XPLORLABS

PORTABLE ELECTRICAL POWER

EDUCATOR

THE BOLOGNA TEST

CASE STUDY OF SCIENCE AND ENGINEERING

SCIENTISTS ASK WHY. ENGINEERS ASK HOW.

AGE GROUP
Middle School

CATEGORY
Electrical Power

COMPLETION TIME
2 Class Periods

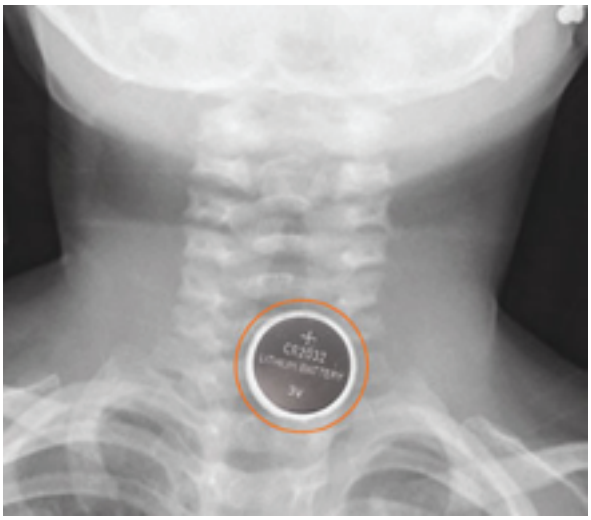
QUESTIONS TO XPLORE

HOW DO SAFETY SCIENTISTS AND ENGINEERS SOLVE PROBLEMS?

CAN WE SEE THE ENERGY IN A SINGLE BUTTON CELL BATTERY?

Safety scientists ask why a phenomenon happens. Safety engineers ask how they can solve the problem and keep people safe. Both ask how they can design and communicate solutions. The button cell battery is a case study in science and engineering for safety.

Innovation inherently creates risk. When it comes to portable electrical power, like button cell batteries, heat and size can become unintentional consequences. Button cell ingestions, especially by children, have become an increasing focus of the safety community. Consumer advocates, manufacturers, the medical community, product safety organizations, retailers, and others have come together to address this critical issue. As battery technology has evolved from traditional electrolytes to lithium ion, there has been a signifi cant change in the severity of ingestion incidents.



Button Battery Ingestion Statistics
http://www.poison.org/battery/stats

Poison Statistics: National Data 2014
http://www.poison.org/poison-statistics-national

EDUCATOR

LITHIUM-ION BUTTON BATTERIES CAN CAUSE SEVERE INJURIES WHEN SWALLOWED.

Electronic devices are a part of daily life. And they're getting smaller, slimmer, and sleeker. But inside the battery compartment of mini remote controls, small calculators, watches, remote keyless entry, flameless candles, singing greeting cards, and other electronics, may be a very powerful coin-sized button cell battery. When swallowed, these button cell batteries can get stuck in the throat and cause severe burns. Small children often have easy access to these devices, and many parents do not know there is a risk. thebatterycontrolled.com.au • September, 2016

CAN THE ENERGY IN A BUTTON CELL BATTERY BE SEEN?

It can. In this investigation, you will set up a demonstration of a button cell battery's ability to burn through bologna. This test was developed as a way to demonstrate what happens when a child swallows a button cell battery and gives us the ability to see the energy stored inside a battery expressed as heat. We'll use a button cell battery, that is typical in a remote control or garage door opener, some saline that acts like saliva, and the bologna, that acts like esophagus tissue.

Mobility and electronics have significantly increased the demand for small, portable, and powerful sources of energy in dozens of household products. To mitigate risks associated with button cell batteries, specifically child ingestions, think about questions that focus on the elimination of the hazard and what engineering solutions are possible. For instance, how can engineers begin to solve the button cell batteries problem? What solutions do you propose? How can you help design a way to keep young children from getting access to these small batteries now that you have observed what happens when they swallow them?

SUMMARY OF LAB

In small groups, students will place a piece of bologna on a noncombustible surface. They will place one dropper full of saline in the center of the meat slice, then place a button cell lithium-ion battery in the pool of saline on the bologna. Using a timer, they will observe what happens each minute for 10 minutes.

XPLORING THE ISSUE

BACKGROUND INFORMATION FOR TEACHER

Ingestions of button cell batteries have become an increasingly important focus for product safety organizations, like UL, as well as consumer advocates, manufacturers, the medical community, retailers, and parents. All are working to address the critical issue of reducing the risk of children removing button and coin cell batteries from a product and ingesting the batteries. These lithium batteries can cause serious injury and even death to a child, so keeping them securely within a toy or household item is a needed safety precaution.

Incidents involving button battery deaths and severe injuries have been increasingly prevalent. The incidents most often involve children under four years old. Severe problems can arise when one becomes lodged in the digestive tract or elsewhere in the body. The electric current produced by the battery can ionize saliva, forming a corrosive alkaline that damages surrounding tissues.

The strength of lithium batteries makes them a common choice to provide power in small-sized products. These lithium ion batteries are called "button cell batteries" because of their size and shape. The first two numbers are diameter in mm; second numbers are thickness in mm. For instance, a CR2032 is 20mm wide and 3.2mm tall.

Because they are used so widely in so many products, young children can gain access to the battery and many children are swallowing them. When a child swallows a button cell battery, the battery can get stuck in child's esophagus (see photo of xray page 2).

When this happens, the battery causes esophageal burns because of the flow of electricity in the saliva – damaging tissue in significant ways. For parent/doctor accounts of the damage to children's tissues, visit http://thebatterycontrolled.com.au.

This problem is compounded by the similarity in appearance that the button cell has to a coin (penny or nickel–penny is 19mm diameter; nickel is 21mm diameter.) In an xray, the battery looks like a harmless coin. In this instance, many

XPLORING THE ISSUE

medical professionals try to wait out the passage of the "coin" rather than doing an invasive procedure. Oftentimes, the ingestion of the button cell was not witnessed, complicating the doctor's understanding of the problem.

Meanwhile, the voltage in the button cell battery causes ions in saliva to be conductive and the interface between tissue and battery becomes alkaline – pH goes way up and the saliva becomes highly basic. The corrosive saliva damages the tissue. The tissue then turns black in a short amount of time.

The bologna test is a way to observe the energy contained in a button cell battery and what happens in the child's throat when one is ingested and trapped.

ENGINEERING SOLUTIONS

As scientists figured out the reasons that the batteries were causing severe tissue burns, safety engineers began to design solutions. The following possible solutions focus on mitigating or minimizing the risk of ingestion:

- Educate consumers about the hazards for products and button cell batteries
- Engineer product designs that prevent access to button cell batteries in products
- Engineer button cell battery packaging design that is childproof

Some of these solutions have been implemented in the form of:

- Button cell batteries have a small sticker on the back that keeps the saliva from conducting the voltage in the battery
- Button cell battery packages are child proof
- In AV remote controls, making it strategically more difficult for a child to access the batteries, a tool is necessary to open the battery compartment door or compartment door has two independent motions to open (similar to safe caps in medications)
- Markings and instructions on product packaging labels

TRADEOFFS

Seniors may not be able to manipulate the battery compartment doors. Consumers that are more interested in having more portable power than they are in the ingestion hazards.

BUTTON CELL BATTERY

MATERIALS

PART A

- [ ] 1 piece of bologna
- [ ] 5ml saline solution
- [ ] CR2032 lithium button cell battery
- [ ] Noncombustible surface for placing bologna on (not a paper plate)
- [ ] Stopwatch
- [ ] Dropper for saline
- [ ] Disposable gloves for cleanup/battery disposal
- [ ] Student lab notebook or student XplorLab pages

NOTES

Because it is a demonstration, smaller groups of students are more effective. If cost of the batteries is an issue, this can also be a classroom demonstration done by the teacher and observed by all of the students. Batteries are sold individually in some places, or in packs of 4.

The saline stays pooled on the bologna, but will be absorbed by the meat. It is helpful for the students to have everything ready to go so that they are ready to start their timer and place the battery on the bologna immediately after placing the dropper of saline on the meat.

The reaction will continue after 10 minutes if you/your students would like to continue monitoring the phenomenon.

ROLES

THE STUFF SUPERVISOR

Gathers and cleans up materials

THE EXPERIMENT EXEC

Runs the experiment

THE DIRECTOR OF DOCUMENTS

Reads the procedure to the group and helps the group members with data collection

THE PRINCIPAL PRESENTER

Shares the group's work with the rest of the class

PROCEDURE - EDUCATOR

ENGAGE

WHAT EDUCATOR DOES

Introduce the issue – Innovation inherently creates risk. When it comes to portable electrical power, like button cell batteries, heat and size can become unintentional consequences. Children are severely, sometimes fatally, injured by swallowing button-cell batteries.

Watch video on
http://thebatterycontrolled.com.au
How do scientists and engineers solve safety problems?

WHAT STUDENTS DO

Engage in discussion about the issue.

Watch video.

XPLORE

WHAT EDUCATOR DOES

Introduce activity and set expectations for group roles.

Discuss safety issues, procedure, and any vocabulary terms that are new to students.

Ask students to make a prediction about what they will observe.

WHAT STUDENTS DO

- Each group collects all of the materials for the group.
- Place bologna slice on noncombustible surface.
- If button cell battery has a sticker on one side, remove it.
- Place one dropper full of saline in the middle of the bologna.

PROCEDURE - EDUCATOR

XPLORE CONT.

WHAT STUDENTS DO CONT.

- Place battery directly on top of the saline in the middle of the bologna.
- Begin the stopwatch.
- Write or draw and label the drawings of detailed observations every minute for 10 minutes.
- Clean up according to safety protocols (wear gloves, dispose of battery properly).

XPLAIN

WHAT EDUCATOR DOES

Ask the students what they think happened based on their observations. Xplanation: The saline is a conductive medium that supports electrical current flow from the battery through the saline. The current flow busts up the molecules in the saline into hydrogen and oxygen – and the oxygen atoms react with the surface of the battery. This increases the pH of the saline and causes the burn.

WHAT STUDENTS DO

Write or discuss what was observed and possible reasons for the phenomenon. Discuss the Xplanation with group. Now that they know what happened, can they see evidence of the Xplanation?

PROCEDURE - EDUCATOR

ELABORATE

WHAT EDUCATOR DOES

Engineering solutions – ask students to brainstorm designs that would protect children. Share solutions that battery and product manufacturers are using by visually showing the students the following:

- The small sticker on the back of the button cell battery that keeps the saliva from conducting the voltage in the battery
- Childproof button cell battery packages
- An AV remote control that requires a tool to open the battery compartment door or that the compartment door has two independent motions to open (similar to safe caps in medications)
- The markings and instructions on product packaging labels

WHAT STUDENTS DO

In small groups, draw or write about solutions students can invent to protect small children. Is it better to focus on the battery or on the products the batteries go into? Did students observe any designs of packaging or of the batteries that you used for this investigation? What were they? Do students think they are effective? Why or why not?

EVALUATE

WHAT EDUCATOR DOES

Can the students discuss the role of the scientists vs the role of the engineer in the case study of the button cell battery?

WHAT STUDENTS DO

Tell, draw, or write about the role of the scientists vs the role of the engineers in this problem solving case study.

PROCEDURE - EDUCATOR

XTEND

XTENSION

Tell it! Ask the students to make a Public Service Announcement (PSA) about button cell battery use, risks, and hazards for small children. Include ideas for safer designs. PSAs can be oral, visual, or written. Video it and submit it to our XplorLabs Challenge!

NRC FRAMEWORK

PRACTICE 1: ASKING QUESTIONS AND DEFINING PROBLEMS

PRACTICE 2: DEVELOPING AND USING MODELS

MS-ETS1 ENGINEERING DESIGN

[Benchmarks] MS-ETS1-1 Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

SCIENCE AND ENGINEERING PRACTICES

Asking Questions and Defining Problems

Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

DISCIPLINARY CORE IDEAS

ETS1.A: Defining and Delimited Engineering Problems

The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints includes consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

CROSSCUTTING CONCEPTS

Influence of Science, Engineering and Technology on Society and the Natural World

All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)

NRC FRAMEWORK

MS-PS3 ENERGY

[Benchmarks] MS-PS3-5. Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.

SCIENCE AND ENGINEERING PRACTICES

Engaging in Argument from Evidence

Construct, use, and present oral and written arguments supported by empirical evidence and scientific reasoning to support or refute an explanation or a model for a phenomenon. (MS-PS3-5)

DISCIPLINARY CORE IDEAS

PS3.B: Conservation of Energy and Energy Transfer

When the motion energy of an object changes, there is inevitably some other change in energy at the same time. (MS-PS3-5)

CROSSCUTTING CONCEPTS

Energy and Matter

Energy may take different forms (e.g. energy in fields, thermal energy, energy of motion). (MS-PS3- 5)

COMMON CORE STATE STANDARDS CONNECTIONS

RST.6-8.9 Compare and contrast the information gained from experiments, simulations, video or multimedia sources with that gained from reading a text on the same topic. MP.2 Reason abstractly and quantitatively.

XPLORLAB'S HAZARDOUS-BASED SAFETY ENGINEERING PROCESS

- Identify the energy source
- Is the energy source hazardous?
- Identify means by which energy can be transferred to a body part
- Identify safeguards that will prevent energy transfer to a body part (think about eliminating the energy transfer, warning about the energy transfer, and/or guarding against the energy transfer.