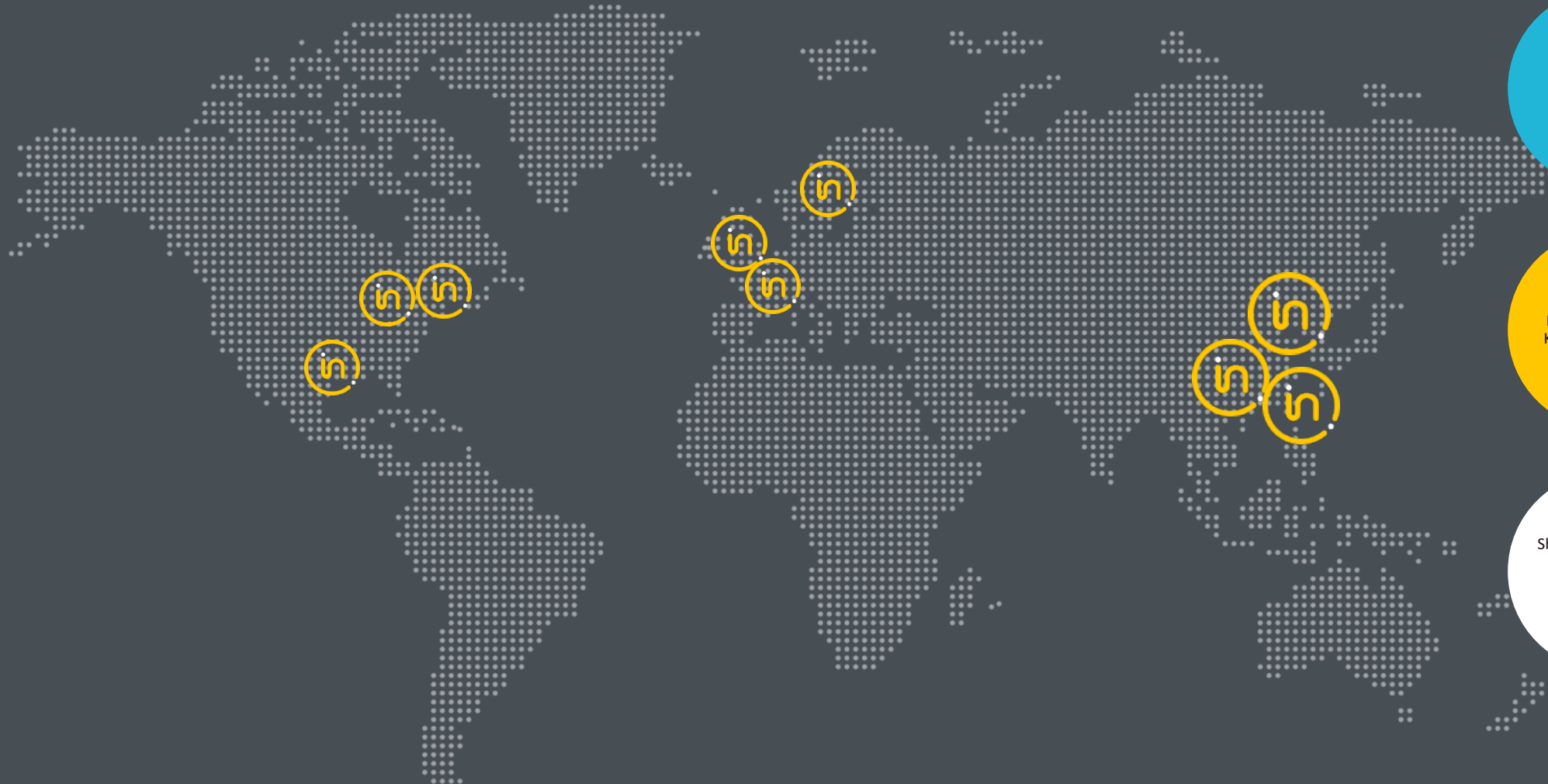
End Product Considerations

05

Q & A



A GLOBAL ENERGY STORAGE FOOTPRINT



North America:
Detroit, MI
Grand Rapids, MI
San Antonio, TX

EMEA:
Milton Keynes, UK
Kaufbeuren, Germ.
Kista, Sweden

APAC:
Shanghai, Hangzhou,
Guangzhou, &
Shenzhen, China
Hong Kong
Taipei, Taiwan

BATTERY TESTING AND CERTIFICATIONS

From hearing aids to electric busses

- UN 38.3
- CB Scheme
- IEC/UL/CSA 62133-2
- ETL Safety Mark
- UL 1642 (Non-rechargeable Lithium)
- UL 2054 (Household / Commercial)
- UL 1973/9540
- Electric Vehicle Battery
- SAE J2464
- Custom Abuse Testing
- Performance and Life Cycle Evaluation



FAILURE ANALYSIS

Review of battery and electronics design

- Critical examination of supporting documentation such as:
 - FMEA
 - Manufacturing controls
- Dissection and analysis of fresh and failed cells
- Material Analysis:
 - CT Scan
 - SEM-EDS
 - X-ray
 - GC-MS
- Technical Manufacturing Audits



SYSTEMATIC FAILURE ANALYSIS INVESTIGATION APPROACH



- Depending on the type of failure, activities listed below may be involved:
 - Situation appraisal
 - Review of battery and electronics design
 - Critical examination of supporting documentation such as: FMEAs; manufacturing control charts; analysis of design fundamentals; and product release criteria.
 - Dissection and analysis of failed and fresh cells
 - Material analysis such as CT-scanning, SEM-EDS, X-ray, GC-MS etc.
 - Verification of the failure by testing
 - Technical manufacturing audit, looking for deviations from industry design/process best practices



Intertek employs a **systematic investigation approach** for failure analysis.

TECHNICAL MANUFACTURING AUDIT



- Intertek performs technical manufacturing audits where we assess how well the manufacturer is applying industry best practices.



Our auditing approach is based on an **open, questioning attitude**.

- We carefully review design and process FMEAs and discuss that which the manufacturer has identified as critical, then question why and ask what actions they take when issues arise.
- We review scrap, field returns, and customer complaints.
- We conduct a physical audit of manufacturing processes, taking deep dives into those we consider areas of concern.
- We look for evidence of technical understanding and application of industry best practices.
- We assess the severity and likelihood that deviations from best manufacturing practices may result in product failures.

BATTERY FAILURE ANALYSES



- We are often asked to investigate and evaluate the root cause of accidents related to battery technology, for example:
 - Provided technical advice including detailed battery autopsy for a fire involving a Li-Ion battery involved in a specialty automobile.
 - An insurance company asked us to give an independent statement on probable cause of a battery fire in a hybrid electric city bus. Our statement was used in settling a cost dispute.
 - A UPS system supplier contracted us to give an independent statement of safety risks related to a specific UPS battery installation methodology. Our statement was a prerequisite for approval of the installation.
 - A battery reseller asked us to give an independent statement on probable cause of a cellular phone battery explosion.



02

TRANSPORTATION REGULATIONS AND TESTS





CLASSIFYING LITHIUM BATTERIES



UN Battery Designations for Lithium/ Li-Ion Batteries

- Class 9 Material
 - Present a hazard during transportation, but do not meet the definition of any other hazard.
- UN3090: Lithium (Lithium Metal) Batteries
- UN3091: Lithium Batteries contained in/packed with equipment
- UN3480: Lithium-Ion Batteries
- UN3481: Lithium-Ion Batteries contained in or packed with equipment

UN 38.3 REQUIREMENTS

LATEST and GREATEST section 38.3

Recommendations on the Transport of Dangerous Goods. Manual of Tests and Criteria.

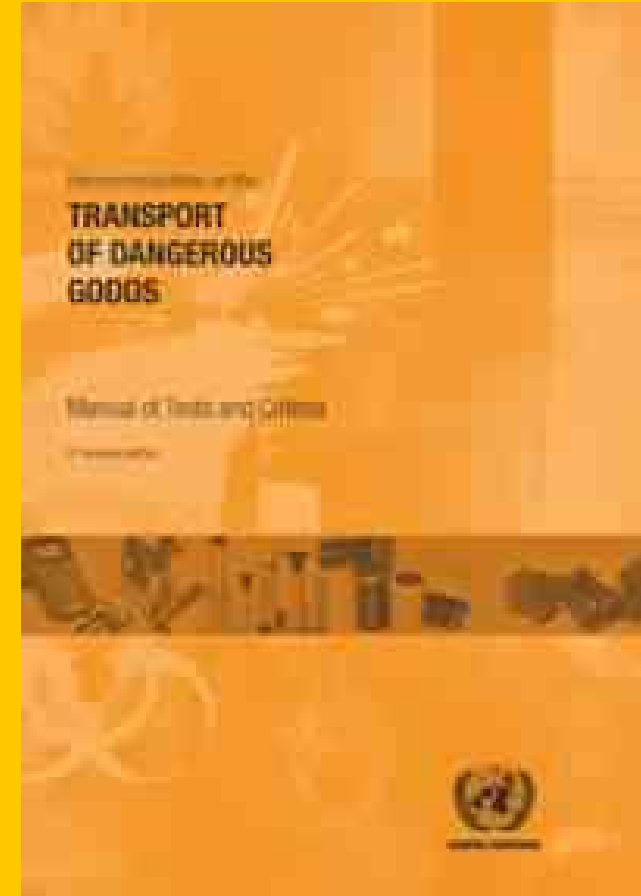
7th Edition

Issued 2019

Date of Enforcement: January 1, 2021

Notes:

- 49 CFR 171.7 Reference Materials
- Essentially unchanged from 6th edition, revised (2017)



TESTS T1 – T8



T1-T5 (Same Samples, Tested in Order, All Types)

T1: Altitude Simulation

T2: Thermal Test

T3: Vibration

T4: Shock

T5: External Short Circuit

T6: Impact/Crush (Primary and Secondary Cells Only)

T7: Overcharge (Secondary Batteries Only)

T8: Forced Discharge (Primary and Secondary Cells Only)



POWERBANKS AND INTEGRATED BATTERIES



- Per clause 38.3.2.1:
- Integrated batteries may be tested when installed in the equipment.
- Considerations:
 - Internal battery “pack” is never shipped separately from the equipment.
 - Verifying Voltage loss: how to measure or verify the cell/battery voltage before/after tests: diagnostic or other means to access actual voltage.
 - Pre-test cycling modes (consider how the battery can be charged/discharged prior to testing): USB or direct connections.

UN 38.3 Lithium Battery Test Summary

Cell, Battery or Product Model Number

Item Number:

Item Name:

Cell, battery, or product manufacturer's contact information

Name:

Address:

City:

State:

ZIP:

Country:

Telephone:

E-mail:

Website:

Test Laboratory

Name:

Address:

City:

State:

ZIP:

Country:

Telephone:

E-mail:

Website:

Cell or Battery Description

Cell or Battery:		Physical Description (dimensions, appearance):		
Cell or Battery Type:				
Watt-hour rating or Lithium Content:				
Completed Cell or Battery Weight:				
Unique Test Report ID Number:		Date of test report:		
List of Tests Completed:				
Yes	No	Pass	Fail	Additional Comments (or indicate compliance with other standards, e.g., Underwriters Laboratory): Reference to assembled battery testing requirements, if applicable (i.e., 38.3.3 (f) and 38.3.3 (g)). Reference to the revised edition of the Manual of Tests and Criteria used and to amendments thereto, if any:

Signature with name and title of signatory as an indication of the validity of information provided:

Date:

TEST SUMMARY REQUIREMENTS



Included from the 6th edition, amendment 1 (2017), specific requirements for a UN 38.3 Test Summary (“TS”) have been defined.

As per section 2.9.4 of the Model Regulations:

“Manufacturers and subsequent distributors of cells or batteries shall make available the test summary as specified in the Manual of Tests and Criteria, Part III, subsection 38.3, paragraph 38.3.5.”

Adoption and Enforcement:

US CFR: **January 1, 2022**

(Initially intended for adoption by Jan 1, 2021)

No specific format/template required (Example here is from [phmsa.dot.gov](https://www.phmsa.dot.gov))

03

PRODUCT SAFETY REQUIREMENTS





What does a safety mark tell me?

- Safety marks such as ETL, UL, and CSA signify that the product has been tested to, and found to comply with, national safety standards by a qualified, independent testing laboratory
- The presence of a safety mark also means the product is 'listed' in the NRTL's "directory" – public record.
- And, is part of an on-going follow-up program that ensures the products continuously comply with the applicable standards

NRTL CERTIFICATION

How do I know whether product has been certified?

- Each NRTL uses its own unique, registered certification mark(s) to designate conformance
- Each NRTL must register its certification mark(s) w/the US Patent & Trademark Office
- The manufacturer physically places the mark on the products
- An NRTL must ensure that its mark is applied to each unit, or if not feasible, to the smallest package containing each unit



NRTL CERTIFICATION



What standards can an NRTL use in certifying products?

- An NRTL must use "appropriate" standards in certifying products for workplace safety (see Test Standard Approval Criteria in the NRTL Program Directive)
- American National Standards Institute (ANSI), Underwriters Laboratories (UL), the National Fire Protection Association (NFPA), International Electro-technical Commission (IEC), IEEE, and ASTM International, etc.



CE MARKING

What about "CE Mark", or equipment certified by foreign testing organizations?

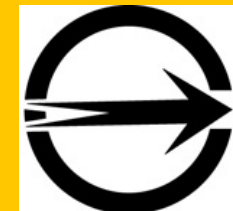
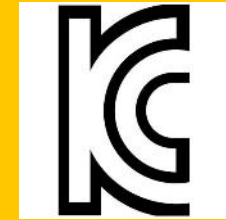
- The CE mark is a generic mark used in the European Union (EU) to indicate that a manufacturer has declared that the product meets EU safety requirements
- CE is unrelated to the requirements in the US
- In the US, the product must have the specific mark of a recognized NRTL
- However, data used to attain NRTL certification, may be applicable to declaration of compliance for CE marking
- CE marking is based on compliance with EU directives and EN-based product standards.



GLOBAL CERTIFICATIONS

What about the rest of the world?

- NRTL or CE mark may be accepted in some countries
- IECEE CB SCHEME:
 - Provides a global “PASSPORT”
 - Based on IEC Standards
 - Ease of attaining local “VISA” (country-specific marks of conformity)
 - For BATT: not fully adopted in US/ CAN (although 62133-2 as a specific standard is adopted)



CONSUMER ALKALINE CELLS

From product safety and transportation standpoint:

- Alkaline batteries can be treated as non-hazardous waste (but can be collected separately)
- From Product safety standards:
 - Alkaline batteries generally deemed safe for fire and overheating hazards, no separate certifications recommended
- From performance Standpoint:
 - ANSI C18.1: Gives performance measurement guidelines
 - Primarily used for benchmarking brands
 - NOTE Brands adjust chemistries frequently based on market data



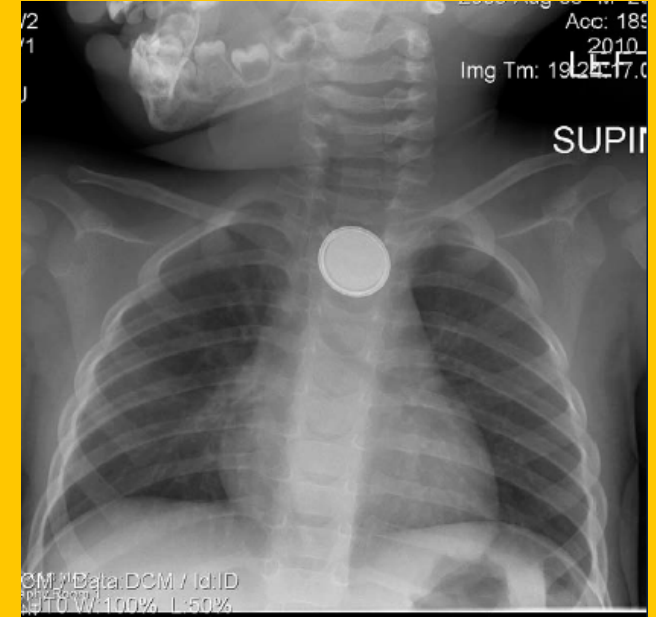
LITHIUM COIN CELLS

UL 4200A: Key requirement for product with removable/ accessible coin cells:

5.5 Products that locate removable or replaceable button/coin cell batteries inside a battery compartment shall be designed to prevent children from removing the battery by one of the following methods in (a) or (b) below. Compliance is checked by the tests of Section 6.

- a) A tool, such as a screwdriver or coin, is required to open the battery compartment; or
- b) The battery compartment door or cover requires the application of a minimum of two independent and simultaneous movements to open by hand.

NOTE: for Transportation, the Test Summary Sheet is not required, and most applications (where the Coin cell is installed in the device) does not have packaging/labeling requirements as other cell/batteries sizes and capacities.



IEC 62133 ADOPTION, TRANSITION

IEC 62133-2 Edition 1.1

Released 2017, revised 2021

Added to IECEE CB Scheme in May 2017

EU adopted as EN 62133-2 in process of adoption

UL 62133-2 (2020):

CSA 22.2 #62133-2 (2020):

**North American Bi-national Standard
Harmonized to IEC 62133-2 1st edition**

- Separate test requirements for cells and batteries, both apply.



NORTH AMERICAN NRTL CERTIFICATIONS

US- Based “Legacy” Standards:

UL-1642: Lithium Batteries

Focus on single-cells

Used for evaluation of Lithium-Metal (PRIMARY)

Used for evaluation of Lithium-Ion (SECONDARY)

UL-2054: Household and Commercial Batteries

Focus on Portable Batteries

Typically Battery Packs

References UL 1642 for Lithium Cells





WHAT ABOUT UL 1642 AND UL 2054?

IEC/CSA/UL 62133-2 is a first step in global harmonization.

UL 2054/ UL 1642 are still active standards.

End product standards still reference UL 2054 or UL 1642 as a requirement.

MAJOR DIFFERENCES at CELL LEVEL:

- **UL 1642/ UL 62133:** Aged vs fresh samples
- **UL 1642:** Higher sample quantity, half are cycled up to 90 days pre-test.
- **UL 62133:** Lower quantity, fresh samples only



WHAT ABOUT UL 1642 AND UL 2054?

IEC/CSA/UL 62133-2 is a first step in global harmonization.

UL 2054/ UL 1642 are still active standards.

End product standards still reference UL 2054 or UL 1642 as a requirement.

MAJOR DIFFERENCES at BATTERY PACK LEVEL:

- **UL 2054 vs IEC/UL 62133:** Temps and Faults
- **UL 2054:**
 - Requires fault condition testing under most conditions.
 - Includes some retests under “worse” case situations
 - Includes temperature testing under nominal conditions
- **IEC/UL 62133:**
 - Test for design intent, fault conditions not considered.
 - Single test cases
 - No component-specific testing required.

04

END PRODUCT CONSIDERATIONS

Batteries as Components and “Battery Systems”

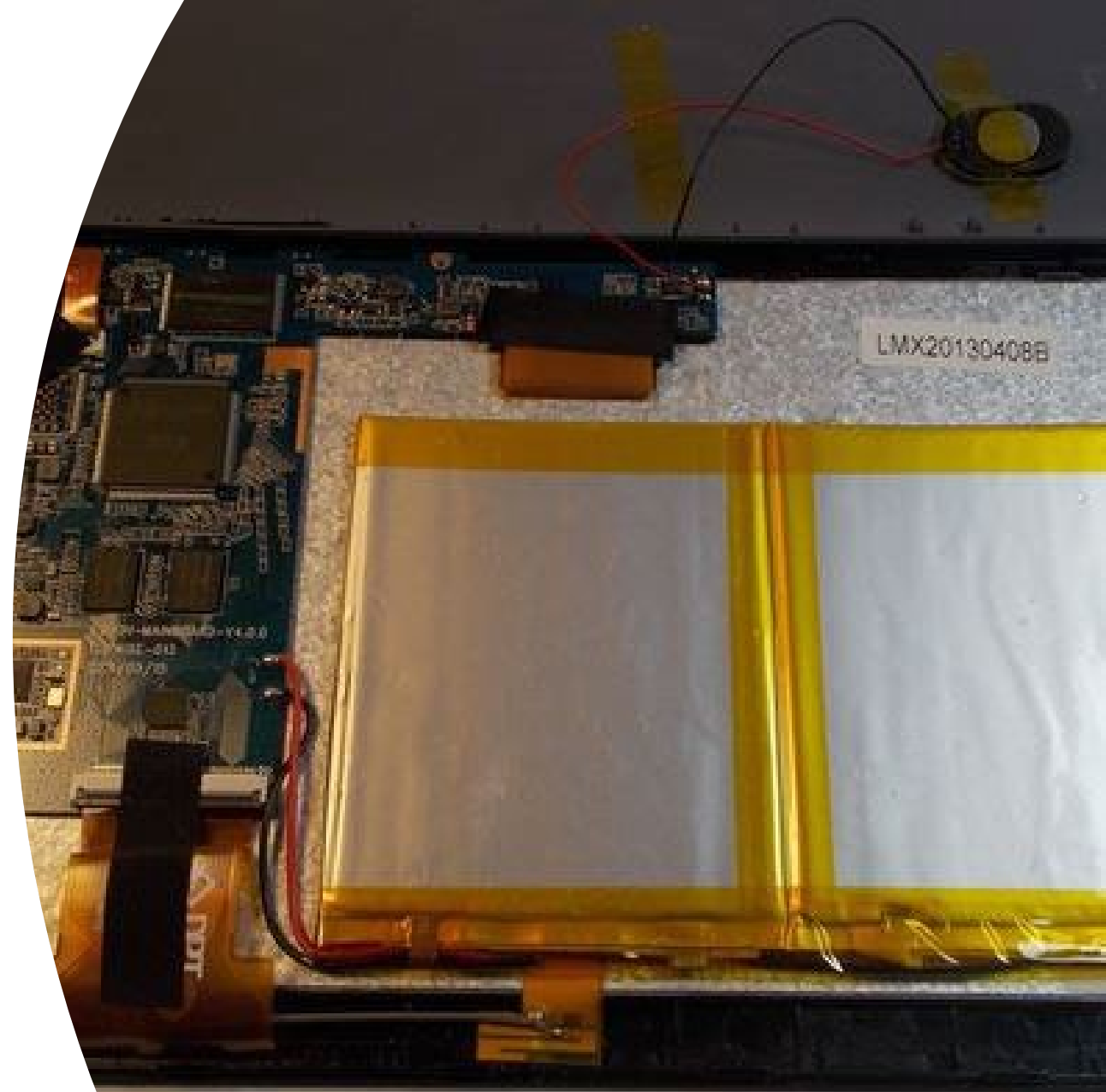


END PRODUCT CONSIDERATIONS

Design trends:

- Cells/batteries integrated to the device vs Battery “PACK”
- Protections/controls at the device level, not within the battery pack
- Battery as a component is incomplete
 - Fault conditions cannot be evaluated at the battery level
 - Temperature test must be done in the device
 - Construction evaluation must be done in the device

SO, what to do with my Battery??



INTEGRATED BATTERIES IN END-PRODUCTS

UL 2595: Battery powered appliances

- Harmonized to IEC 62841-1, Annex K : Hand-held tools, transportable tools and lawn and garden machinery
- Since battery packs for power tools are submitted to different use patterns (such as rough use, high charging and discharging currents) their safety can be evaluated only by this annex and not by using other standards for battery packs, such as IEC 62133, unless otherwise indicated in this annex. All relevant requirements of IEC 62133 are addressed in this annex.
- Component Cells must comply with IEC 62133, but not the BATTERY PACK



THE “NEW” ITE/ A/V STANDARD IEC 62368-1

Annex M of IEC 62368-1 also references IEC62133 in addition to several BMS(Battery Management System)-evaluation requirements.

M 2.1: “Batteries and their cells shall comply with the relevant IEC standards for batteries as listed below.

...IEC 62133 (all parts), IEC 62133-1....

**So, the battery is certified
to IEC 62133 (or 62133-2),
we’re done, right??**



IEC 62368-1 ANNEX M



Annex M of IEC 62368-1 provides multiple scenarios, tests and fault or worse/worst case conditions. In some cases, the battery-level evaluation may have covered some/all of individual clauses, but consider that:

IEC 62133-2 does NOT include:

- Abnormal conditions
- Fault Conditions (IEC 62133-2 “Should” clause, needs to be verified)

Check actual certification reports, some mfrs include fault conditions intentionally during compliance tests (The “Smart” ones at least)

NOTE: Functional Safety requirements are not specified in IEC 62368-1

OTHER KEY PRODUCTS

Power Banks

Global Standpoint: IEC/UL/CSA 60950-1/62368 is best route.

Treat as a device, rather than a battery

US-only:

USB type: UL Subject (Draft) 2056, updated 2020

Power Pack

Vehicle booster or more than USB: UL 2743: Addresses concerns of charging cables and higher power outputs

IEC 62368-1 for international markets

Hoverboards/Scooters/ Personal Mobility Devices

Hoverboard to UL 2272 (includes battery tests)

UL/ULC 2271: includes Personal Mobility Device in scope.

Requires cell testing regime.

IEC 62133-2 for rest of world

Forklifts/ Industrial Vehicles

UL 2580 Electric Vehicle Batteries (US/CAN)

IEC 62619 Industrial Batteries (Rest of world)



OTHER KEY PRODUCTS

PEDELEC/E-BIKE/EPAC

UL 2849 : E-Bike Electrical Systems Standard

- UL 2271/UL 2580 or
- IEC/UL62133-2 /UL2054 + Individual Tests with Single Fault conditions:
 - a) Overcharge
 - b) Short Circuit
 - c) Imbalanced Charging
 - d) Shock
 - e) Vibration
 - f) Thermal Cycling

Separate BMS (BMS not included in Battery Pack): shall be separately evaluated to Functional Safety Requirements

IEC 62133-2 for Europe/ ROW (based on EN 15194)





QUESTIONS?

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