

# Navigating the Regulatory Maze of Lithium Battery Safety



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## Introduction

Governments regulate those areas in life where significant hazards are presented. One example is automotive regulations, which cover issues ranging from gas tank safety to crash protection to lighting strike. Regulations reach beyond the manufacturing of the vehicle to encompass usage of the vehicle and require that drivers are licensed and have auto insurance. Government regulation to protect individuals from the hazards associated with lithium batteries is no different. When a risk of significant personal hazard is exposed, a regulation will likely follow. This paper provides a high level, U.S.-centric view of global lithium battery safety standards and regulations.

## Standards, Organizations, and Regulations

To someone new to battery testing and certification, the number of lithium battery standards, governing organizations, and regulations can be overwhelming. One problem is that these various standards and organizations sound all too similar: UL 1642; IEEE 1625; IEEE 1725; ISO/IEC 17025. Industry veterans further complicate understanding by simply referring to the standards' numbers: 1642; 1625; 1725; 17025. And sometimes, people truncate even further (IEC 60086 becomes 086). Plus, in addition to battery standards, there are technical committees (such as TC108) and sub-committees (such as SC 21A). And, of course, the organizations themselves: IEEE; IEC; IECEE. Sound confusing? Take a look below:

There are U.S. entities and their European counterparts. Japan has their own standards, as do other parts of the world. Equipment manufacturers often have additional internal standards and specifications which they apply in order to better protect both their brand and consumers. Some regulations are statutory requirements, while others are guidelines, and some are not mandatory at all but are essentially required if company wants to sell their product to a retailer or device manufacturer who requires all device components to be safety listed.

Still confused? Fundamentally, the battery safety industry, which initially appears to be extremely complex, is actually fairly straightforward. Developing an understanding of just a small handful of organizations and battery standards will suffice to address well over 90% of your potential confusion.

This paper takes a simple, first step towards understanding lithium battery certification and regulation and is not intended to be an exhaustive, complete listing of all standards covering lithium batteries.



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## U.S. Based Organizations & Standards

### OSHA (Occupational Safety and Health Administration)

In the U.S., workplace and product safety essentially begins with OSHA, an agency of the United States Department of Labor. Its mission is to prevent work-related injuries, illnesses, and occupational fatality by issuing and enforcing standards for workplace safety and health. For the purposes of this paper, OSHA's role is to approve and maintain a list of NRTLs.

### What is an NRTL?

Under the narrow scope of this paper, a Nationally Recognized Testing Laboratory is a testing facility recognized by OSHA as having the resources and competence to provide product safety testing and certification for lithium batteries and cells. The test standards which NRTLs follow are not developed or issued by OSHA, but are issued by U.S. standards organizations -- such as ANSI (the American National Standards Institute) or UL (Underwriter's Laboratories) -- both of which produce consensus-based product safety test standards. Intertek is one of over a dozen NRTLs.

### Certification Marks Issued by an NRTL

Each NRTL has their own registered certification mark. Because all NRTLs are equivalent under OSHA, all NRTL marks carry the same authority and regulatory significance: they indicate that the certified product complies with specific safety requirements of the subject standard.

For example, when Intertek certifies a battery to UL 2054, they issue their own NRTL mark, *the ETL Mark*, to certify that the battery complies to the safety requirements contained in UL 2054. In this case, the product will be UL 2054 certified but it will not have the UL Mark. Instead, it will be labeled with Intertek's mark, the ETL Mark.

*NOTE: Most NRTLs -- including Intertek -- will accept another NRTL's test results, but some will not. For example, when testing a battery to UL 2054, most NRTLs will accept another NRTL's cell level UL 1642 test data and apply it to their UL 2054 testing. This saves the client time and money. When a NRTL does not accept test data from another and requires all testing to be performed by themselves, the client incurs the redundant costs of duplicate testing plus program delays.*

### CE Marking

The European Union's CE Marking requirements help to ensure that all safety requirements are met. CE Marking is a self declaration made by the manufacturer to acknowledge that a product meets requirements for EU product safety. The CE Mark does not apply to products sold in the U.S.

### The American National Standards Institute (ANSI)

ANSI is a private non-profit organization which develops consensus-based standards. ANSI standards are published by NEMA (National Electrical Manufacturers Association). ANSI's C18

is a comprehensive battery standard covering general information, battery specifications and safety standards for consumer batteries of all types (standard alkaline AA, 3A, C, D, etc; lithium coin cells; rechargeable NiMH; etc.). ANSI's safety standards for primary and rechargeable lithium and lithium-ion cells and batteries are listed here:

- **ANSI C18.2M, Part 2**  
(*Portable Rechargeable Cells and Batteries - Safety Standard*).
- **ANSI C18.3M, Part 2**  
(*Portable Lithium Primary Cells and Batteries - Safety Standard*)

*NOTE: In its attempt to harmonize C18 test details with competing standards, ANSI takes care to review all relevant global standards during the writing process. In this effort of standards harmonization, ANSI is not alone. ANSI's UL and IEC counterparts also look to harmonize across standards. An interesting side note is that despite these efforts, differences still exist – and some are likely to persist through several revision cycles!*

## International Organizations and Standards

### ISO/IEC 17025

In the context of this paper, ISO/IEC 17025 is the certification of a quality management system for battery test labs. A2LA and 17025 are often used interchangeably, but they are not one and the same. A2LA is but one of many organizations who are authorized to issue a company's certification of compliance to ISO/IEC 17025.

### UN/DOT

The UN (United Nations) issues recommendations for the transport of dangerous goods worldwide. The U.S. DOT (United States Department of Transportation) defines shipping regulations for the U.S. under 49 CFR, Sections 100 - 185. Section 173.185 specifically addresses specifications and exceptions and packaging for lithium batteries; section 172.101 covers shipping. Together, the UN and DOT guidelines define test requirements for the safe packaging and shipment of lithium metal and lithium ion batteries. Safety test criteria are defined in the "*Recommendations on the Transport of Dangerous Goods, Manual of Tests and Criteria, Part III, Section 38.3.*"

- **UN/DOT 38.3** (also known as the T1-T8 Tests and UN ST/SG/AC.10/11/Rev. 5). Covers transportation safety testing for all lithium metal and lithium ion cells and batteries. The test criteria span 8 different tests (T1 - T8) and are all are focused on hazards associated with transportation.

- **UN/DOT 38.3** is a self-certify standard. Independent third party test lab certification is not required. However, because of potential liability issues, most companies choose to use third party test labs.

*NOTE: There are several additional international organizations serving the transportation industry which have their own lithium battery regulations. Although these regulations are based on UN/DOT 38.3 battery safety test criteria and rely heavily on packaging/shipping guidelines provided in 49 CFR sections 173.185 and 172.101, some differences regarding shipping/transportation exemptions and inclusions exist.*

*Listed here for reference are the major international transportation organizations:*

- **PHMSA** (Pipeline and Hazardous Materials Safety Administration, U.S. DOT)
- **IATA** (International Air Transport Association)
- **ICAO** (International Civil Aviation Organization)
- **IFALPA** (International Federation of Air Line Pilots' Associations)
- **IMDG Code** (International Maritime Dangerous Goods code)

*With recent lithium-ion battery incidents raising many questions, regulations regarding transportation are in flux as of the writing of this paper. All this uncertainty has resulted in a United Nations panel recommending a prohibition against shipping lithium-ion batteries as cargo on passenger aircraft. ICAO has reversed a January 1, 2013 ruling that had allowed up to 35 kilograms of lithium batteries as cargo on passenger aircraft. However, passengers are still allowed to bring up to 5 kilograms (11 pounds) of lithium-ion batteries onto planes.*

## Underwriters Laboratories (UL)

UL is an independent product safety certification organization which, in conjunction with other organizations and industry experts, publishes consensus-based safety standards. For lithium batteries, key standards are:

- **UL 1642** (*Lithium Batteries*) – This standard is used for testing lithium cells. Battery level tests are covered by UL 2054.
- **UL2054** (*Household and Commercial Batteries*) – For lithium batteries, UL 2054 defers all component cell level testing to UL 1642.
- **UL 2580** (*Batteries for use in Electric Vehicles*)

*NOTE: Any NRTL can obtain approval to certify against specific UL standards if they apply for and pass a number of OSHA-defined criteria designed to assure the test lab has the rigor, resources, and experience to conduct the tests.*

## The International Electrotechnical Commission (IEC)

IEC is a non-profit standards organization that writes International Standards for all electrical, electronic and related technologies. IEC standards address general, safety, and transportation specifications. For lithium batteries, key standards are:

- **IEC 62133** (*Secondary Cells and Batteries containing Alkaline or other Non-Acid Electrolytes – Safety Requirements for Portable Sealed Secondary Cells, and for Batteries made from them, for use in Portable Applications*)
- **IEC 60086-4** (*Primary Batteries – Safety of Lithium Batteries*)
- **IEC 61960** (*Secondary Cells and Batteries containing Alkaline or other Non-Acid Electrolytes – Secondary Lithium Cells and Batteries for Portable Applications*)
- **IEC 62281** (*Safety of primary and secondary lithium cells and batteries during transport*)  
This standard is similar to UN/DOT 38.3.

## IECEE

The IEC System for Conformity Testing and Certification of Electrotechnical Equipment and Components is known as the IECEE. As part of its charter to facilitate international trade in electrical equipment (battery safety in context of this paper, IECEE operates a scheme known as the CB Scheme.

### The CB Scheme

The CB Scheme is an international program (under IECEE) for the exchange and acceptance of product safety test results among participating laboratories and certification organizations around the world. The CB Scheme offers manufacturers a simplified way of obtaining multiple national safety certifications for their products — providing entry into over 45 countries. CB Test Certificates are issued by approved NCBs / CBTLs.

- **NCB** (National Certification Bodies (NCB), under IECEE's CB Scheme)
- **CBTL** (Certified Body Testing Lab (CBTL), under IECEE's CB Scheme)
- **Category BATT:** Under IECEE, a number of IEC Standards are listed under "Category: BATT; Product: Batteries." Category BATT covers over two dozen standards (much more than the four IEC standards listed in this paper).

## The Institute of Electrical and Electronics Engineers (IEEE)

IEEE is an international non-profit organization covering technologies related to electricity, and develops safety standards for industry, including batteries. For lithium batteries, key standards are IEEE 1725 and IEEE 1625 both of which are design guidelines, not pass/fail safety standards:

- **IEEE 1725** (*Rechargeable Batteries for Cellular Telephones*)
- **IEEE 1625** (*Rechargeable Batteries for Multi-Cell Mobile Computing Devices*)

## CTIA

The Wireless Association, formerly known as the Cellular Telephone Industries Association (CTIA), is an international trade group. In the context of this paper, CTIA certifies compliance to IEEE 1725 and IEEE 1625 standards.

*NOTE: CTIA has taken IEEE 1625 and 1725 standards and generated pass/fail criteria in order to convert IEEE's safety guidelines into something quantifiable and certifiable. In addition, CTIA is currently developing an industry standard method for measuring battery life in smart phones.*

## CTIA Authorized Test Lab (CATL)

Through their CATLs, the CTIA manages a program to permit operators and their suppliers to validate Li-ion battery compliance with the IEEE Standards 1725 and 1625.

## SAE International

SAE International (Society of Automotive & Aerospace Engineers) is a professional organization for the aerospace, automotive, and commercial vehicle industries. SAE develops standards for engineering professionals. With hybrid and full electric vehicles now entering the marketplace in large numbers, the need for battery standards is getting greater attention. Key SAE standards for lithium batteries include:

- **SAE J 2929** (*Electric and Hybrid Vehicle Propulsion Battery System Safety Standard - Lithium -Based Rechargeable Cells*)
- **SAE J 2464** (*Electric and Hybrid Electric Vehicle Rechargeable Energy Storage System (RESS) Safety and Abuse Testing*)

## JIS (Japanese Standards Association)

- **JIS C8714** (*Safety Tests for Portable Lithium-Ion Secondary Cells and Batteries for use in Portable Electronic Applications*)

## BATSO (Battery Safety Organization)

- **BATSO 01** (*Manual for Evaluation of Energy Systems for Light Electric Vehicle (LEV) — Secondary Lithium Batteries*)

## EU Directives

- **2006/66/EC**

**EU Battery Directive** (*Governing batteries and accumulators and waste batteries and accumulators and repealing Directive 91/157/EEC*)

- **2001/95/EC**

**General Product Safety** (*Manufacturers must also consider other Directives that may apply to their product; even though apparently optional they may be of relevance to safety depending on the design, construction and application of the battery pack*)

## Lithium Battery Safety in Practice

Other than the near universal standard industry practice and market-based demands for listing and recognition of cells and batteries as components and end-products, there are no mandatory requirements for lithium battery safety testing. This applies to UL, IEC, IEEC and the like. Because product safety is important (brand image, liability, etc.) and because passing safety certifications are one means of assuring product is safe, the practice of testing to UL, IEC, IEEC, and the like, is both routine and assumed by most consumers.

Also, unless a company intends to be extremely restricted in its options for transporting their lithium batteries (ground transport as Class 9 Hazardous Goods), they will need to certify that their batteries have passed UN/DOT 38.3.

### First Decision – UN/DOT 38.3

→ Should you self-certify or use an independent third-party testing lab?

- Using a third-party lab helps to mitigate liability should an incident occur
- If using a third-party test lab, it is best if the lab is ISO/IEC 17025 accredited, and approved by OSHA as a Nationally Recognized Testing Laboratory (NRTL).
- Whichever option you choose, all levels must be tested – cells, modules, packs



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## Second Decision – Cell Testing

→ Is cell testing necessary? If yes, which standard should you use? UL 1642? IEC 62133?

*NOTE: It is highly likely that cells are already tested to UL 1642 and certified/listed by a third-party laboratory. Typically, new cell designs are certified/listed by the cell manufacturer and battery certification is the responsibility of the end-user / application device manufacturer.*

### UL 1642

- Cell listing for U.S. markets typically use UL1642
- For Battery certification, UL 2054 applies

*NOTE: For lithium batteries, UL 2054 Section 2.1 (Lithium Cells) internally references UL 1642 for the cell level test requirements.*

### IEC 61233

- The European-based IEC 61223 is rapidly becoming a global standard
- IEC 62133 is required for battery certification through the CB Scheme

### ANSI C18

- Although ANSI C18 is U.S.-based, third-party certification/listing (i.e. ETL Certification) to UL standards is more universally applied for lithium battery safety.

## Third Decision – Battery Certification

→ Depending on your market needs, one of the following should be considered:

**UL 2054** (for general battery safety certification; global recognition and acceptance)

**IEC 62133** (for Europe and CB Scheme certification)

**SAE J2464 / J2929** (for Electric and Hybrid Vehicles; other standards for Light Electric Vehicles)

*NOTE: Consider using application specific standards for medical devices, power tools, etc.*

## About Intertek

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