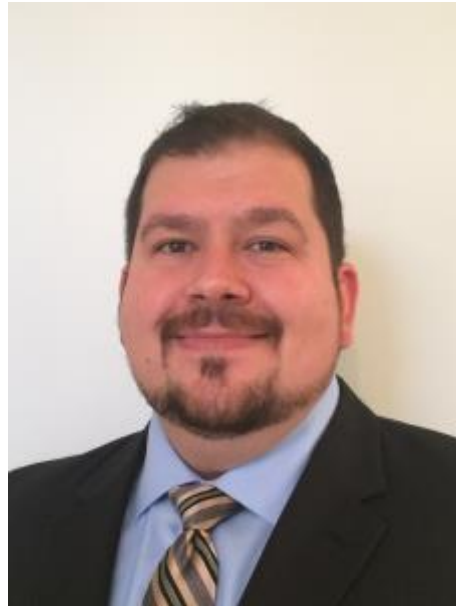


Hoverboards, 2272 and You!

Safety Concerns and Certification Options for Self-Balancing Scooters

2016 (Amended March 19, 2016) Rich Byczek
Global Technical Lead for Electric Vehicles and Energy Storage
Intertek





Rich Byczek

Global Technical Lead – Electric Vehicle and Energy Storage

Intertek

Our Founding Father



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Outsourcing



Advisory



Training



Quality Assurance

More than
100
countries

More than
1,000
laboratories
and offices

over
40,000
people

- FTSE 100 company in the Support Services sector
- Market capitalization: ~\$7.1 billion USD in 2014 (£4.8B)
- Revenue generation: ~\$3.2 billion USD in 2014 (£2.1B)

- Scope and Background
- Standards Activities
- North American Certification Considerations
- Lithium Ion Battery Transportation
- Component and System Requirements
- Risk Assessment and Functional Safety
- Next Steps

What are “Hoverboards” ?

1. Self balancing scooters.
2. One or more wheels
3. May or may not have a handle or “steering wheel”
4. May or not have a seat or other rider supports
5. Generally Lithium-ion battery powered
6. May be capable of indoor/outdoor/ off-road driving
7. Many variants, many options

Scope of Products



Valued Quality. Delivered.



- Segway PT first launched in 2001
- “Hoverboards” appear 2013/2014
- 2015 Holiday season spike

- Per CPSC: 52 fire incidents involving “self balancing scooters” between Dec 2015 and Feb 2016

<https://www.cpsc.gov/Global/Business-and-Manufacturing/Business-education/SelfbalancingScooterLetter.pdf?epslanguage=en>

- National Trading Standards (UK): detains >15,000 “unsafe” hoverboards.

<http://www.tradingstandards.uk/extra/news-item.cfm/newsid/1848>

Product Bans and Notices

1. Amazon: currently restricts hoverboard sales at www.amazon.com

<https://www.amazon.com/gp/help/customer/display.html?ie=UTF8&nodeId=201981360>

a) Battery to UN 38.3, cell to UL 1642, Charger to UL 60950-1

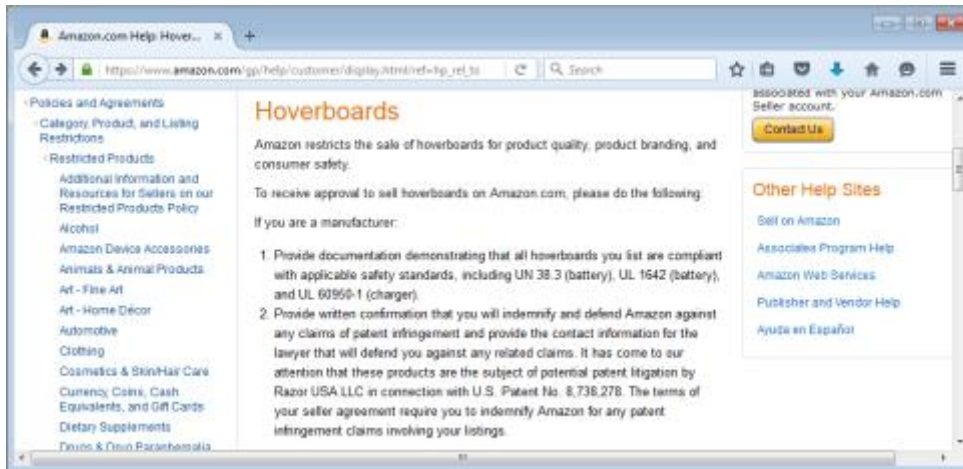
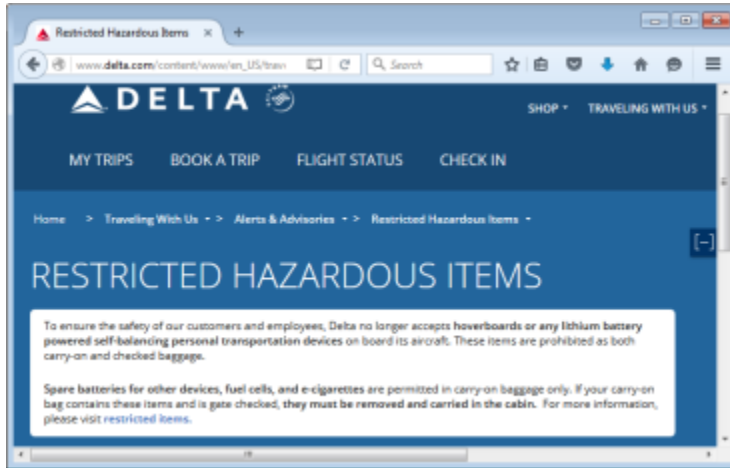
2. CPSC (Consumer Product Safety Commission) letter on February 18, 2016:

a) Product listed to UL 2272

<https://www.cpsc.gov/Global/Business-and-Manufacturing/Business-Education/SelfbalancingScooterLetter.pdf?epslanguage=en>

3. Multiple Airlines: ban of self-balancing scooters on passenger aircraft (checked or carry-on)

http://www.delta.com/content/www/en_US/traveling-with-us/advisories/restricted-hazardous-items.html



U.S. CONSUMER PRODUCT SAFETY COMMISSION
4330 EAST WEST HIGHWAY
BETHESDA, MD 20814

Robert J. Howell
Acting Director
Office of Compliance and Field Operations

Tel: 301-504-7621
email: rhowell@cpsc.gov

February 18, 2016

Manufacturers, Importers, and Retailers of Self-Balancing Scooters

Dear Sir or Madam:

The U. S. Consumer Product Safety Commission (CPSC) is an independent federal regulatory agency responsible for protecting consumers from unreasonable risks of injury and death from consumer products. Our authority is set forth in the Consumer Product Safety Act (CPSA), 15 U.S.C. §§ 2051 – 2089.

I am writing this letter to urge you to make certain that self-balancing scooters that you import, manufacture, distribute, or sell in the United States comply with currently applicable voluntary safety standards, including all referenced standards and requirements contained in UL 2272 – *Outline of Investigation for Electrical Systems for Self-balancing Scooters*. The UL standard can be purchased from Underwriters Laboratories Inc. (<http://www.comm-2000.com/>). Additionally, all lithium ion battery products must comply with test requirements under UN/DOT 38.3 *Transport of Dangerous Goods for Lithium Metal and Lithium Ion Batteries*.

Self-balancing scooters that do not meet these voluntary safety standards pose an unreasonable risk of fire to consumers. Consumers risk serious injury or death if their self-balancing scooters ignite and burn. From December 1, 2015, through February 17, 2016, CPSC received reports, from consumers in 24 states, of 52 self-balancing scooter fires resulting in over \$2 million in property damage, including the destruction of two homes and an automobile. We

UL:

UL 2272 Outline of Investigation for Electrical Systems for Self-Balancing Scooters, Jan 29, 2016

- Focus on electrical and fire risks of the battery system, charger and drive train.
- Initial STP meeting March 8, 2016
- Additional details later in this presentation.

ASTM:

Subcommittee F15.58

- Focus on mechanical hazards
- Complementary to UL 2272 to avoid overlap
- Initial meeting February 24, 2016
- Using ASTM F2641 as reference/ base

CEN:

CEN/ TC 354: Draft EN xxx: Non-type approved light motorized vehicles for the transportation of persons and goods and related facilities — Personal light electric vehicles — Safety requirements and test methods

- Includes electrical and mechanical risks as well as EMC requirements.
- Compliance with machinery and EMC directives – path for CE marking
- “PLEV” : Personal Light Electric Vehicle
- Scope Includes “self-balancing vehicles with or without seating position”

Look back at CPSC letter from Feb 18...

“I am writing this letter to urge you to make certain that self-balancing scooters that you import, manufacture, distribute, or sell in the United States comply with currently applicable voluntary safety standards, including all referenced standards and requirements contained in UL 2272–Outline of Investigation for Electrical Systems for Self-balancing Scooters.”

The UL standard can be purchased from Underwriters Laboratories Inc. (<http://www.comm-2000.com/>). ...”



What is a product listing?

- **3rd party certification of compliance to applicable safety standards**
- Includes follow-up services (continuous conformance testing)
- Accepted by AHJ

Who is the AHJ?

Do I need “UL Approval?”



- What is a product listing?
- Who is the AHJ?
 - “Authority Having Jurisdiction”
 - Electrical Inspectors, fire marshalls
 - Landlords/ Building Owner
 - Insurance Providers
 - Retailers, airlines, shipping providers
- Do I need “UL Approval?”



*Aren't manufacturers required to use UL for their compliance testing?
Isn't this mandated by the standards themselves?*

- The simple answer to both questions is "no"
- To satisfy the prerequisite of having your products tested by an independent organization, the true legal requirement is that the laboratory which performs the testing be a Nationally Recognized Testing Laboratory (NRTL) recognized by OSHA
- **NOTE: this is not a FEDERAL MANDATORY REQUIREMENT. Certification is voluntary, but may be required by the AHJ**

In the United States – OSHA

- OSHA (U.S. Department of Labor: Occupational Safety & Health Administration) oversees workplace safety regulations, which are US law and contain requirements for "approval" (i.e. testing & certification) of certain products by an **NRTL – Nationally Recognized Testing Laboratory**
- Requirements are found in Title 29 of the U.S. Code of Federal Regulations and the provisions for NRTL certification are generally in Part 1910 (29 CFR Part 1910)



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



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What about Canada??



Valued Quality. Delivered.

Standards Council Canada

Similar to OSHA NRTL program.

SCC accredits Certification and Inspection organizations.

Listing marks in common with US NRTL



FOLLOW UP SERVICES / INSPECTIONS

Applies to all NRTL's, all certified products (OSHA Requirement):

Initial Factory Inspection: Similar to ISO Quality Audit, but focus on the Safety Aspects of your product.

Follow-up Inspections: All Certified products or Components must submit to a Follow-Up service (Inspection) Program.

Typical:

Quarterly: Onsite Factory Inspections

Annually: Unlisted/Non-Recognized Component

Submission, may be increased or decreased due to system complexity or production rate.



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 directives
- CE is unrelated to the requirements in the US
- In the US, the product must have the specific mark of a recognized NRTL
- CE marking is based on compliance with EU directives and EN-based product standards.
- However, data used to attain NRTL certification, may be applicable to declaration of compliance for CE marking



Look back at CPSC letter from Feb 18...

“Additionally, all lithium ion battery products must comply with test requirements under [UN/DOT 38.3](#) Transport of Dangerous Goods for Lithium Metal and Lithium Ion 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
- **UN3171: Battery Powered Vehicle**



Per IATA Notice on December 29, 2015, using the definition:

“For the purpose of this special provision, vehicles are self-propelled apparatus designed to carry one or more persons or goods.”

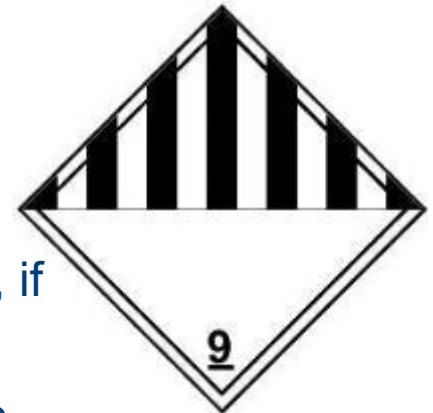
<https://www.iata.org/whatwedo/cargo/dgr/Documents/lithium-battery-vehicles-cargo.pdf>

UN Battery Designations for Lithium/ Li-Ion Batteries

- Lithium batteries are **ALWAYS** considered dangerous goods.
- Some packaging requirements are basic, but the lithium battery is still a unique situation.
- Per UN Model Regulations 2.9.4

Lithium batteries..”may be transported under these entries, if they meet the following provisions.”

Otherwise, they must be shipped as fully regulated Class 9 Shipments/



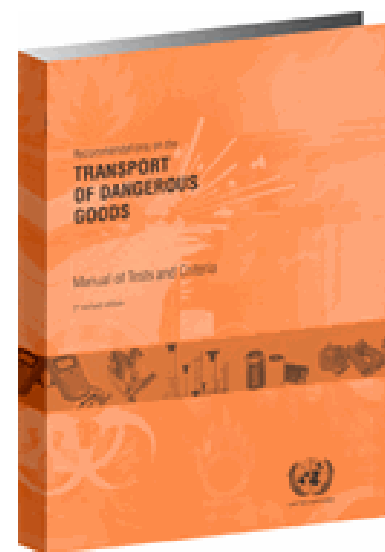
CURRENT section 38.3

Recommendations on the Transport of Dangerous Goods. Manual of Tests and Criteria. 5th Revised Edition, Amendment 2

Issued 2009, Amendments in 2011, 2013

Per International Guidance Documents:

- US: 49 CFR Section 171.7
- IATA: International Air Transport Association
- ICAO: International Civil Aviation Association
- IMDG: International Maritime Dangerous goods



Enforcement: Competent Authorities for Dangerous Goods

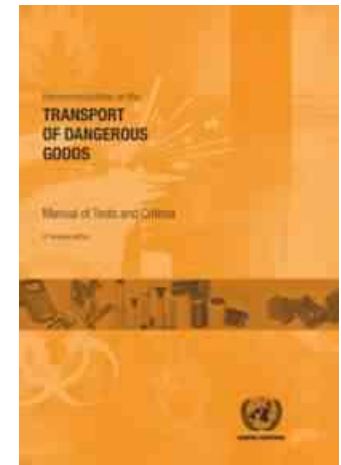
www.unece.org/trans/danger/publi/manual/rev5/manrev5-amendments.html

LATEST and GREATEST section 38.3

Recommendations on the Transport of Dangerous Goods. Manual of Tests and Criteria. **6th Revised Edition**

Issued 2015

Date of Enforcement: January 1, 2017



**** There are some typographical errors currently, corrections coming soon...**

http://www.unece.org/trans/danger/publi/manual/manual_e.html

- Dangerous goods are regulated by Transportation Authorities (in US: DOT/PHMSA)
- Separate from Electrical safety requirements
- Self Declaration rather than NRTL/3rd party certification
- Cells and Battery pack must be tested!
- UN 38.3 tests do NOT need to be repeated with the device (battery-level testing is sufficient for both UN 3480 AND 3481)



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)

“Outline of Investigation for Electrical Systems for Self-Balancing Scooters”

- Focus on the ELECTRICAL and FIRE safety of the device, and subsystems.
- Does NOT evaluate the OVERALL safety (i.e. mechanical hazards and driving performance related parameters)
- * Mechanical hazards are being addressed by the ASTM activity.
- Classification vs. Product Listing

ETL CLASSIFIED



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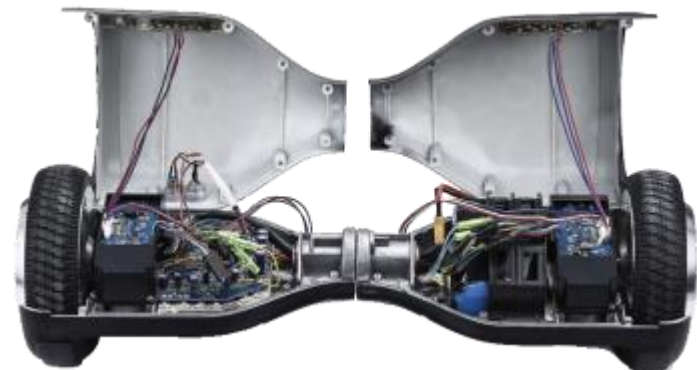
ENCLOSURES and CONSTRUCTION

- Impact, crush and vibration resistance evaluated by test.
- Corrosion resistance of metallic enclosures
- Flammability of materials (V-1 rating minimum)
- Crush test: under review
- Ingress protection: Finger probe (IP3x) and Water Splash (IPx4)
- Note that ENCLOSURE \neq ALL EXTERIOR parts
- Consider the portion of the device which acts as physical protection or barrier, rather than cosmetic



WIRING and CONNECTORS

- Correct ratings for Voltage/ Current/ Temperature: wires and fusing
- Charging connectors shall be keyed or otherwise prevent reverse polarity connections and inadvertent short circuits.
- Removable battery connector durability per UL 2251 : UNDER REVIEW
- Prevent abrasion: wire routing and bushings
- Instructions for User-serviceable parts (i.e. replaceable lighting)
- Hazardous voltage spacing per UL 60950-1



BATTERY CHARGERS:

- May be integral or separate accessory
- Electrical safety per:
 - UL 1310: for Class 2 (<100Watt) output circuits
 - UL 1012: for higher output circuits
 - UL 60950-1: when utilizing existing power supply from other applications (ITE requirements which reflect UL 1310/ 1012)
- Charging connectors shall be keyed or otherwise prevent reverse polarity connections and inadvertent short circuits.



BATTERY and CELLS:

- Cells
 - Evaluated or certified per UL 2580 (EV Battery)
 - Based on UL 1642
 - Allowance for larger size cells
 - “Hard” short circuit test: 20milli-ohm vs. 100milli-ohm max.
 - Increase heating test time (for larger cells)
 - Alternate cell test program, per IEC 62660-2
- Batteries
 - Based on UL 2271 (LEV Applications)
 - Consider Charging system (within UL 2272)
 - Overcharge, Short circuit, Over discharge, Imbalanced charging tests.
- UN 38.3 is separate, but still required.



MOTOR:

- Evaluation based on UL 1004 series.
- Locked Rotor
- Overload conditions: under review

SYSTEM LEVEL:

- Temperature test
- Partial Immersion: test level under review
- Dielectric withstand/ isolation resistance
- Consider location and voltage levels of power throughout the system.



PROTECTION CIRCUITS AND SAFETY ANALYSIS:

- Risk Assessment/ Functional Safety Approach
- UL 991 (Solid State), UL 1998 (Software Based)
- Safety FMEA (Failure Modes and Effects Analysis)
 - Maintaining battery within operating range (voltage/ current/thermal)
 - Shock and fire hazards
 - Redundancy of safety related controls/ features
 - Active vs. passive protection

CLASSIC SERIES

PROJECT NO: 10000000000000000000
 DATE: 11/11/11
 REV: 1

FAILURE MODES AND EFFECTS ANALYSIS (FMEA)

Product: BATTERY PACK (TYPE 1)
 Process: BATTERY PACK (TYPE 1)
 Test: BATTERY PACK (TYPE 1)

Failure Mode	Failure Effect	Failure Cause	Failure Mechanism	Failure Mode	Failure Effect	Failure Cause	Failure Mechanism	Failure Mode	Failure Effect	Failure Cause	Failure Mechanism	Failure Mode	Failure Effect	Failure Cause	Failure Mechanism
1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge	1. Battery pack does not charge

REVISIONS

Rev	Description	Date
1	Initial release	11/11/11

REVISIONS / REVISIONS TO MAKE

Rev	Description	Date
1	Initial release	11/11/11

OTHER AREAS TO CONSIDER:

- Handling and serviceability (user replacement of parts)
- Charging
- Regenerative braking (i.e. internal charging)
- Fully charged and partial charge conditions

CLASSIC SERIES

Product: [REDACTED]
 Model: [REDACTED]
 Part No: [REDACTED]

UL 2272 COMPLIANCE TEST PLAN

Product: [REDACTED]
 Model: [REDACTED]
 Part No: [REDACTED]

Test No.	Test Name	Test Method	Test Result	Test Date	Test Location	Test Engineer	Test Status	Test Comments
1	Initial inspection of the battery pack & cells to ensure they are in good condition.	Visual inspection	Pass					
2	Charge test	Charge the battery pack at the maximum rated current for 16 hours at 25°C.	Pass					
3	Discharge test	Discharge the battery pack at the maximum rated current for 16 hours at 25°C.	Pass					
4	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
5	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
6	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
7	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
8	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
9	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
10	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
11	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
12	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
13	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
14	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
15	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
16	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
17	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
18	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
19	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					
20	Temperature test	Charge the battery pack at the maximum rated current for 16 hours at 25°C, then discharge at the maximum rated current for 16 hours at 25°C.	Pass					

TEST SUMMARY

Test No.	Test Name	Test Result
1	Initial inspection of the battery pack & cells to ensure they are in good condition.	Pass
2	Charge test	Pass
3	Discharge test	Pass
4	Temperature test	Pass
5	Temperature test	Pass
6	Temperature test	Pass
7	Temperature test	Pass
8	Temperature test	Pass
9	Temperature test	Pass
10	Temperature test	Pass
11	Temperature test	Pass
12	Temperature test	Pass
13	Temperature test	Pass
14	Temperature test	Pass
15	Temperature test	Pass
16	Temperature test	Pass
17	Temperature test	Pass
18	Temperature test	Pass
19	Temperature test	Pass
20	Temperature test	Pass

UL 2272 STP meeting on March 8, 2016

- Note “Under review” throughout this presentation
- Revised proposal within next 30-60 days
- Utilize UL’s CSDS system and ANSI notices for public comment.

Areas of concern to add:

- Regenerative braking
- Methods of operating for test: simulated modes vs. dyno
- Handle/ carrying requirements (mechanical stress and drop heights)
- Canadian component references for Bi-national release

YES, you may certify to an “OUTLINE OF INVESTIGATION” (i.e. published draft standard)

- NRTL’s determine if the standard applies and within their scope of competency.
- Certification to draft standard is for US-only.
- Standards Update System: upon release of approved standard (US and/or Canadian variants), may require updating design or certification test and evaluation
 - Consult your NRTL for timelines and retest/ re-evaluation requirements.
- Changes once voted and approved may be implemented prior to final release: consult your NRTL.
- Later combination with mechanical hazards for comprehensive certification pending ASTM activity.

Q&A?



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