

The slides used in this presentation are intended to be used in an event with verbal elaboration by a knowledgeable presenter. The slides highlight key U.S. product safety requirements for discussion. The text is not a comprehensive statement of legal requirements or policy and should not be relied upon for that purpose. Moreover, with the passage of time, it may not reflect the latest information. You should consult official versions of U.S. statutes and regulations, as well as published CPSC guidance when making decisions that could affect the safety and compliance of products entering U.S. commerce.

Video: Welcome to the 2021 CPSC Podcast Series – Overview of Battery Safety Requirements



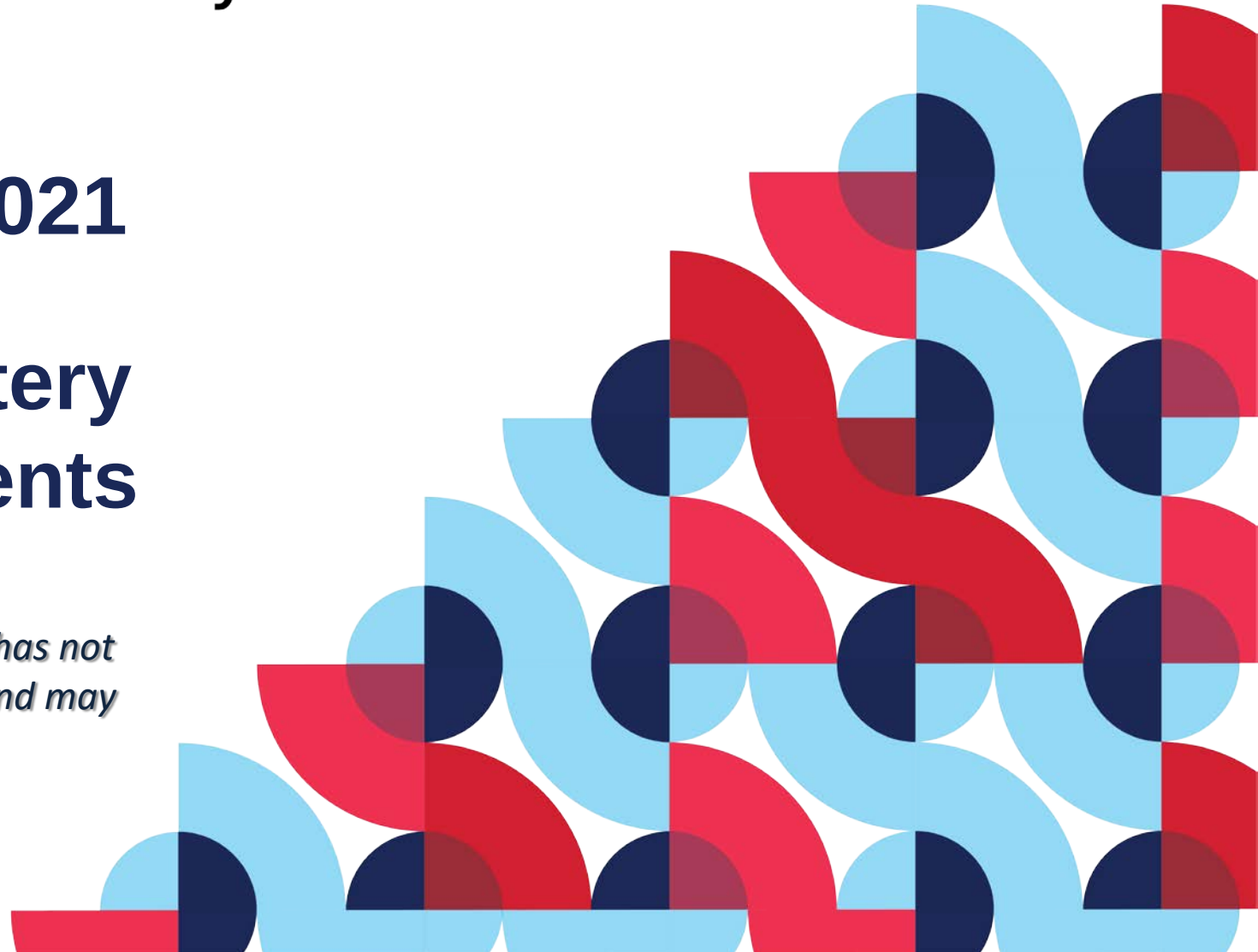


United States
Consumer Product Safety Commission

Podcast Series 2021

Overview for Battery Safety Requirements

This presentation was prepared by CPSC Staff. It has not been reviewed or approved by the Commission and may not reflect its views.



Biographies



Sylvia Chen
U.S. Consumer Product Safety Commission
Program Manager for East Asia and Pacific
Office of International Programs

Sylvia Chen is Program Manager for East Asia and Pacific at the U.S. Consumer Product Safety Commission (CPSC). In that role, she is responsible for managing the Commission's bilateral and multi-lateral programs related to consumer product safety in Australia, Japan, Korea, Taiwan and New Zealand. She also supports the CPSC's work with China. Since she joined the CPSC in 2008, Sylvia has been working with product safety regulators, industry organizations, manufacturers, exporters, buyers and other sourcing professionals to provide them with guidance and technical support in understanding U.S. requirements, in particular the latest requirements for consumer products. To that end, she has organized or coordinated many of the agency's international education and outreach activities.

Sylvia has a Bachelor of Arts degree in English and American Literature from Peking University. In 1991, she graduated from The Ohio State University with a Master's degree in East Asian



Joseph Tsai, Senior Compliance Officer
Regulatory Enforcement Division
Office of Compliance and Field Operations
U.S. Consumer Product Safety Commission

Joseph joined the U.S. Consumer Product Safety Commission (CPSC) in April 2008, as a Compliance Officer in the Regulatory Enforcement Division of the Office of Compliance and Field Operations.

As a Compliance Officer, he is responsible for enforcing the mandatory regulations for children's products, such as, toys, pacifiers, and rattles under the Federal Hazardous Substances Act (FHSA) and Consumer Product Safety Act (CPSA).

In addition, he advises stakeholders on requirements for tracking and certification for children's products under the CPSA. His specific responsibilities include advisement on the implementation of regulations, standards, and bans under the FHSA and the CPSA, and providing advice and guidance to consumers and the regulated industry.

Prior to joining the CPSC, Mr. Tsai was an officer at U.S. Customs and Border Protection, and a research scientist with Scripps Research Institute, La Jolla, California. Mr. Tsai holds a Bachelor of Science degree from University of California, Los Angeles (UCLA), and a Master of Science degree from University of California, San Diego (UCSD).



\$1 Trillion

Deaths, injuries,
and property
damage from
consumer product
incidents cost the
nation more than \$1
trillion annually.¹

The US CPSC is a federal government agency charged with protecting the public from unreasonable risks of injury or death associated with the use of consumer products under the agency's jurisdiction.

¹ <https://www.cpsc.gov/s3fs-public/FY2019PBR.pdf>

CPSC is committed to protecting consumers from products that pose a fire, electrical, chemical, biological, or mechanical hazard.

CPSC's work to improve the safety of the more than 15,000 types of consumer products in its jurisdiction - such as toys, cribs, power tools, cigarette lighters, textiles, and household chemicals – has contributed to a decline in the rate of deaths and injuries associated with consumer products over the past 40 years.

CPSC's Podcast Series 2021

Podcast	Topics
#1	Overview of Children's Sleepwear Requirements
#2	Enhancing the Safety of Emerging Technology through Risk Assessment: Wearables
#3	Overview of Battery Safety Requirements
#4	Overview of Gates and Enclosures Requirements
#5	Overview of Consumer Safety and Micromobility Devices
#6	Overview of Cribs and Play Yards Requirements

“Questions on this
Presentation? Send an email to
CPSCinChina@cpsc.gov”

Overview of Battery Safety Requirements: Lithium-Ion Battery Safety for Consumer Products into the United States

Overview

- Electrical Product Safety
 - Fire and Shock Data
- Hazard Mitigation Strategies
 - Industry Consensus Standards
 - Technical Regulations
 - 15(j) Requirement
 - Complying with Industry Consensus Standards
 - CPSC Data Systems
 - High-Energy Density Batteries Project
 - Battery Recalls
 - Root Causes
- Case Study – Products with No Standard
- Case Study – Products with Well-Established Standards
- Best Manufacturing Practices - Assuring Safety of Lithium-Ion Cell-Powered Products

Electrical Product Safety

- Electricity is a powerful, useful energy source that is potentially hazardous.
- Electrical product failures or misuse can cause hazards, such as:
 - Fires
 - Electric shock
 - Thermal burns (from exposure to hot surfaces)
 - Chemical burns (from batteries),
 - Injuries (lacerations from moving parts) or
 - Loss of critical function (a smoke alarm not signaling a fire).
- Products that generate, distribute, or use electrical energy should be compliant with applicable standards and installed according to applicable electrical codes to help minimize safety risks to consumers from these products.

Electrical Fire Data

67,900 structure fires
from electrical equipment per year

660 deaths, 3,410 injuries
\$1.738 billion in property
losses per year

Top electrical

1. Cooking equipment, such as range/ovens, microwaves and small appliances
2. Distribution systems, such as installed wiring
3. Heating and cooling equipment

¹ Average base on 2015-2017 data

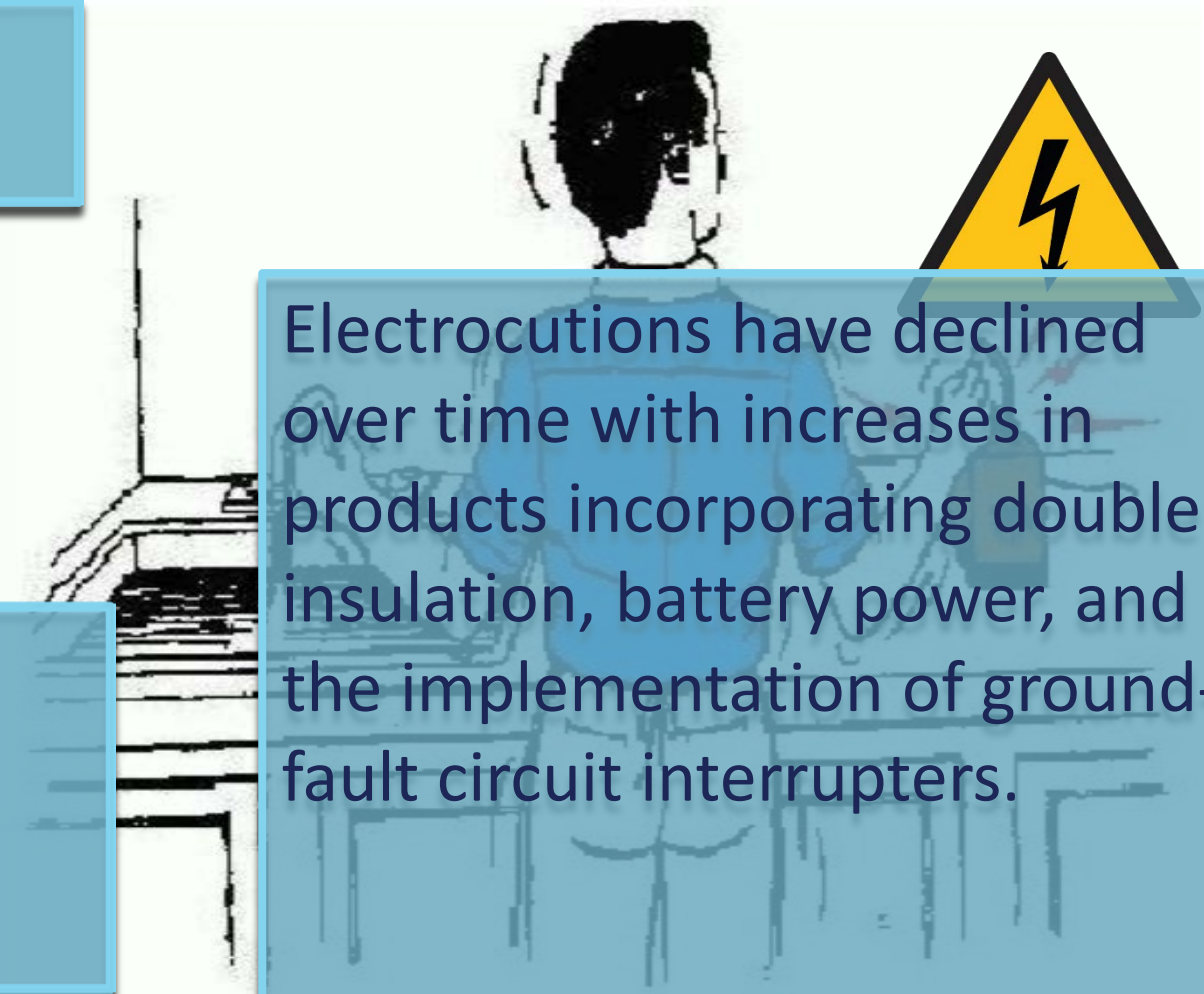
Electric Shock Data

60 consumer product-related electrocutions per year



Top four involved products:

1. Large Appliances
2. Small Appliances
3. Power Tools
4. Lighting Equipment

A blue-tinted illustration of a person sitting at a desk with a computer. A yellow lightning bolt warning sign is positioned above the person's head.

Electrocutions have declined over time with increases in products incorporating double insulation, battery power, and the implementation of ground-fault circuit interrupters.

¹ Average based on 2004 - 2013 data

Hazard Mitigation Strategies

CPSC staff uses a multipronged approach

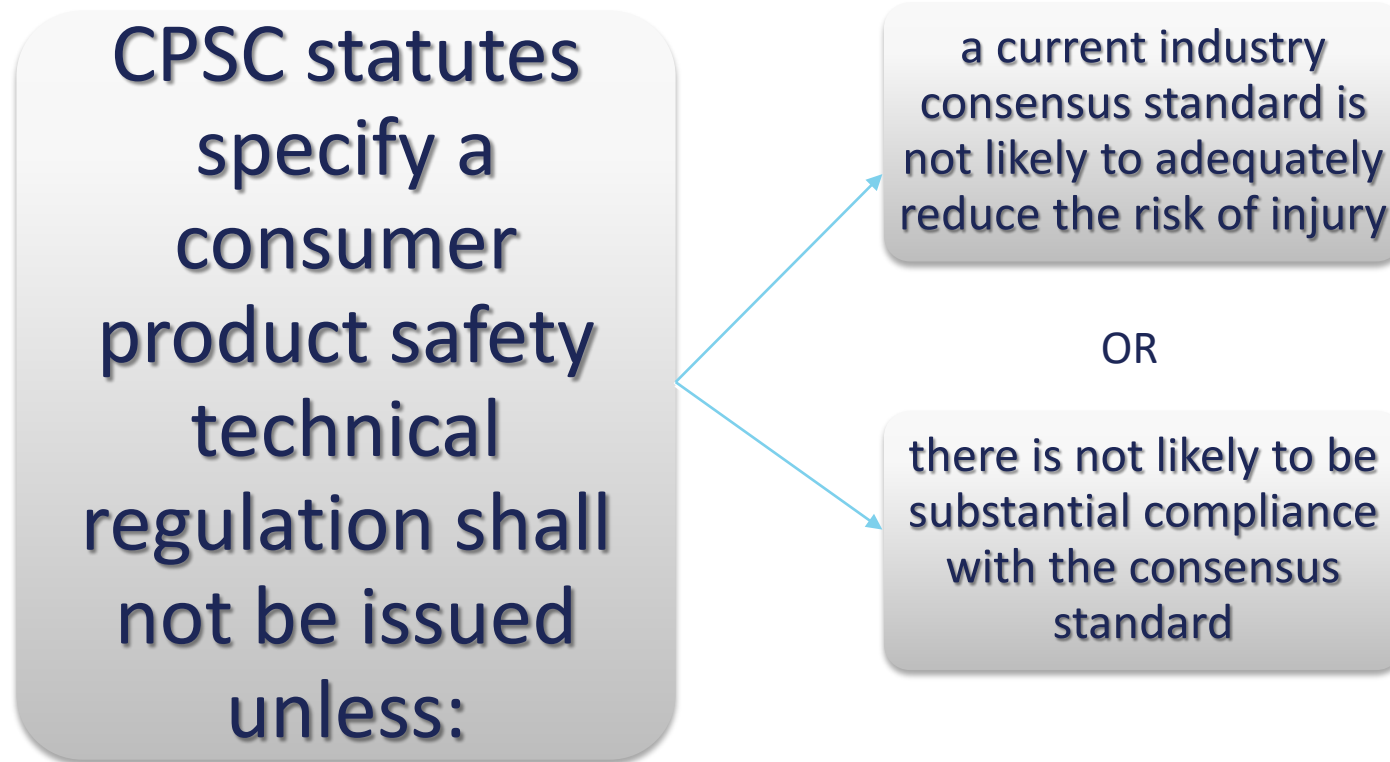
- Support improvements to industry consensus standards/codes
- Distribute safety information to consumers
- Create and enforce technical regulations and bans
- Recall products with defects after identifying hazards through investigations

Hazard Mitigation Strategies: Industry Consensus Standards

Staff relies on industry consensus standards to establish minimum levels of safety.

- Most electrical product safety standards have been developed and maintained under the auspices of Underwriters Laboratories (UL). Other standards developers for electrical product safety include the Institute of Electrical and Electronics Engineers (IEEE) and the National Electrical Manufacturers Association (NEMA)

Hazard Mitigation Strategies: Technical Regulations



Check the CPSC website or contact CPSC staff to determine what requirements your product needs to meet: <https://www.cpsc.gov/Business--Manufacturing>

Battery-operated toys, electric toys, and citizens band (CB) station antennas are some electrical products subject to technical regulations

Hazard Mitigation Strategies: Technical Regulations for Electrical Products

Battery-Operated Toys

- ASTM F963-17, *The Standard Consumer Safety Specification for Toy Safety*, which is a comprehensive standard addressing numerous hazards that have been identified with toys. CPSC incorporated this industry consensus standard into a mandatory standard for toys (16 CFR part 1250).

Electric Toys

- 16 CFR 1505 – Requirements for electrically operated toys or other electrically operated articles intended for use by children. This covers any toy, game, or other article designed, labeled, advertised, or otherwise intended for use by children that is intended to be powered by electrical current from nominal 120 volt branch circuits

CB Antennas

- 16 CFR part 1204 - Safety Standard for Omnidirectional Citizens Band Base Station Antennas

Hazard Mitigation Strategies: The 15(j) Requirement

- CPSC can recall products, or prevent importation of products, if they fail to meet critical safety requirements of a certain specific industry consensus standard
- Section 15(j) of the CPSA provides authority to specify for any consumer product or class of consumer products, characteristics whose existence or absence are deemed a substantial product hazard under section 15(a)(2) of the CPSA.
- A product within the scope of section 15(j) must have specific observable product characteristics that are required by a industry consensus standard.

Hazard Mitigation Strategies: The 15(j) Requirement

- The Commission has determined that products that do not comply with a 15(j) regulated requirement present a defect and are a substantial product hazard.
- Therefore products that do not comply with an applicable 15(j) requirement cannot be imported into or sold within the US.
- Handheld hair dryers, holiday lights, and extension cords are electrical products subject to 15(j) regulated requirements

Hazard Mitigation Strategies: 15(j) Requirement - Handheld Hair Dryers

16 CFR § 1120.3(a) – Household and commercial handheld hair dryers must have an **integral immersion protection circuit interrupter plug** (as per UL 859 and UL 1727)



Hazard Mitigation Strategies: 15(j) Requirement – Seasonal and Decorative Lighting Products

16 CFR § 1120.3(c) – Seasonal and decorative lighting products must meet the **minimum wire size** requirements of UL 588, have **sufficient strain relief** and include **integral overcurrent protection**.



Hazard Mitigation Strategies: 15(j) Requirement – Seasonal and Decorative Lighting Products

Not In Scope

- Class 2-powered Products
- Solar-powered Products
- Rope Lights/Luminaires



Hazard Mitigation Strategies: 15(j) Requirement – Extension Cords

16 CFR § 1120.3(d) – Extension Cords must meet the **minimum wire size** requirements of UL 817, have **sufficient strain relief**, be **properly polarized** and indoor-use cords must have **outlet covers** while outdoor-use cords must be **jacketed**.



Hazard Mitigation Strategies: 15(j) Requirement – Extension Cords

Not In Scope

- Detachable Power Supply Cords
- Relocatable Power Taps
- Appliance Cords



Hazard Mitigation Strategies: Complying with Industry Consensus Standards

Electrical products not subject to a regulation do not require certification by an accredited third party lab (e.g., UL, Intertek or CSA) to a industry consensus standard, but staff observes a high rate of voluntary compliance.

- Many retailers will only sell electrical products if they have been third party certified.
- Some states and municipalities require certification for all electrical products to be sold in those jurisdictions.
- The Occupational Safety and Health Administration (OSHA) requires certification by a Nationally Recognized Testing Laboratory (NRTL) for electrical products used in a workplace.

CPSC staff strongly recommends that manufacturers or exporters/importers seek third party certification for their electrical products as a means of hazard mitigation.

Hazard Mitigation Strategies: Complying with Standards

- Compliance with applicable regulations, standards, and the *NEC* are highly effective ways to mitigate hazards from equipment that generates, distributes, or uses electrical energy.
- CPSC statutes assign the responsibility for safe products to all parts of the supply chain.



- Importers, although reliant on foreign producers, are responsible for the safety of products they bring into the United States

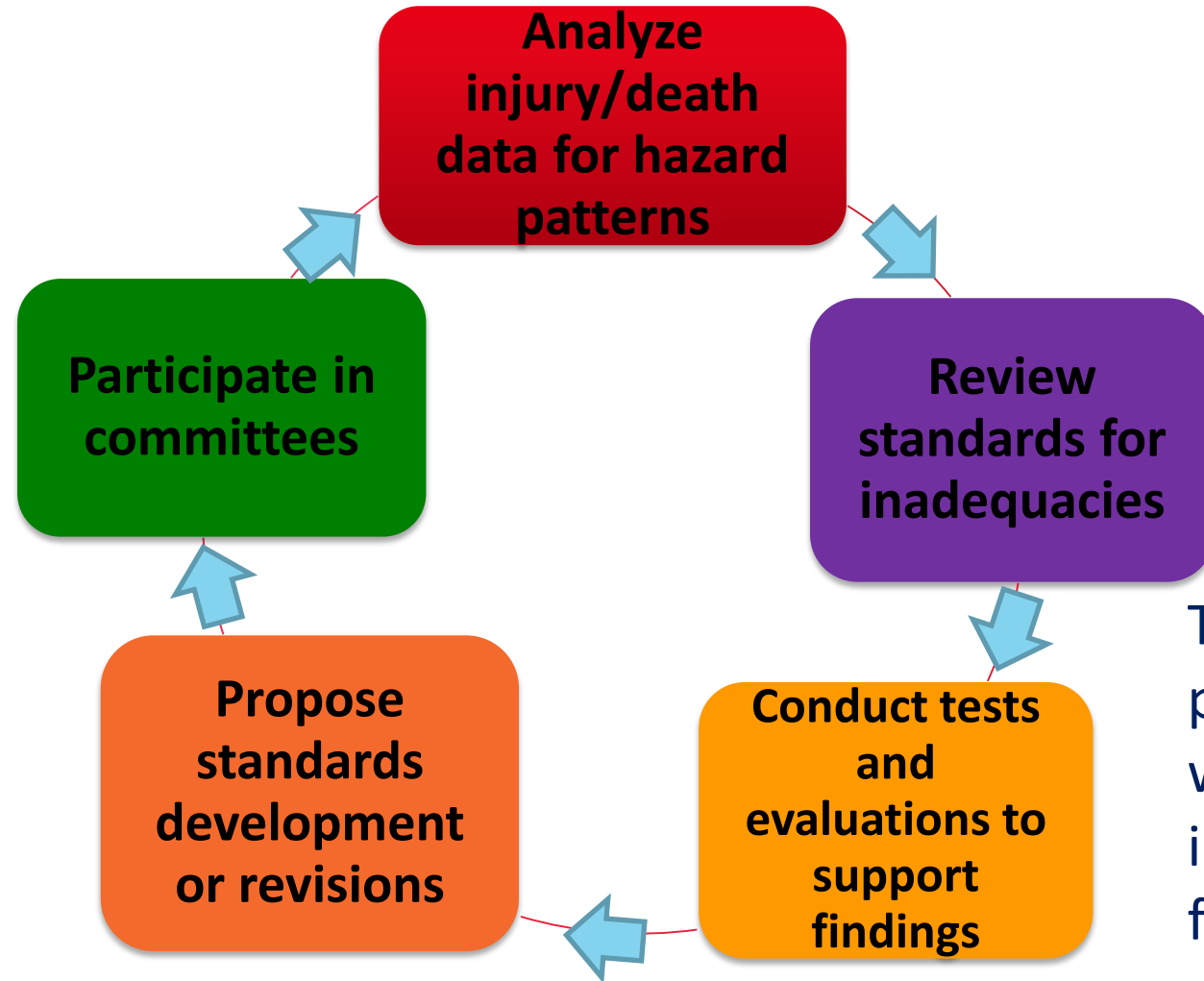
Hazard Mitigation Strategies: Responsibility to Comply

Manufacturers and importers should follow best practices to ensure that their electrical products do not pose unreasonable risks of injury.

- Comply with consensus standards and technical regulations
- Obtain certification from an accredited lab to assure and demonstrate products meet applicable industry consensus standard
- Maintain quality and configuration control
 - Assess impact of material or component substitutions

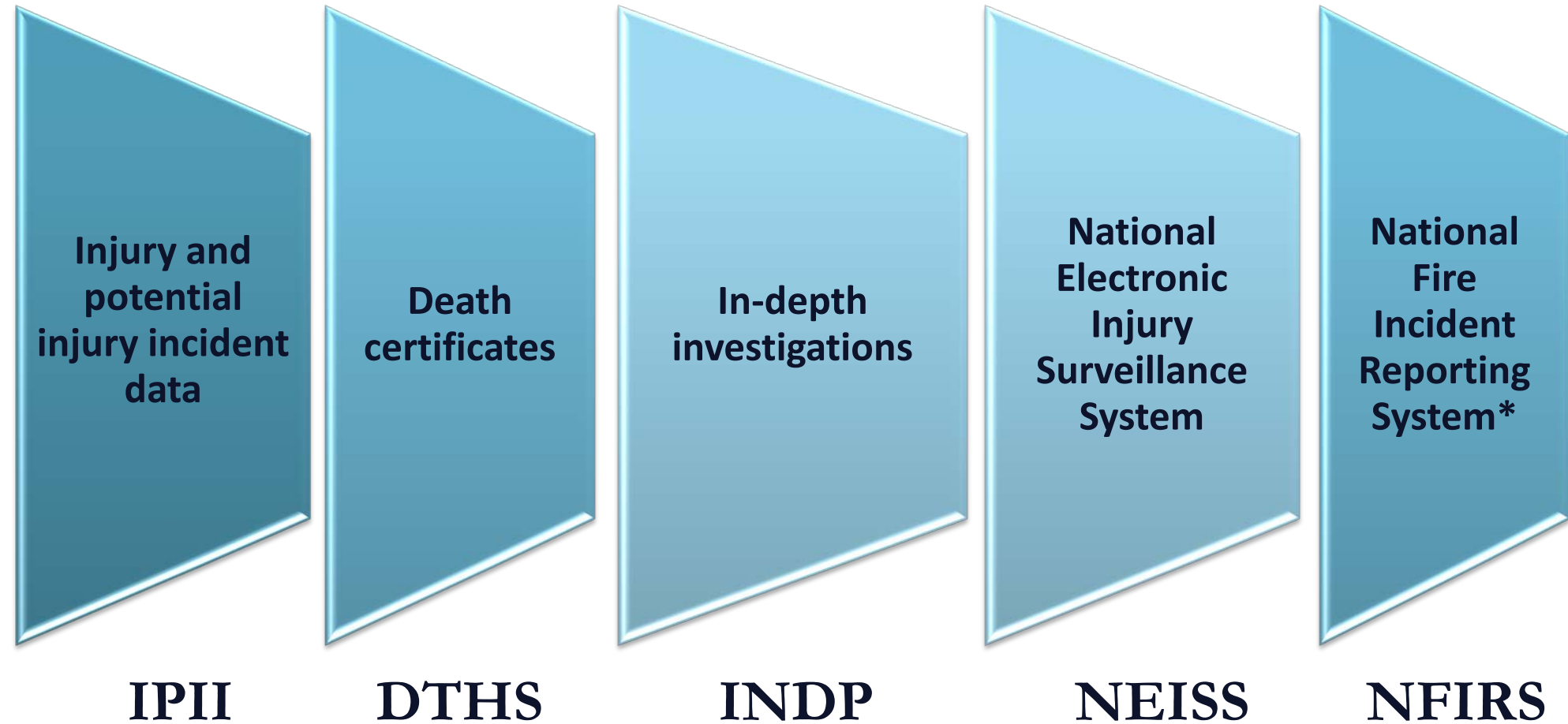
Industry Consensus Standards Process: CPSC Staff Participation

With such a heavy reliance on industry consensus standards, staff is engaged in the process of maintaining adequacy of industry consensus safety standards, including addressing emerging hazards, by actively participating through development and proposal of new or modified requirements.



This is an ongoing process that begins with staff gathering incident information from CPSC's data collection systems.

Industry Consensus Standards Process: CPSC Data



*NFIRS is operated by the United States Fire Administration

CPSC Data: IPPI



Saferproducts.gov is CPSC's public portal for incident reports and searches

- Medical Examiners and Coroners Alert Program (MECAP)
- News Clips
- Hotline Calls
- Internet Reports
- Compliance Reports
- Federal and State Agency Referrals
- Other Reports
 - Provides anecdotal account of product-related incidents

CPSC Data: DTHS

- Contracts with 50 states
- Purchase approximately 8,000 per year
- Time lag
- Daily review
- Analytical use
 - Death certificates provide specific details on death-related incidents caused by products but minimal product details

CPSC Data: INDP

CPSC Field staff conduct follow-up investigations on selected initial incident reports

- On-site Investigations
 - Local-level collaboration
 - Medical examiner
 - Police
 - Fire
 - Sample collection opportunity
- Telephone Interviews

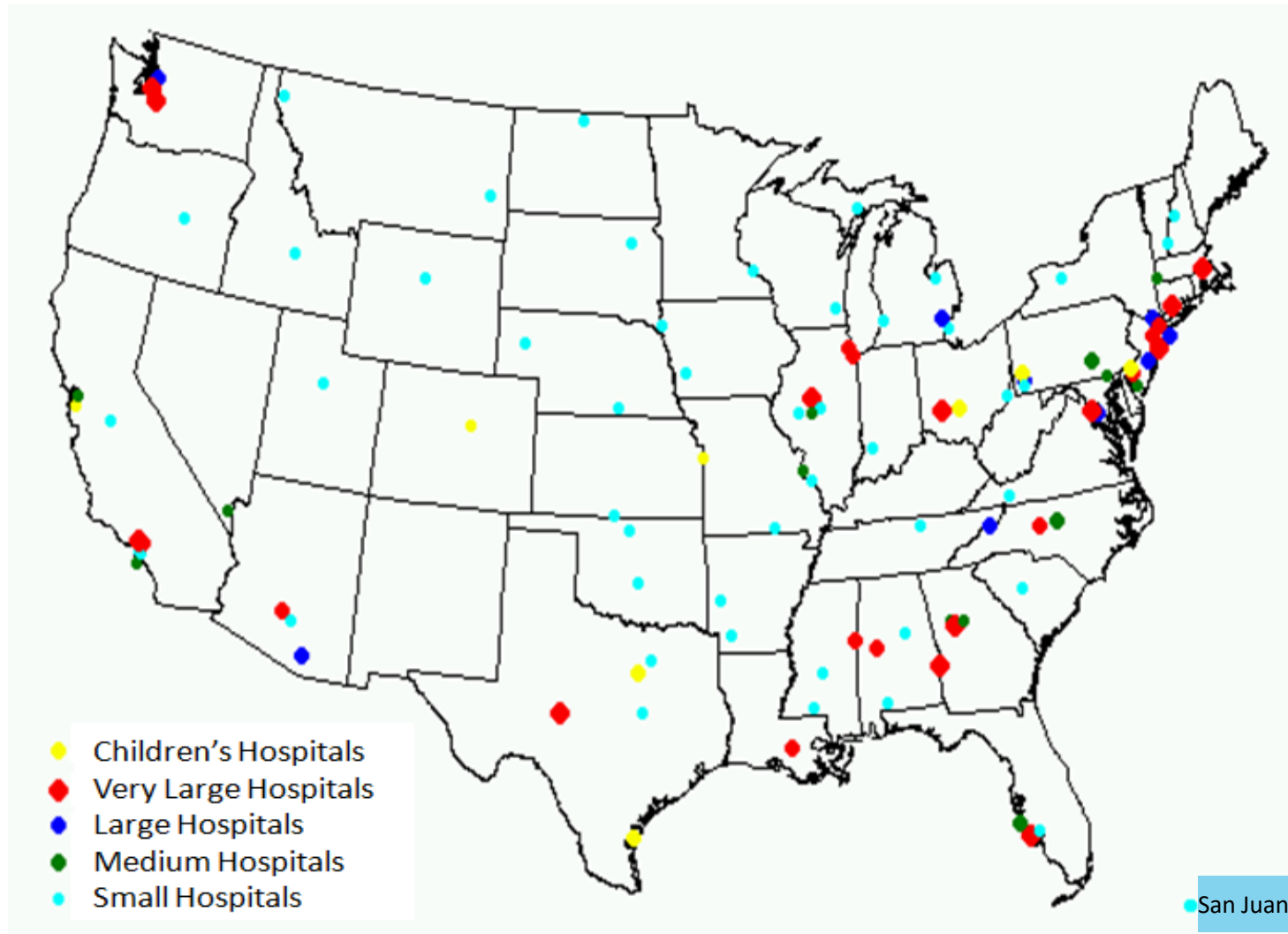
INDP reports provide specific details on a product and its involvement in an incident

CPSC Data: NEISS

- National sample
 - Data collected from approximately 100 hospital emergency rooms around the country
 - Submitted daily by hospital coders
 - Data weighted to provide consumer injury estimates nationwide
 - About 395,000 consumer product-related injury reports annually
- Data available from 1980 to present

Provides statistically significant data with details on product-related injuries, but less detail on specific products

CPSC Data: NEISS Hospital Locations



CPSC Data: NEISS Variables

- Treatment date
- Case number
- Age
- Sex
- Injury diagnosis (2)
- Body part injured
- Disposition from ED
- Products involved (2)
- Locale
- Type/work-related
- Fire dept. involvement
- Intent
- Race/ethnicity
- Narrative (2 lines)

CPSC Data: NEISS – Data Accessible at CPSC.gov

https://www.cpsc.gov/cgibin/NEISSQuery/home.aspx



United States
CONSUMER PRODUCT SAFETY COMMISSION

En | Es | 汉字

Menu

Search CPSC

Home » Research & Statistics » National Electronic Injury Surveillance System (NEISS) » NEISS Estimates Query Builder

NEISS Highlights, Data and Query Builder

User Affiliation (Required)

☐ Media ☐ Consumer ☐ Researcher ☐ Industry ☐ Other

NEISS Data Highlights

Year: Report Content:

Archived Annual NEISS Data

Year: File Format:

NEISS Estimates Query Builder

CPSC Home

Questions on how to query the NEISS system should be directed to NEISSWeb@cpsc.gov

NEISS Home

Inside CPSC

[Accessibility](#)
[Privacy Policy](#)
[Budget, Performances & Finance](#)
[Open Government](#)
[Information Quality Act](#)

[FOIA](#)
[Inspector General](#)
[No Fear Act Data](#)
[USA.gov](#)
[Sitemap](#)

Connect with us:




U.S. Consumer Product Safety Commission
4330 East West Highway Bethesda, MD 20814

CPSC.gov is an official website of the United States government.

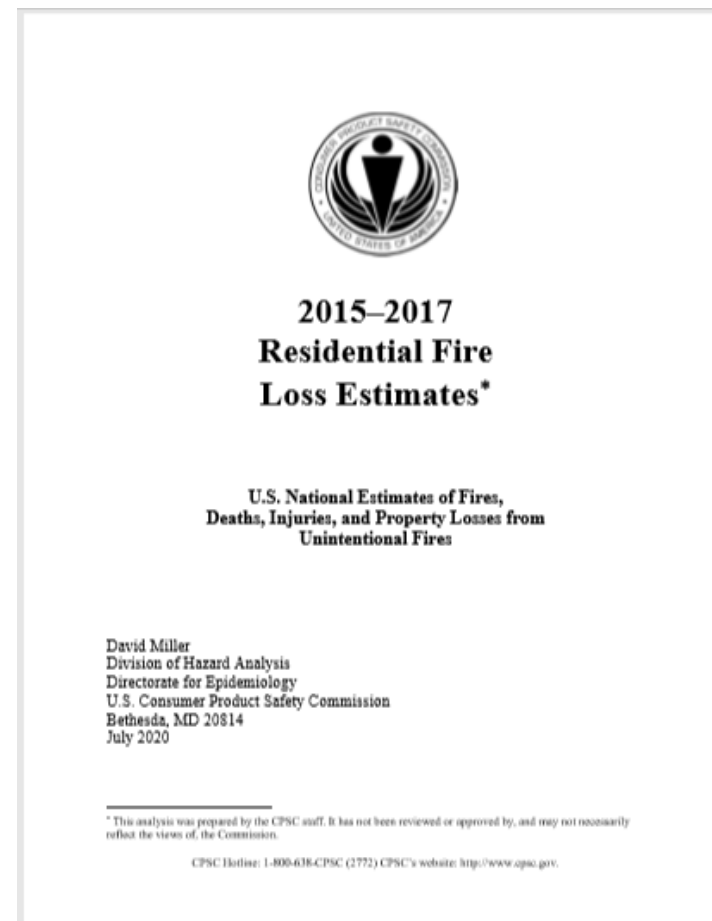
Contact Us: [800-638-2772](tel:800-638-2772) (TTY [800-638-8220](tel:800-638-8220))
Toll Free Consumer Hotline | Time: 8 a.m. - 5:30 p.m. ET

Website Feedback

CPSC Data: NFIRS

NFIRS is a collection of voluntarily reported fire incidents input by the attending fire service.

This is not a statistical sample, but staff uses these data in conjunction with the National Fire Protection Association's annual national fire survey to develop annual estimates of fires and their causes.



https://www.cpsc.gov/s3fs-public/2015to2017ResidentialFireLossEstimates.pdf?lrPHs2JTqq5ijz9zvLHL3zfukzWUKw_X

CPSC Hazard Mitigation Strategies: High-Energy Density Batteries Project

Since 2016, staff has been engaged in a project to address hazards associated with high energy density batteries in consumer products.

Efforts included industry consensus standards work, import surveillance and compliance, and industry, interagency, and intergovernmental cooperation. Staff issued two status reports on the project:

- Status Report on High-Energy Density Batteries Project February 12, 2018 - https://www.cpsc.gov/s3fs-public/High_Energy_Density_Batteries_Status_Report_2_12_18.pdf?UksG80UJqGY0q4pfVBkbCuUQ5sNHqtwO
- FY 2020 Status Report and Action Plan for the High-Energy Density Batteries Project March 2020 - https://www.cpsc.gov/s3fs-public/High%20Energy%20Density%20Batteries_Status%20Memo_FY20_1-6bCleared-04012020.pdf?Qj4t_otWKfBZYLpvu4l6sUvx9ZJfFc4f

CPSC Hazard Mitigation Strategies: High-Energy Density Batteries Project

Also staff sponsored the Naval Surface Warfare Center Carderock Division to conduct a study on lithium battery technology and an evaluation of mitigation techniques for multi-cell battery pack failures, issuing the following reports:

- *Emerging Energy Storage Technologies* October 2020 - https://www.cpsc.gov/s3fs-public/NSWCCD-63-TR-2020-39_Emerging-Energy-Storage-Technologies_DIS_A_VERSION_ForPostingVersion12012020.pdf?wYqrWGAQQL53BlqSYr8RfCwb2eiznIT
- *Evaluation of Cell-to-Cell Propagation in Lithium-Ion Batteries Containing 18650 Sized Cells* January 2020 - https://www.cpsc.gov/s3fs-public/Consumer%20Product%20Safety%20Commission%20%28CPSC%29%20Staff's%20Statement%20on%20Naval%20Surface%20Warfare%20Center%2C%20Carderock%20Division's%20%28NSWCCD%29%20Report%20on%20%Evaluation%20of%20Cell-to-Cell%20Propagation%20in%20Lithium-Ion%20Batteries%20Containing%2018650%20Sized%20Cells%.pdf?KKybsoSCNBqeX46SxJbUq2NqkkzZk_Wd

Staff is continuing to evaluate means of mitigating multicell battery pack failures and is participating in a cooperative effort with Canadian and Mexican governments to evaluate power banks.

Battery Product Recalls: Fiscal Years 2017-2020

From FY 2017 to FY 2020, there were 32 recalls of 15 different types of products, totaling nearly 1.75 M units

Product Type	Number of Recalls	TOTAL Units Recalled
Laptop/Notebook Computers	8	880,132
Hoverboard/Self-balancing Scooter	6	5,220
Power Bank	4	448,243
Speakers	2	205,621
Hand/Foot Warmers	2	16,707
Guitar	1	81,491
Motorized Blinds	1	57,361
video Monitor	1	26,423
Cellphone	1	10,065
Lantern	1	5,855
Sound Machine	1	4,976
Skateboard	1	3,490
Power Recliner	1	2,185
Golf Cart	1	1,049
Vape Pen	1	384

Battery Recalls: Top Four Recalls by Number of Units (2017-2020)

Firm	Product/Recall Number	No. of Units
Apple Inc.	Laptop 19-152	432,000
Amazon.com LLC	AmazonBasics Portable Power Bank 18-728	257,760
Daniel M. Friedman & Associates (Steven Madden Ltd)	Universal rechargeable power banks 19-017	170,500
Brookstone Stores, Inc.	Indoor/outdoor wireless speaker 19-090	164,511

Battery Recalls: Recalls of Lithium-ion Battery Products – Root Causes

Quality-Control Problems in Cell Manufacturing

- Improper placement of leads
- Contaminants in cell
- Uneven forming of cell
- Poor quality welds
- Insufficient electrode overlap
- Physical damage to cell
- Missing insulating tape on terminal tab

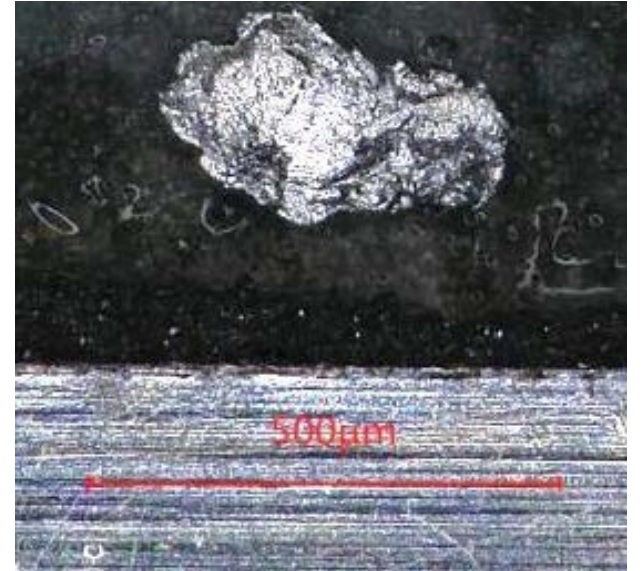
Battery Pack Design Problems

- No safety circuits
- Inadequate (or any) overcharge/over-discharge protection
- Inadequate physical protection

Battery Recalls: Recalls of Lithium-ion Battery Products – Example Root Cause

Cylindrical Cell Contamination – Certified Cell

- Laptop overheating incidents revealed defective cells
- Examined cells found to have metallic particles (iron) adhered to electrode
- Metallic particles can perforate separator and short electrodes
- Cell can overheat, possibly go into thermal runaway



Battery Recalls: Recalls of Lithium-ion Battery Products – Example Root Cause

Cylindrical Cell Contamination – Certified Cell

Root Cause: Manufacturing error when electrode-cutting chuck was repositioned improperly - interference occurred, creating iron particles

Corrective Actions Taken by Manufacturer:

- Corrected alignment of chuck by next shift
- Tracked assembly line production from affected dates
- Limited scope of recalled products
- Implemented process to control further issues with chuck alignment
- Reviewed and reduced other metal-to-metal processes in cell manufacturing

Battery Recalls: General Cell Contamination Mitigation Actions

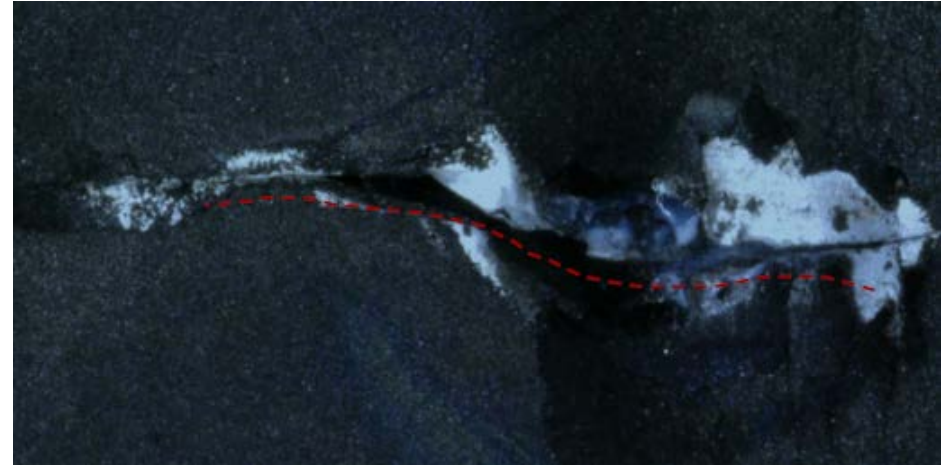
Processes used to mitigate cell contamination

- Magnets to capture loose ferrous particles
- Suction to capture other particles
- Air ventilation and filtration systems in production areas to minimize contaminants
- Cell dissection to look for foreign particles
- X-rays – non-destructive inspection for foreign particles and assembly anomalies
- CT Scanner – more detailed non-destructive inspection

Battery Recalls: Root Cause – Physical Damage Example

Damaged outer foil in polymer cell

- Can cause internal soft shorts

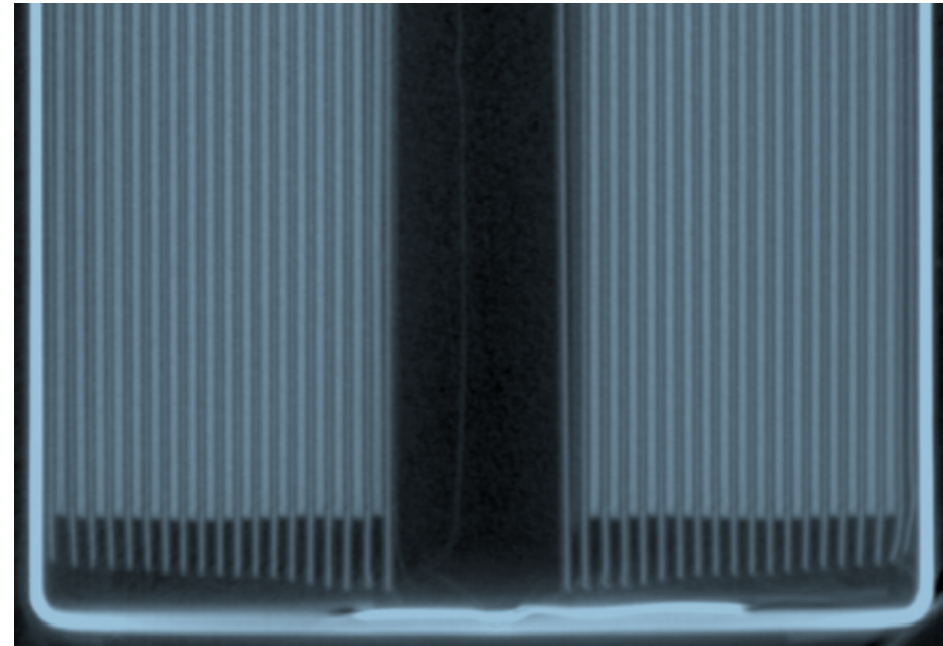
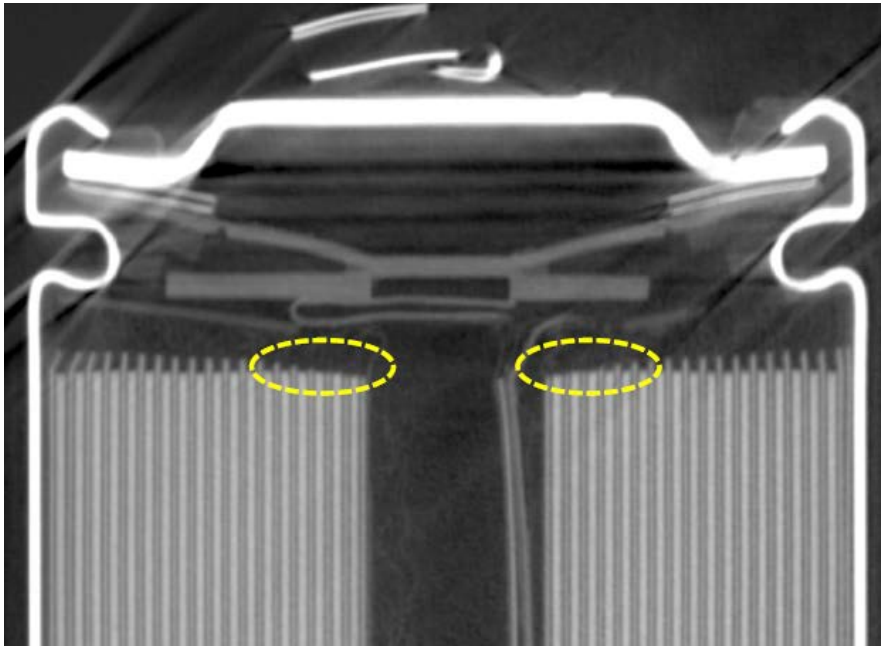


Mitigation Strategies

- Improve handling procedures and enhance worker training
- Conduct visual inspection before batteries leave the factory

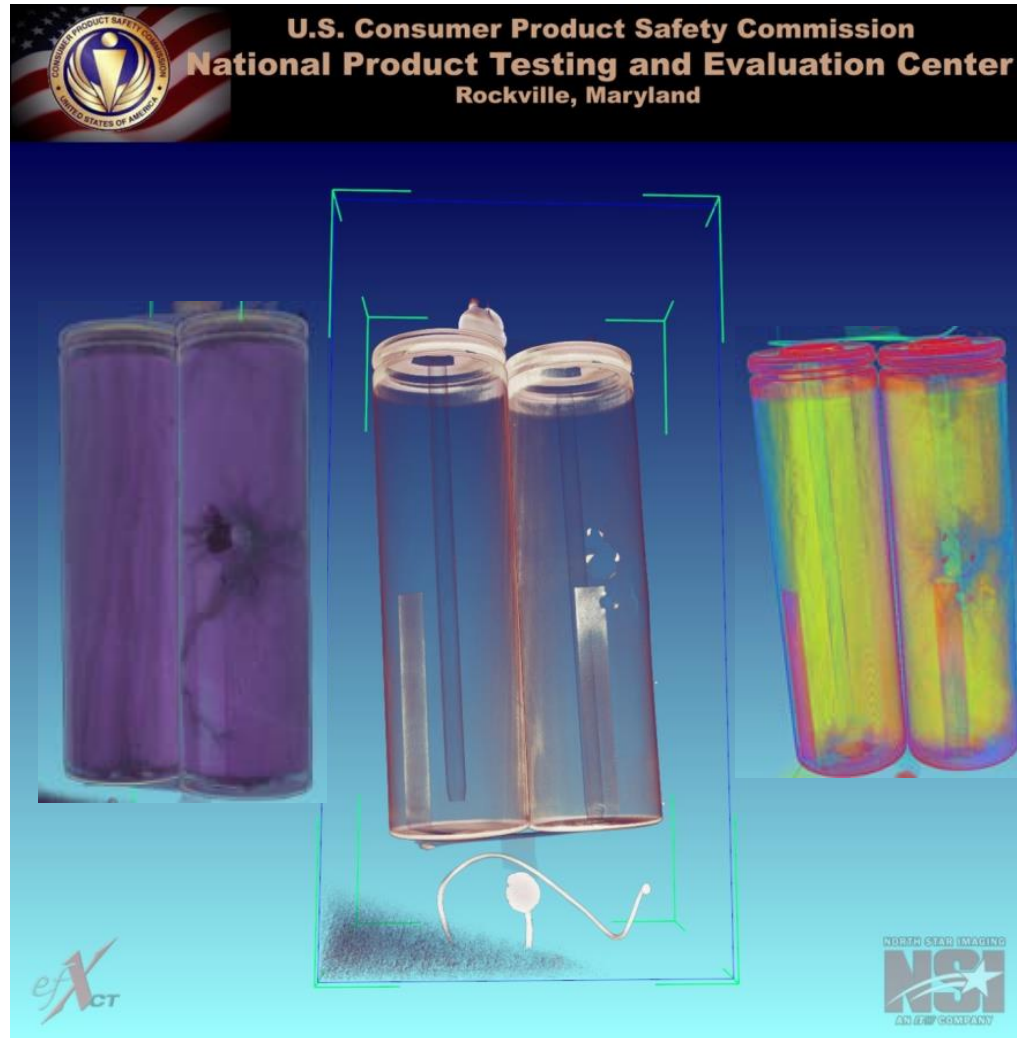
Battery Recalls: Root Cause – Electrode Overlap Example

- Insufficient electrode overlap
- May result in lithium plating at edges and eventual short circuit
- Negative-to-positive electrode overlap $> 100\ \mu\text{m}^*$



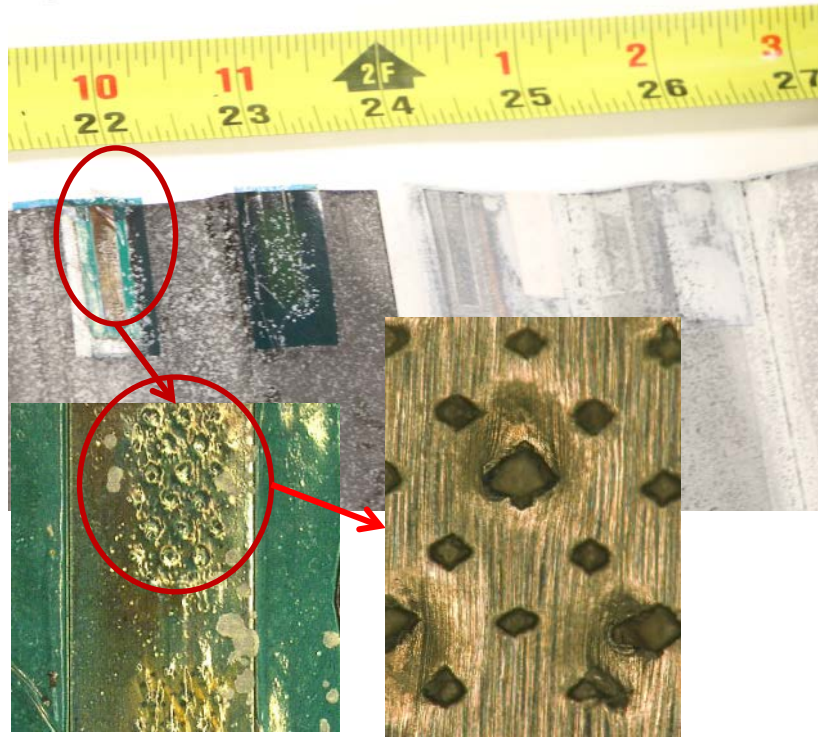
* IEEE 1625 (Laptops) and IEEE 1725 (Cell phones) standards

Battery Recalls: X-ray Analysis



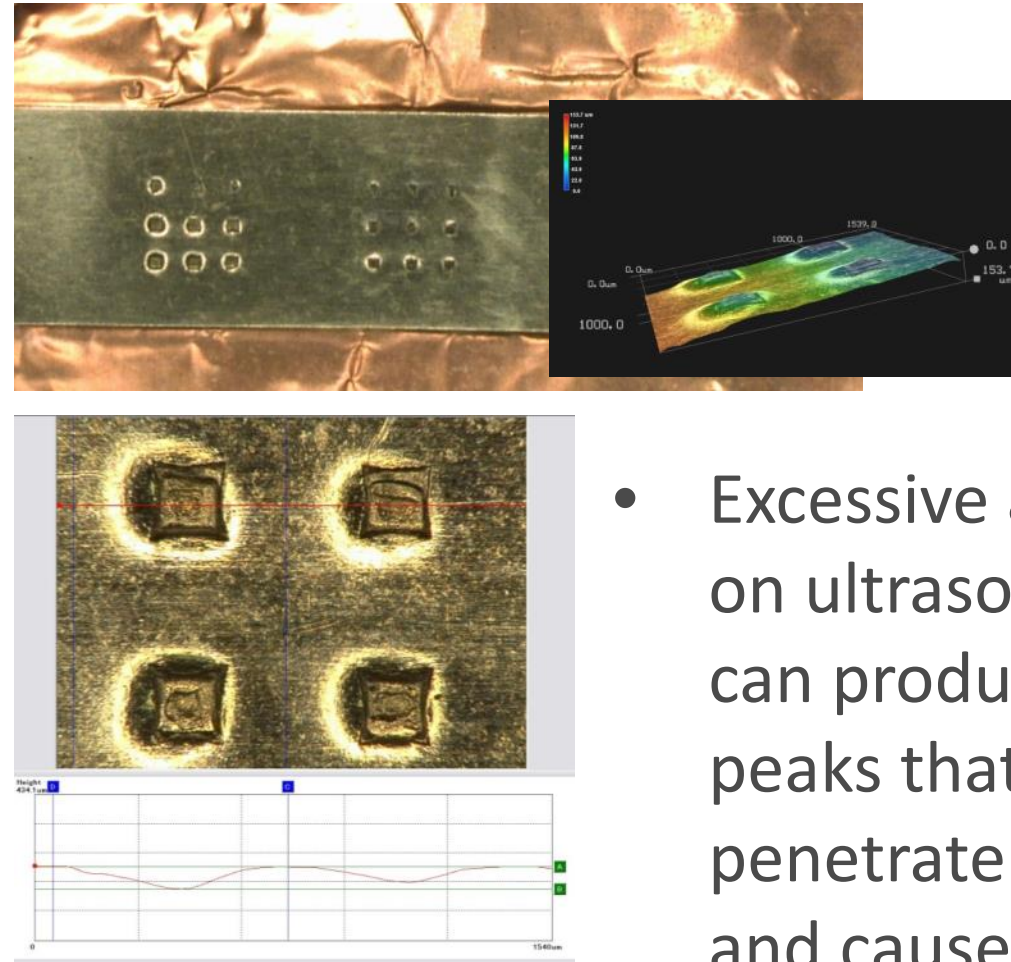
- X-rays and Computed Tomography x-rays are useful tools for cell screening, as well as failure analysis

Battery Recalls: Analysis – Dissection and Visual Inspection



Each Layer thickness

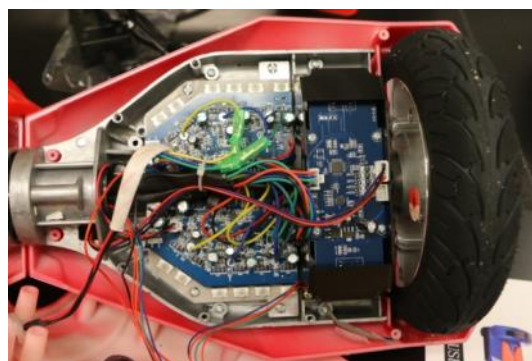
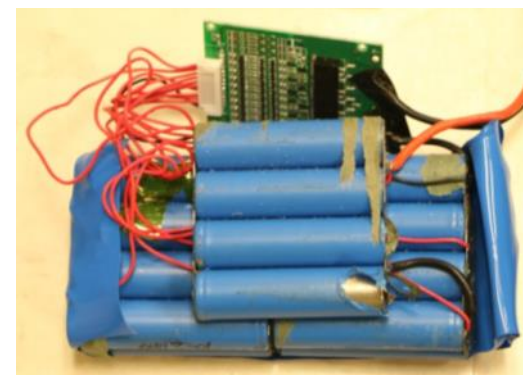
- Separator = 10 ~ 20 μm
- Tabs = 20 ~ 80 μm
- Cu and Al foil = 10 ~ 20 μm
- Coatings = 40 ~ 60 μm



- Excessive amplitude on ultrasonic welds can produce high peaks that could penetrate separator and cause shorts.

Case Study: Products with No Existing Standard

- In late 2015, hoverboards flooded the U.S. market



- These units were powered by a rechargeable lithium-ion multicell battery pack; there was no existing industry consensus standard for the end product

Case Study: Products with No Existing Standard



- Almost immediately, incidents were occurring – fires and falls

Case Study: Hoverboard Incident Data – November 2015 - May 2017

Over 165 fire incidents, causing over \$3M in property damages

- Incidents occurred in 38 states

- During and after charging

- During and after riding

3 Deaths – 1 fire (2 victims, young girls), 1 fall

Estimated over 10,000 Emergency Room Visits

- ~90% from falls, e.g. sudden stops and starts

- ~15% head injuries

- ~50% arm injuries

- ~40% fractures

- ~30% sprain/abrasions

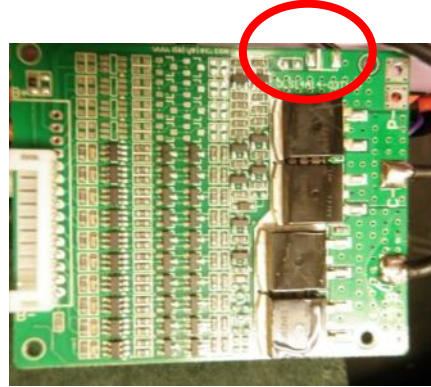
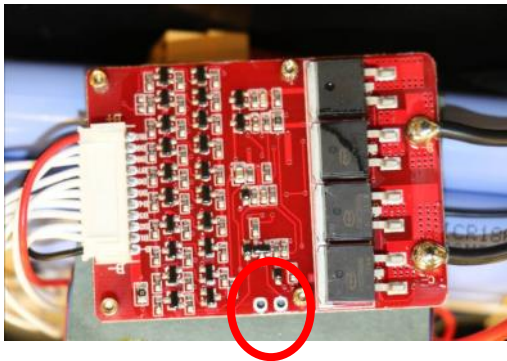
2015/2016 CPSC Staff Assessments of Hoverboards

Staff examined incident units and tested exemplar units on a dynamometer and with riders

- Fire incident units exhibited signs of thermal runaway leading to catastrophic failure of the entire battery pack
- Units were largely similar in construction with 20 Type 18650 cylindrical lithium-ion cells in a 10S-2P (ten pairs of parallel-connected cells in series) configuration.

Case Study: 2015/2016 CPSC Staff Assessments of Hoverboards

Battery management system (BMS) circuits did not incorporate thermal sensing to prevent cell charge/discharge outside of temperature specifications

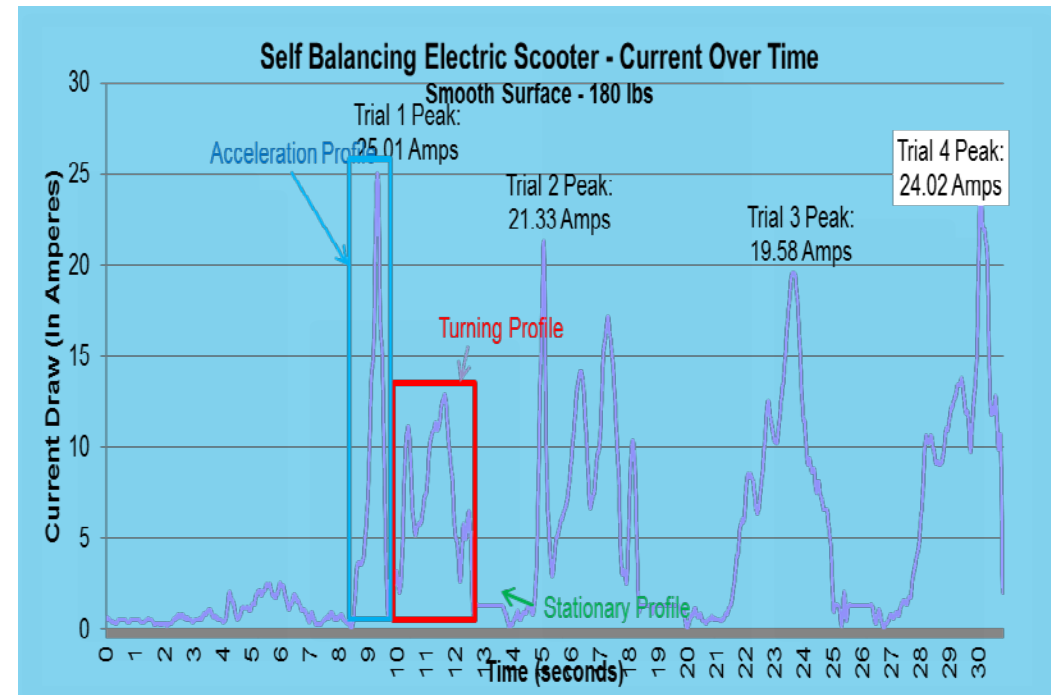
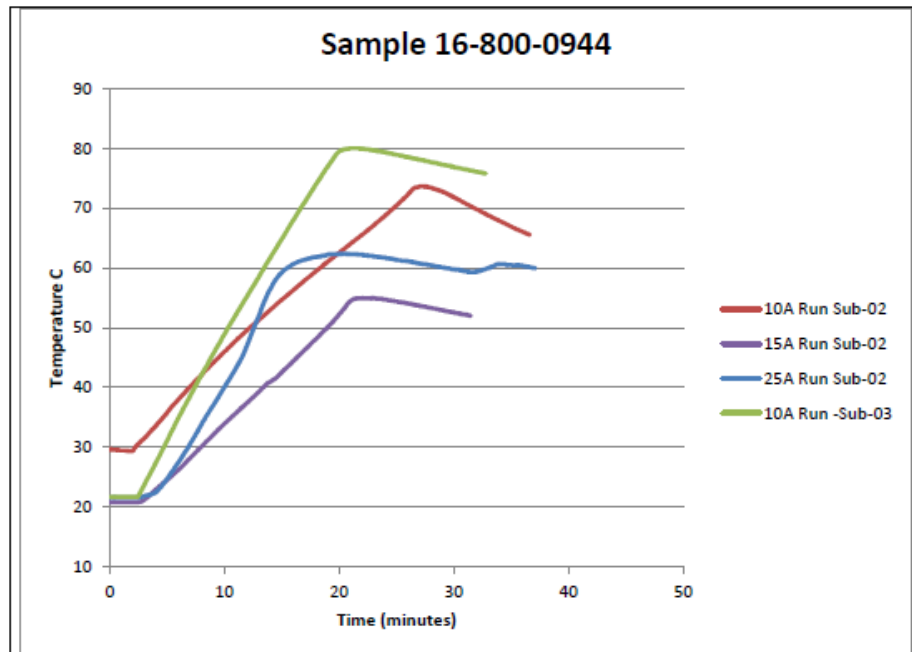


Internal wiring not installed in accordance with standard practices to protect against damage/shorting:

- Loose wires not bundled/secure
- Wires routed through openings in cast metal that was not deburred
- Wiring not sheathed where passing through pivot

2015/2016 CPSC Staff Assessments of Hoverboards

- Rider tests revealed peak battery currents over 20 A
- Dynamometer tests showed battery case temperatures well above typical operating temperatures



2015/2016 CPSC Staff Assessments of Hoverboards - Conclusions

- Inadequate BMS – Failed protective circuit safety analysis
- Inadequate cells (pack) for system load requirements
- Cells not certified to UL 1642 to ensure they have been manufactured in accordance with standards
- Battery chargers not certified to standard (UL 1310, UL 1012, or UL 60950-1)
- Wiring improperly secured and protected in the pivot base, exposed connections could cause short circuit

Units posed a risk of fire – over 500,000 units recalled

Case Study: Products with Well-Established Standards

Even products designed and constructed under well-established standards and with high rates of third party certification can pose risks of fire when best practices are not closely followed.



Photo Source: Google images



Case Study: Products with Well-Established Standards – Cell Phone Recalls

Despite adherence to industry consensus standards and products being certified, manufacturing errors occurred from two different cell manufacturers.

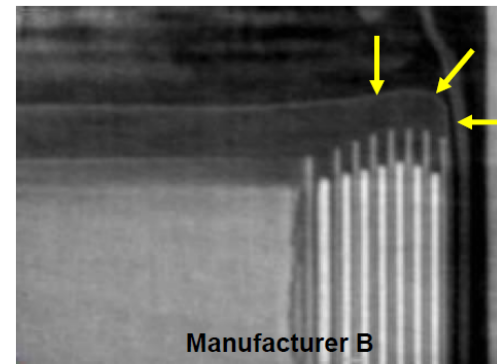
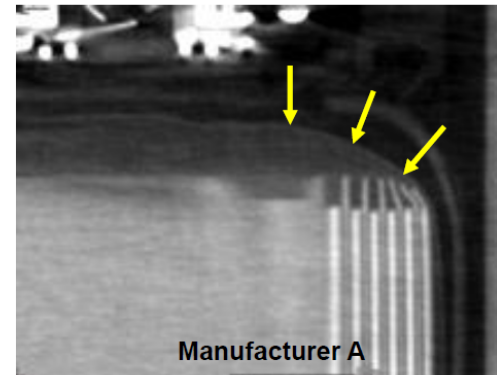
Exponent®

Engineering and Scientific Consulting

4

Root Cause: Manufacturer A

- Based on the results of analysis and testing, the most likely root cause for the thermal failure of certain Manufacturer A cells was determined to be unintended damage to the negative electrode windings consistently in the corner of the cell closest to the negative tab
 - The unintended damage was present in all of the cells examined by Samsung and Exponent
 - The damage was caused by a cell pouch design that provided inadequate volume to accommodate the electrode assembly
 - The observed damage provides multiple potential routes to internal cell faulting and thermal failure with normal cycling, including compromise of the separator and lithium plating
- Exponent's initial analysis of cells from Manufacturer B showed no deficiencies in the pouch, design or manufacturing
 - Manufacturer B cells manufactured after our initial investigation was complete were shown to contain a distinctly different defect that was not present in the initial cells we investigated



* Source: <https://news.samsung.com/global/samsung-electronics-announces-cause-of-galaxy-note7-incidents-in-press-conference>

Case Study: Products with Well-Established Standards – Cell Phone Recalls

Root Cause: Manufacturer B

- Based on the results of analysis and testing, the most likely root cause for the thermal failure of Manufacturer B cells was determined to be internal cell faulting between positive electrode tab welding defects and the copper foil of the negative electrode directly opposite the defective welds
 - Welding defects in some incident cells were found to be tall enough to bridge the distance to the negative electrode foil
 - Some cells examined were assembled without protective tape over the positive electrode tab, increasing the likelihood of an internal cell fault

Positive Tab



Negative Electrode
Opposite Positive Tab



* Source: <https://news.samsung.com/global/samsung-electronics-announces-cause-of-galaxy-note7-incidents-in-press-conference>

Case Study: Products with Well-Established Standards – Cell Phone Recalls

Consequently, the cell phone manufacturer reviewed its internal procedures to tighten its manufacturing controls to assure that it could detect problems. These included:

- X-ray inspection of all cells to check battery corners
- Voltage decay measurement procedures to identify cells with potential problems.
- Increased sampling, cycling, dissection and examination of cycled cells.
- Additional flexing tests of the phones
- Proposed a review and upgrade of IEEE 1725

Best Manufacturing Practices: Assuring Safety of Lithium-Ion Cell-Powered Products

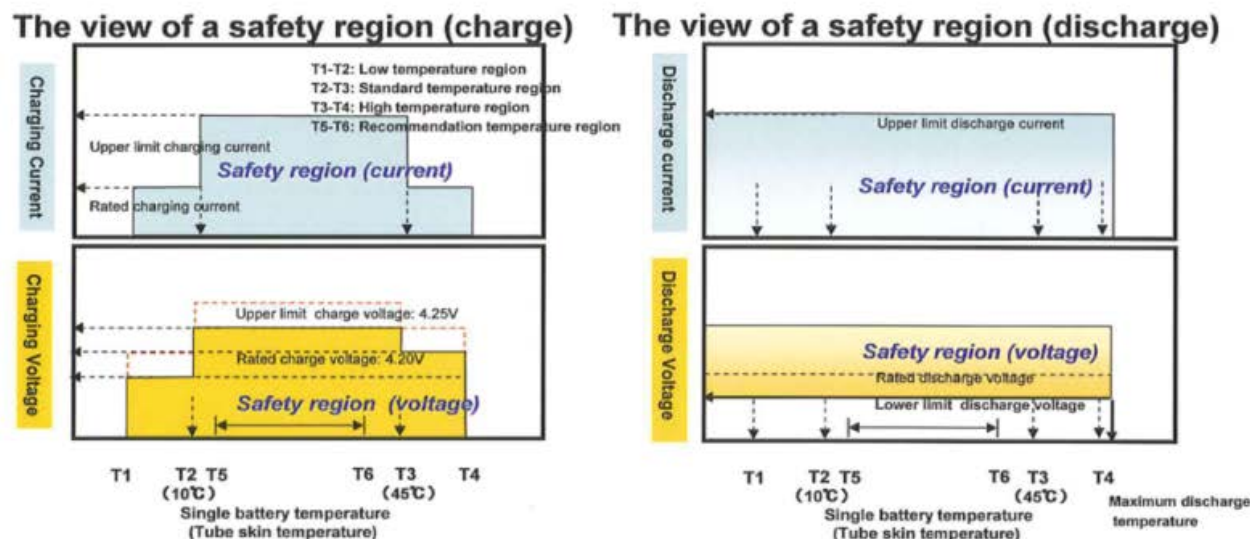
Lithium Battery Safety Basics

- There are various electrode chemistries including LCO, LMO, NMC, and LFP, which have different performance specs and varying levels of safety – be aware of the differences and make sure it's the best one for the application
- Cells contain flammable electrolytes - defective or abused cells can enter thermal runaway condition, producing extreme heat and energetic disassembly
- Critical safety circuits to control voltage, current and temperature during charge and discharge keep cells within their safe operating area

Best Manufacturing Practices – Assuring Lithium Cell Safety

Maintain cells

charging



Temperature domain	- T1	T1-T2	T2-T5	T5-T6	T6-T3	T3-T4	T4-
Capacity	Small			Design center value		Almost similar	
Characteristic	×	△	○	◎	○	△	×
Safety	×	○	○	○	○	○	×

- 14 -

*Japan Electronics and Information Technology Industries Association and Battery Association of Japan Source:

http://home.jeita.or.jp/page_file/20110517171451_cub9MvYFEh.pdf

Best Manufacturing Practices – Assuring Lithium Cell Safety

Addition Industry Guidance

- Disable charging:
 - If cell surface temperatures are exceeded
 - If cell is below 3 V
 - or initiate pre-charge charging rate
 - When charge current drops to .05C (no trickle charging)
- Balance cells in multi-cell packs
- Assure that the charger is compatible with the cells/battery

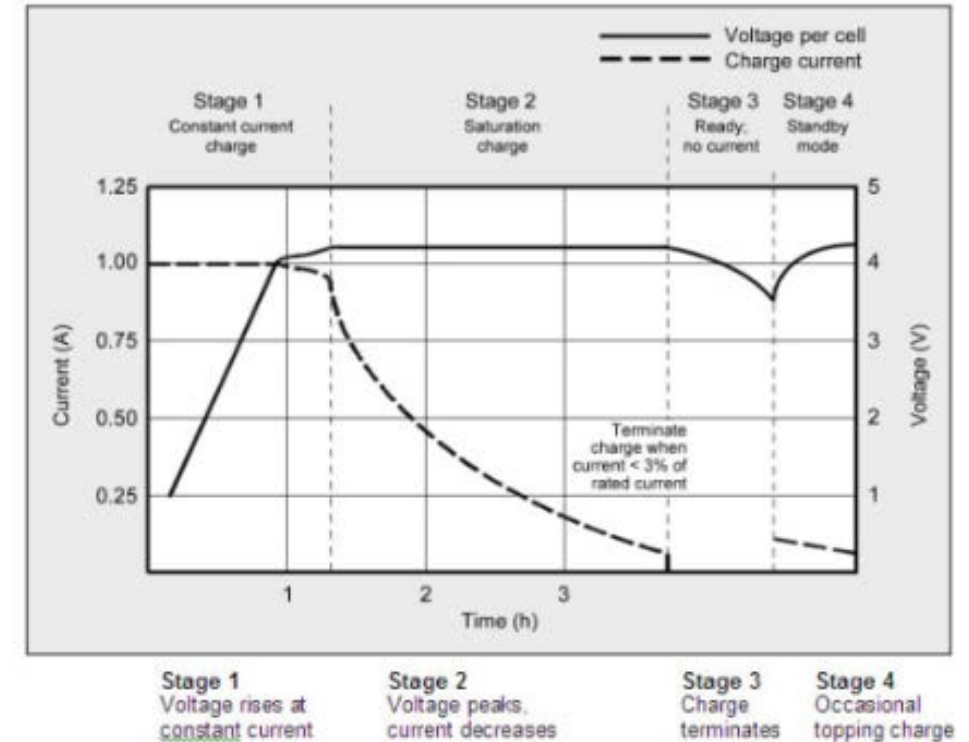


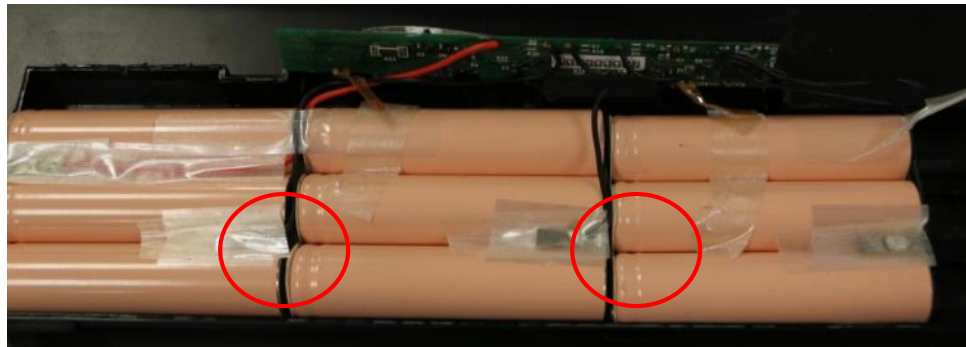
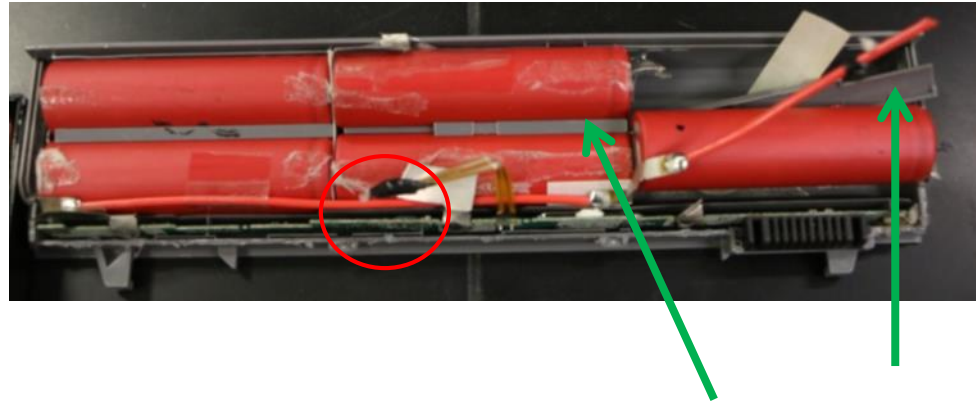
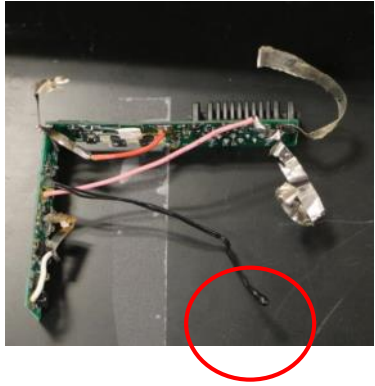
Figure 1: Charge stages of lithium-ion. Li-ion is fully charged when the current drops to a set level. In lieu of trickle charge, some chargers apply a topping charge when the voltage drops.

Courtesy of Cadex

*Source: http://batteryuniversity.com/learn/article/charging_lithium_ion_batteries

Best Manufacturing Practices – Assuring Lithium Cell Safety

Additional Guidance – Thermal Management

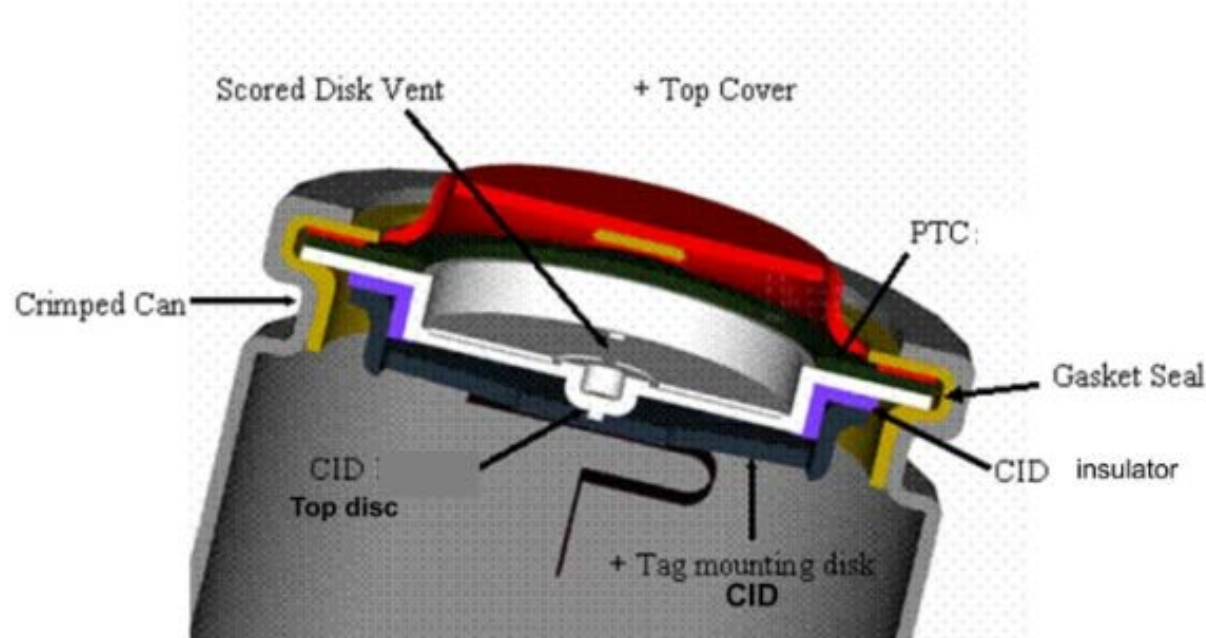


Use thermal sensors to monitor cell surface temperatures (red circles) and/or thermal insulators (green arrows) to avoid excess temperatures

Best Manufacturing Practices – Assuring Lithium Cell Safety

Select cells with Integral Protection

- Current Interrupt Device (CID)
 - Disconnects cell from terminal under excessive internal pressure
- Resettable Positive Temperature Coefficient (PTC)
 - Limits current (May not be suitable for high-drain applications)
 - Does not protect against thermal runaway due to internal faults



Best Manufacturing Practices – Assuring Lithium Cell Safety

Select cells with Integral Protection

- User replaceable cells need an integral BMS to provide charge control and to protect against
 - Over-charge
 - Over-discharge
 - External short-circuit

This board has the following features:

1. Over-charge protection
2. Charge protection
3. Over-discharge protection
4. Over-current protection
5. Short protection

This is what an 18650 battery looks like when it is connected to a PCB:



Figure 5. The anatomy of a protected 18650 battery by Lygte Info

Source: <https://batterybro.com/blogs/18650-wholesale-battery-reviews/18306003-battery-safety-101-anatomy-ptc-vs-pcb-vs-cid>

Best Manufacturing Practices – Assuring Lithium Cell Safety

Staff Recommendations

Lithium-ion battery safety requires diligence from producer to user.

Lithium-ion battery products should:

- Be designed and built in accordance with applicable industry consensus standards; the system from charger to cell should be evaluated together for complete compatibility.
- Use high quality cells, suitable for the application
 - In accordance with manufacturer's specifications
- Be manufactured in strict accordance with industry standard quality control processes
 - Maintain configuration control with only approved material or component substitutions subject to impact assessments

Best Manufacturing Practices – Assuring Lithium Cell Safety Staff Recommendations

Staff recommends lithium-ion battery products:

- Be properly marked with warning labels to inform/educate users of the potential hazards and to closely follow manufacturer's instructions for proper use
- Be third-party certified by an accredited laboratory

Under CPSC's statutes, manufacturers, importers, distributors, and retailers are responsible to assure consumer products to do not present an unreasonable risk of injury or death.

Questions?

Submit questions in English or Chinese
to this podcast:

CPSCinChina@CPSC.GOV



Resources

Chinese Resources at cpsc.gov

<https://www.cpsc.gov/zh-CN/Business--Manufacturing/Business-Education>

企业教育

English Tiếng Việt Español Bahasa Indonesia 한국어 日本語



作为一个制造、进口和批发消费品的企业，您需要遵守一系列《消费品安全改进法》和消费品安全委员会的其它规定。以下步骤将协助引导您熟悉遵守联邦政府安全法规的程序。

第一您制造儿童使用的产品吗？



该法律界定，“儿童产品”就是为12岁或者12岁以下儿童设计或者作为主要使用者的消费品。

第二什么法规适用于我的产品？

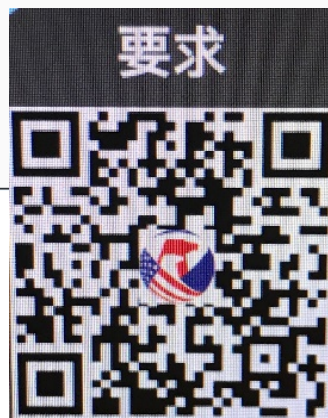


您是美国消费者制造和进口产品的小企业吗？我们的法规机器人为您提供您制造和进口消费品前应该审阅的重要消费品安全要求。机器人引导您回答关于您的产品的一系列问题，整个过程约需5分钟时间。[点击此处访问法规机器人。](#)

第三我如何检测和认证我的产品？



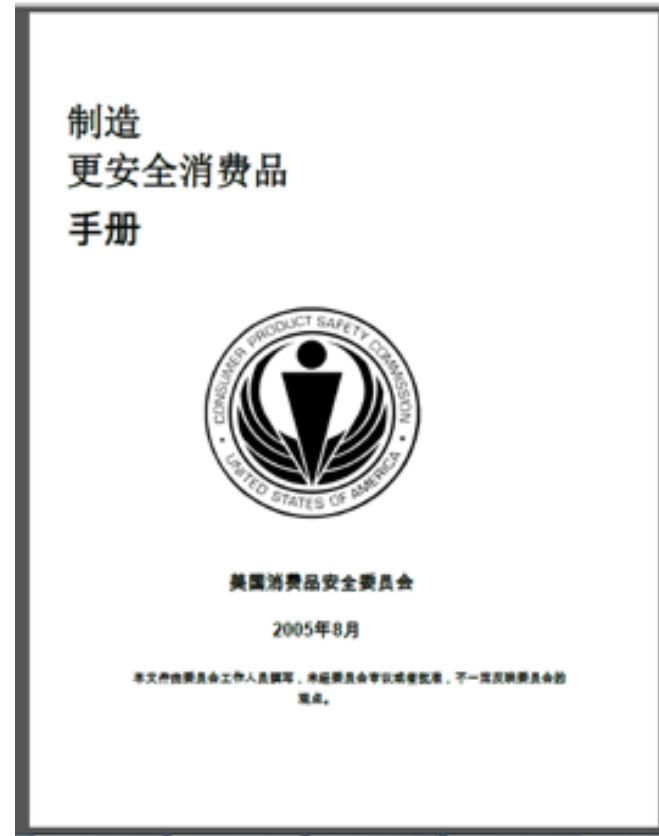
儿童产品第三方检测



企业/产品指导

- 美术材料
- 石棉
- 全地形车
- 沐浴椅
- 婴儿摇篮和婴儿摇篮
- 床边婴儿床
- 自行车
- 自行车头盔
- 亚硝酸特丁醇
- 双层床
- 地毯和垫子
- 婴儿车
- 服装
- 化学品和其它危害物质
- 儿童睡衣
- 消费者登记卡
- 黏压粘合剂
- 婴儿床 (全尺寸)
- 婴儿床 (非全尺寸)
- 拉绳
- 干墙
- 耐用婴幼儿产品
- 电器 (家用)

Chinese Resources at cpsc.gov



<https://www.cpsc.gov/s3fs-public/HandbookforManufacturingChinese.pdf> (中文版本)

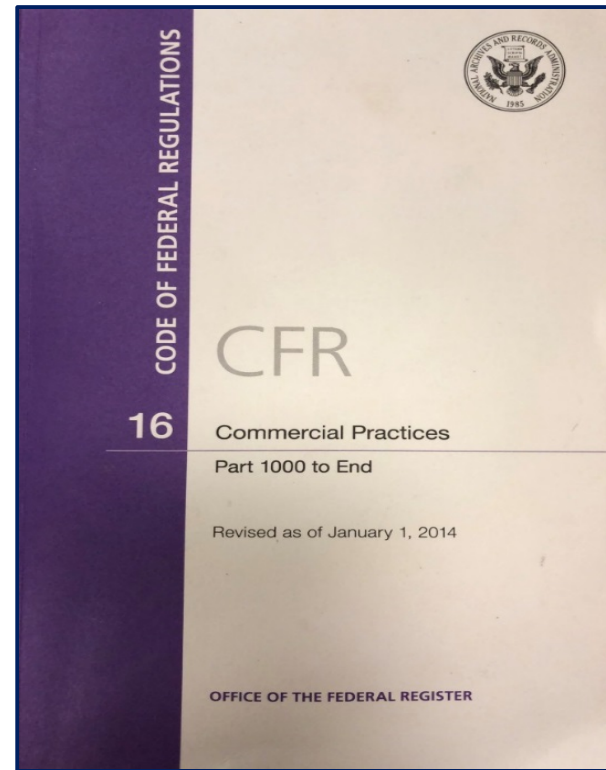
https://www.cpsc.gov/s3fs-public/pdfs/blk_pdf_handbookenglishaug05.pdf (英文版本)



https://www.cpsc.gov/s3fs-public/THE%20REGULATED%20PRODUCT%20HANDBOOK_050613%20CHN%20Final_0.pdf (中文版本)

<https://www.cpsc.gov/s3fs-public/RegulatedProductsHandbook.pdf> (英文版本)

Chinese Resources at cpsc.gov



CFR: Commercial Practices

<https://www.govinfo.gov/content/pkg/CFR-2017-title16-vol2/pdf/CFR-2017-title16-vol2.pdf> (英文版本)



CPSC Laboratory Manuals:

https://www.cpsc.gov/s3fs-public/Laboratory-test-manual-16-CFR-Part-1610-Ch.pdf?MhtbUWNy6jmOPx9b6f.RErt.n.2n_d_h (中文版本)

https://www.cpsc.gov/s3fs-public/Flammability%20of%20Clothing%20Textiles%20Test%20Manual_1610.pdf
(英文版本)

CPSC Business Resources

- Definition of children's product – 16 CFR Part 1200
- Certificates of conformity – 16 CFR Part 1110
- Third-party testing – 16 CFR Parts 1107, 1109, and 1112
- Tracking information – 15 USC § 2063(a)(5)
- Mandatory reporting requirements – 15 USC §2064

CPSC-Accepted
Laboratories Search Page:
www.cpsc.gov/LabSearch



Welcome to CPSC's Regulatory Robot!



<http://business.cpsc.gov>

Online tool designed specifically to help businesses comply with federal consumer product safety requirements.

Asks a series of guided questions, and based on the answers produces a downloadable (PDF) report.

Provides customized guidance with links to product safety regulations that may apply to the product and important information on labeling, certification and testing requirements.

Regulatory Robot

Regulatory Robot is a tool to help identify which requirements are applicable

- **Does not list details of requirements**



Battery Resources

For more information, please visit:

www.CPSC.gov

<https://www.cpsc.gov/Regulations-Laws--Standards/Voluntary-Standards/Topics/Batteries/>