American Solar Challenge

FSGP Safety Training

Overriding Principle

Introduction

- Everyone is required to understand proper handling of batteries and high voltage to avoid any accidents
- All the solar cars are being driven by Lithium based batteries need to apply this knowledge of potential hazards
- Batteries or battery packs require special handling due to their significant energy potential and dangerous characteristics of chemicals used.
- Working on Solar Vehicles require special precautions

Our goal is to create an accident-free event

Agenda

- Introduction
- Lithium Battery Chemistry
- Failure Mechanisms
- Safe Handling Guidelines
- Electrical Concerns
- Hazards and Emergency Response
- Heat and your Body
- Summary

Cell Types

Improper handling of batteries, may result in violent chemical reactions and potentially an explosion, fire, and/or chemical release.

Battery Incident

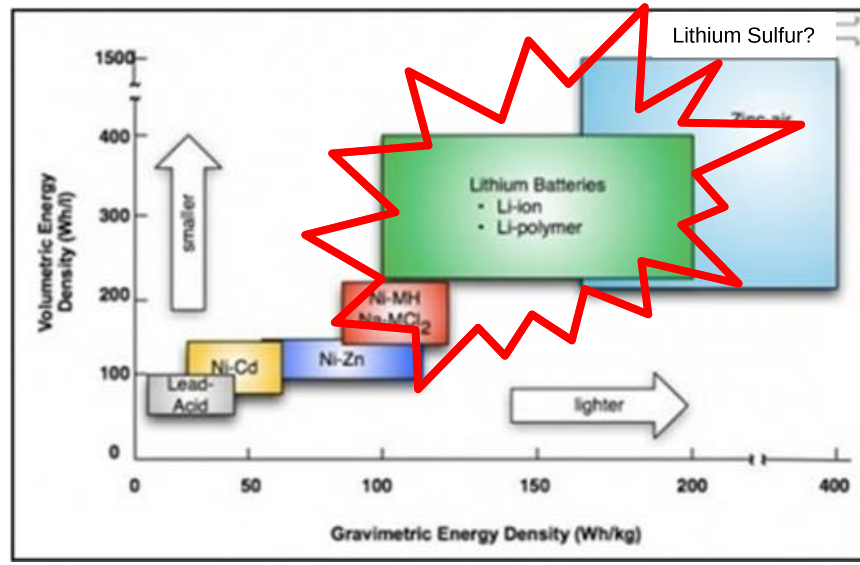
Introduction

ASC has had ~~1~~ ~~2~~ 3 incidents …

It is critical that we prevent these accidents from happening.

Agenda

- Introduction
- Lithium Battery Chemistry
  - Battery Facts
  - Characteristics
  - Electrical Properties
  - State Of Charge (SOC)
  - Battery Construction
  - Typical Lithium-Ion Battery
  - Electrochemical Process
- Failure Mechanism
- Safe Handling Guidelines
- Electrical Concerns
- Hazards and Emergency Response
- Heat and your Body
- Summary



Battery Facts

- 2 major classifications of batteries
- <u>Primary</u>
  - Can be discharged only
  - Examples
    - ✓ Common AAA, AA, C and D flashlight and toy batteries
    - ✓ Hearing aid batteries

- <u>Secondary</u>
  - Can be charged and discharged repeatedly
  - Examples
    - ✓ Phone, laptop batteries
    - ✓ 12 volt car SLI battery
    - ✓ Solar vehicle batteries

Battery Facts

- Batteries do not store electricity!!!
  - Store chemicals that react to produce electricity
  - Store energy as chemical reaction
- Rechargeable batteries are effective energy storage devices
- Unlike electrical circuits, batteries cannot be turned on or off – they are always ON

Batteries are the most effective energy storage device today

Battery Characteristics

Characteristics or Component	Lead-Acid	Nickel Metal Hydride	Lithium-Ion
Construction	Vented or Sealed with Pressure Relief Valve	Sealed	Sealed
Negative Active Material	Metallic Lead	Metal Alloy (AB_2 or AB_5 Class)	Lithiated Graphite
Positive Active Material	Lead Dioxide	Nickel Hydroxide	Lithium in Metal Oxide
Electrolyte	Sulfuric Acid	Potassium Hydroxide	Lithium Salt dissolved in Organic Solvent
Nominal Volts/Cell	2.0 V	1.2 V	3.6 V .
Operating Temp.	- 40°C to 60°C	- 30°C to 55°C	-20°C to 45°C
WEIGHT (mass)	Heavy	Medium	Lightest of all rechargeable
COST	Least expensive	Moderate cost, but rising - Nickel	More reasonable lately
Safety Concerns	Low	Medium to Low	Higher Risk
Life cycle	Short	Medium to Long	Longer life

Electrical Properties

Battery Chemistry

TERMS	DEFINITION
VOLTAGE, V (Volts or V)	Potential difference or electrical pressure between two oppositely charged bodies that causes a flow of electricity when a suitable conductive path is provided
CURRENT, I (Amps or A)	Flow of charge carriers is defined as quantity of electricity that passes through a conductor during a time of one second
RESISTANCE, R (Ohms or Ω)	Opposition of current flow, which is proportional to the collision between electrons and atoms in a conductor
POWER, P (Watts or W)	Amount of electrical work that is being done or consumed in a given time period Power, $P = E/t = V \times I = V^2/R = I^2R$
ENERGY, E (Watt-Hour or Wh) (Joules or J)	Measure of electrical work, which is the movement of charge across an applied voltage Energy, $E = V \times Q$ Energy involved to move one electron across 1V is an electron-volt (1eV = 1.613×10^{-19}J)
CAPACITY, Q (Amp-Hour or Ah) (Coulombs or C)	Quantity of electricity that accumulates or passes through a conductor for a given period of time Charge or Capacity, $Q = I \times t$ 1C is equal to the total charge carried by 6.24×10^{18} electrons
STATE OF CHARGE, SOC (% SOC)	Relative amount of Usable charge available in a battery

State of Charge (SOC)

State of Charge (SOC) is:

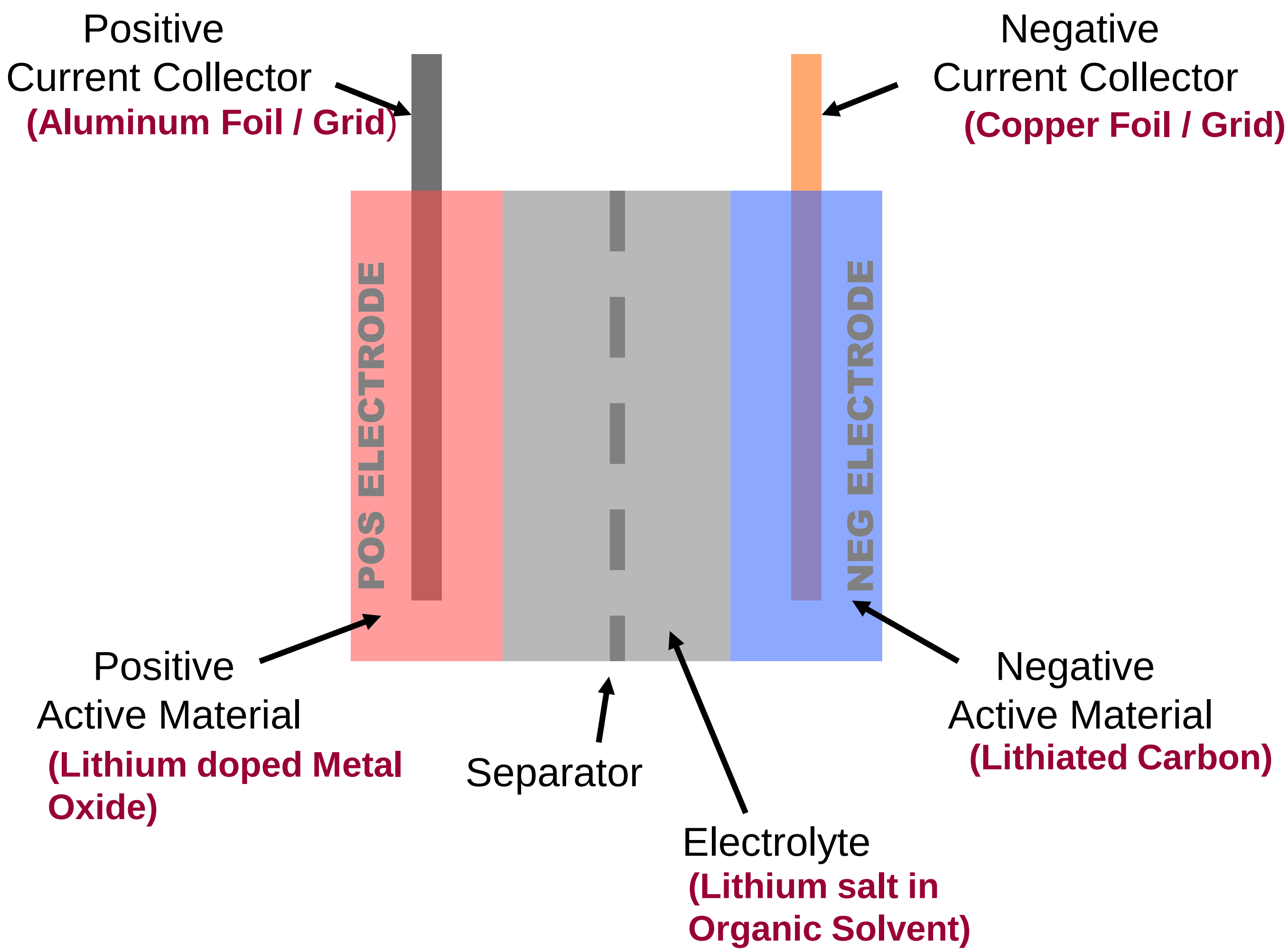
- Relative indicator of available charge
  - Analogous to fuel gauge to indicate available charge quantity (or amount of Coulombs) in a battery cell
- SOC = [Capacity Remaining]/[Nominal Capacity]
  - At Set conditions of temperature, current and end voltage.
- Full Charge: 100% SOC
  - Addition of charge (or Coulombs) to the system would result in unsafe conditions
- Full Discharge: 0% SOC
  - Battery cell is incapable of supplying useable energy or power at the reference current and temperature below the cut-off voltage

Fully discharged does not mean zero volts

0% SOC does NOT mean No Charge!

Typical Lithium-Ion Battery

Lithium-Ion Battery Chemistry



Common Lithium-Ion Cell Material

Lithium-Ion Battery Chemistry

Cathode (Positive)

LAYERED

- $LiCoO_2$ — Lithium Cobalt Oxide
- $LiNiO_2$ — Lithium Nickel Oxide

SPINEL

- $LiMn_2O_4$ — Lithium Manganese Oxide

OLIVINE

- $LiFePO_4$ — Lithium Iron Phosphate

Electrolyte

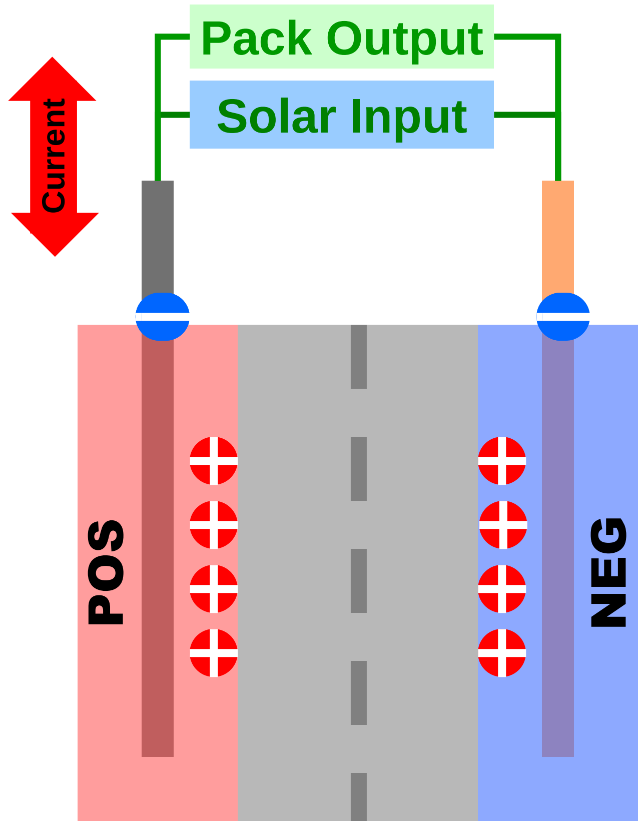
- $LiPF_6$ — Lithium Hexafluorophosphate
- EC — Ethylene Carbonate
- EMC — Ethylmethyl Carbonate
- PC — Propylene Carbonate
- DMC — Dimethyl Carbonate

Anode (Negative)

- Li (Metal)
- Graphitic Carbon **(Soft)**
- Non-Graphitic Carbon **(Hard)**
- Si-M Alloy (M = Ca, Mg, Mn, Mo, Ni, Ti)
- $Li_4Ti_5O_{12}$ — Lithium Titanium Oxide

Electrochemical Process

Lithium Battery Chemistry



While Charging. . .

Positive electrodes become more positive by releasing electrons

$P^K \rightarrow P^{K+1} + e^-$

(Oxidation)

Negative electrodes become more negative by accepting electrons

$N^M + e^- \rightarrow N^{M-1}$

(Reduction)

While Discharging . . .

Positive electrodes become less positive by accepting electrons

$P^{K+1} + e^- \rightarrow P^K$

(Reduction)

Negative electrodes become less negative by releasing electrons

$N^{M-1} + e^- \rightarrow N^M$

(Oxidation)

Agenda

- Introduction
- Lithium Battery Chemistry
- Failure Mechanism
  - Why Lithium-Ion Batteries Fail
  - How Lithium-Ion Batteries Fail
  - Typical Lithium-Ion Battery Reaction
- Safe Handling Guidelines
- Electrical Concerns
- Hazards and Emergency Response
- Heat and your Body
- Summary

What You Should Know

Failure Mechanism

- Under normal conditions of use, Lithium-Ion batteries are safe (0.1- 0.2 PPM failure from the mfg.)
  - All chemicals are contained and sealed
- Battery failure may result in accidents when the cells are **mechanically, electrically, or thermally abused** or functionally compromised
  - Lithium cells are flammable and potentially explosive
  - Lithium cell internal components are reactive with water vapors and/or oxygen
- Lithium-Ion batteries are classified as hazardous materials

Failure Mechanism

- Battery failures can be classified in three main categories:
  - "Infantile" failures
  - Ultimate or End of Life (EOL) failures
  - Abuse failures

Why Lithium-Ion Batteries Fail

Failure Mechanism

- "Infantile" Failures
  - Typically associated with manufacturing defects
  - Possible contamination: water, oxygen or other foreign materials in the raw materials
  - Internal short circuit due to:
    - ✓ Chemical breakdown of separator
    - ✓ Presence of (metallic or other) particle contaminates******
    - ✓ Mechanical movement of components leading to separator failure due to vibration or impact during manufacture
    - ✓ Mechanical mishandling during manufacture

$$\mathrm{MTTF} = \frac{\sum_{i=1}^{n} t(i)}{n}$$

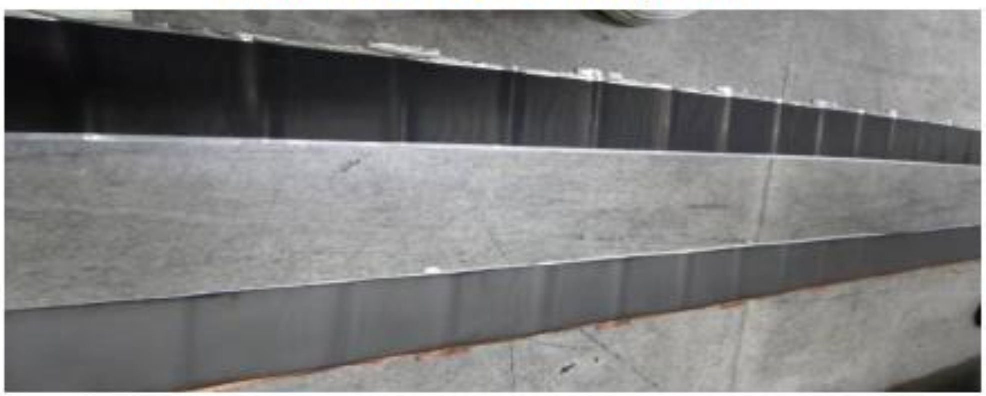
Infantile Failure - Example

Cell

J/R

Unwinding J/R

Unwound electrode and separator



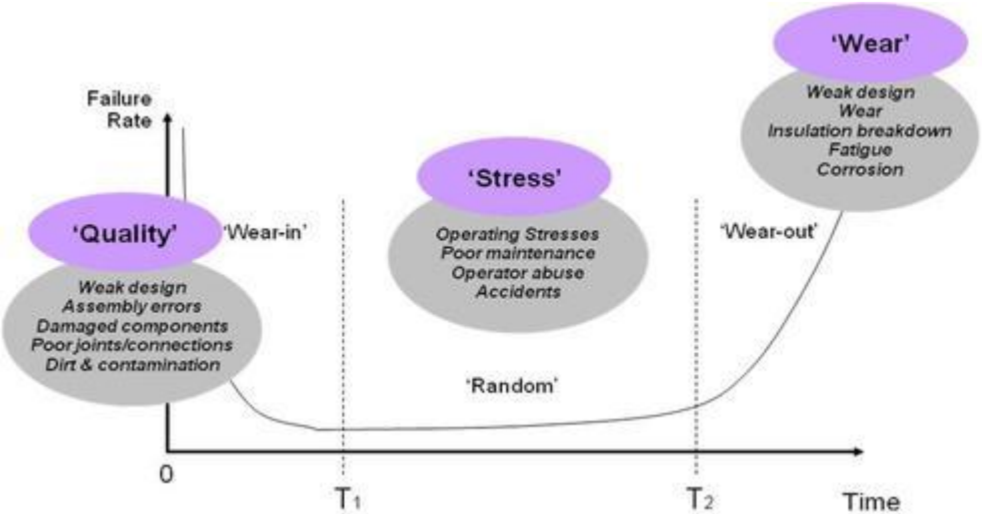
Spots on separator

Why Lithium-Ion Batteries Fail

Failure Mechanism

- Ultimate of End of Life (EOL) Failures
  - Disintegration and/or dissolution of active material structure
  - De-lamination or shedding of active material from current collector substrate
  - Micro-structural degradation
  - Decomposition of electrolyte

All lead to a reduction in capacity!



Why Lithium-Ion Batteries Fail

Failure Mechanism

- Abuse Failures
  - Mechanical
    - ✓ Mechanical shock or vibration may fracture current carrying tabs, terminals or inter-cell connections
    - ✓ Puncture or crush leading to short circuit
    - ✓ Applying loads to terminals of cells due to design
    - ✓ Low pressure environment
  - Electrical
    - ✓ Overcharge, **over discharge (undervoltage)**
    - ✓ external short circuit, Rapid discharging
  - Thermal
    - ✓ Radiant heat – above threshold temperature may lead to spontaneous combustion or explosion
    - ✓ High or low-temperature storage
    - ✓ Thermal shock
    - ✓ Incorrect buss attachment

Why Lithium-Ion Batteries Fail

Failure Mechanism

- Abuse Failures (cont.)
  - While at ASC Event
    - ✓ Solar Vehicle crashes (battery containment (Box) compromised)
    - ✓ Defective protection system – BPS
    - ✓ Bypassing any required switches
    - ✓ Incorrect service on pack - shorting
  - While not at ASC Event
    - ✓ By-passing critical safety controls - BPS
      - Improper charging or discharging
      - Thermal abuses
      - Short-circuit
      - Other abuses

Results of abuse failures

- Lithium-Ion battery failure can be dangerous, especially when reaction progresses rapidly and leads to the onset of thermal runaway

- Possible Causes:
  - Excessive heat
  - Internal faults due to excessively high charge or discharge rates
  - External mechanical abuse
  - Repeated over discharging (undervoltage)

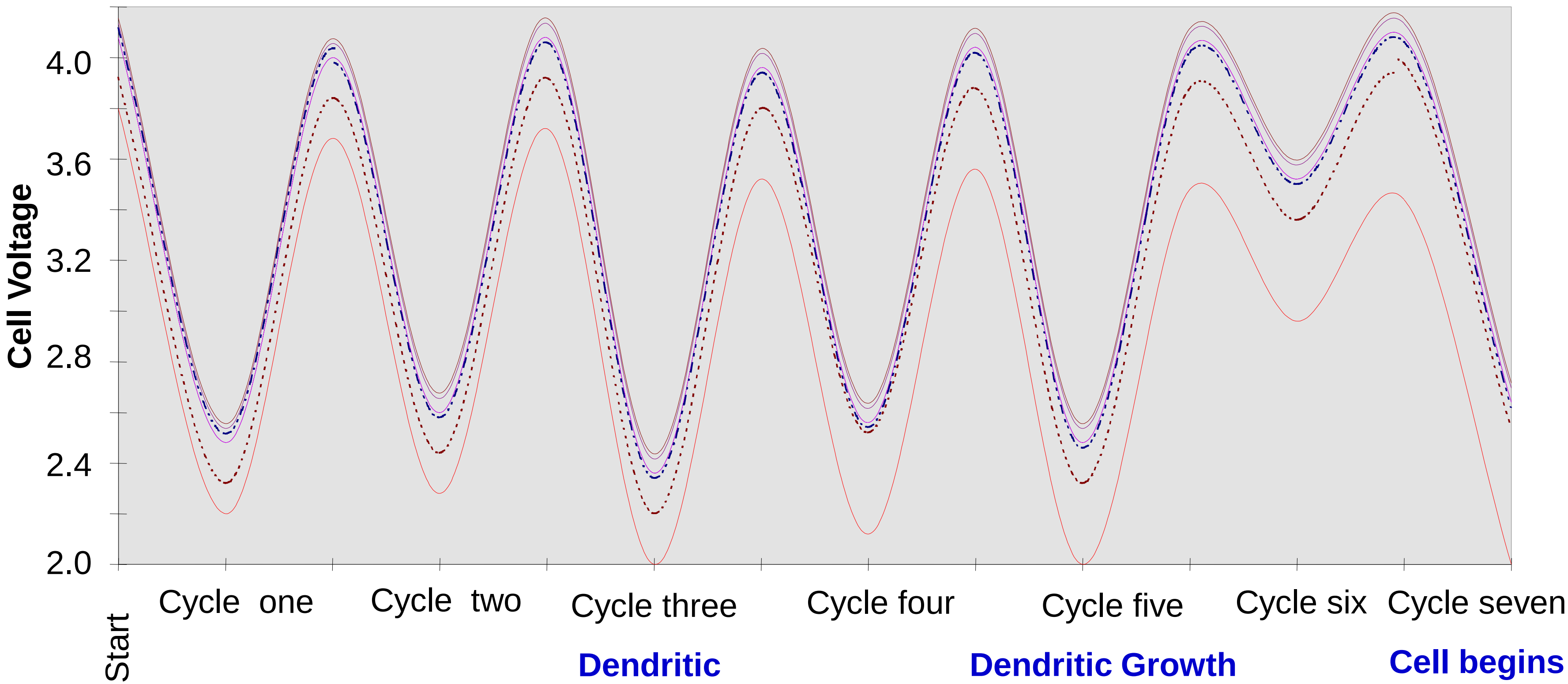
Effects:

- Batteries can become dangerously hot, emit excessive amounts of flammable toxic gas, spew electrolyte, and/or explode
- Some cell chemistries can go into thermal runaway as low as 120°C

The “EFFECT” of Imbalance

Battery Pack Cycling

The End Result – Lithium Ion



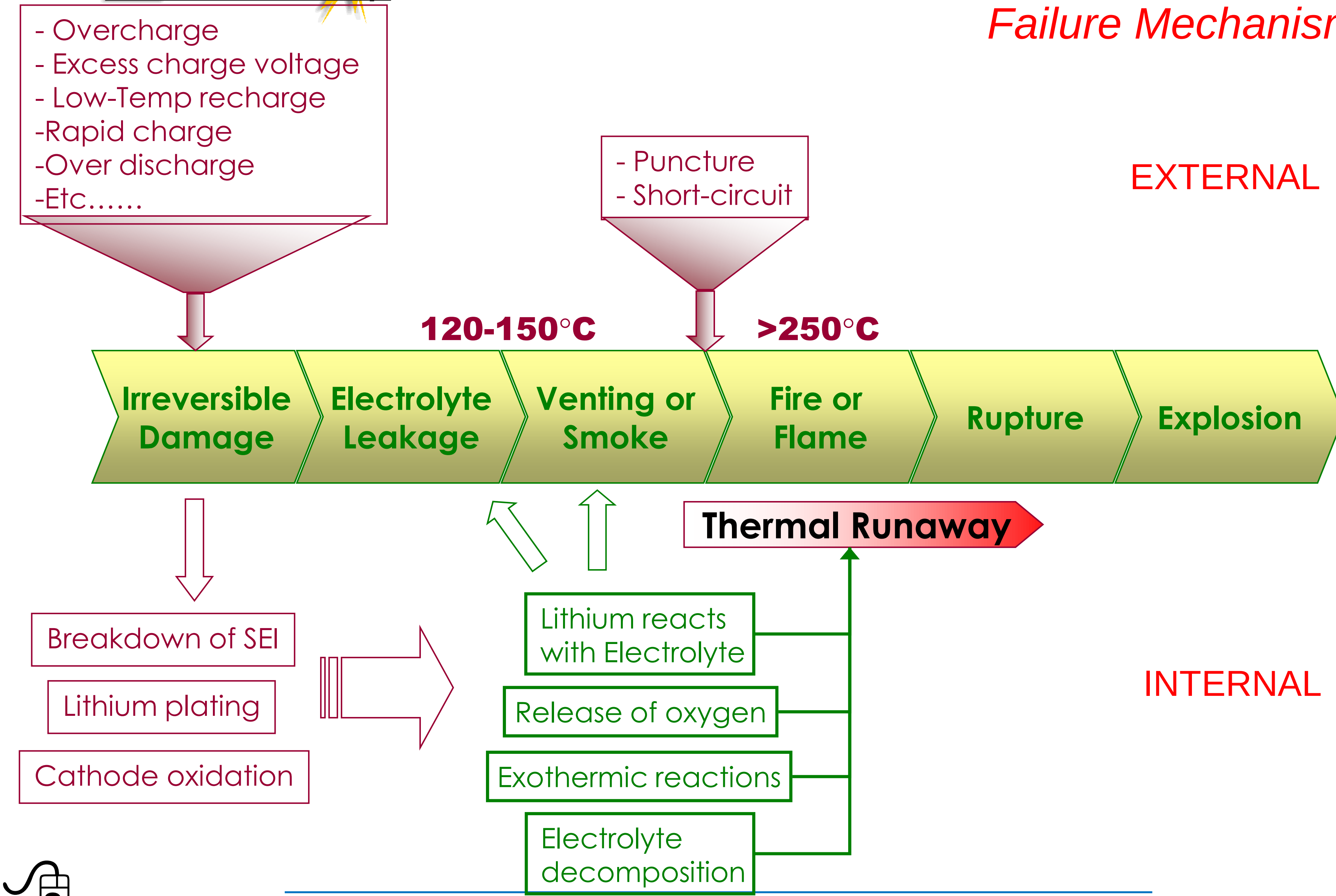
Dendritic Growth Begins

Dendritic Growth continues and causes internal shorts

Cell begins to swell and Fail Abruptly

How Lithium Batteries Fail

Failure Mechanism



Agenda

- Introduction
- Lithium-Ion Battery Chemistry
- Failure Mechanism
- Safe Handling Guidelines
  - Material Standard Data Sheet (MSDS)
  - Proper Personal Protection (PPE)
  - Handling Guidelines
  - Storage and Disposal
- Electrical Concerns
- Hazards and Emergency Response
- Heat and your Body
- Summary

Safe Handling Guidelines

- Material Safety Data Sheet (MSDS & PSDS)
  - understand proper handling and cautions prior to handling the product
  - Documents required from battery manufacturer
- Personal Protective Equipment
  - Safety glasses, cotton clothing, no jewelry, specifically dangling conductive devices
  - Performing potentially more hazardous Tasks? Use face shield and Latex gloves & Jumpsuit
  - Wear electrically insulated gloves whenever handling the system or circuitry over 50V with protective surface to resist abrasion
  - Use inspection and repair tools like calipers and rulers and wrenches that are made from or covered with a non-conductive material

Handling Guidelines

Safe Handling Guidelines

- Avoid applying excessive force to insert or remove cell from packaging, battery holder or housing, which may:
  - Deform battery cells leading to internal short circuit
  - Crush terminal cap
  - Damage seal resulting in a cell venting
- If inspecting cells
  - Return the cells to their original container
  - Or keep them separated and secured in place
  - Do not stack or scatter cells

- All dented cells, individual or within module/pack, should be disposed regardless of electrolyte leakage
  - Denting of sides or ends increases the likelihood of developing an internal short circuit latently and should be discarded
- Cells should be moved in non-conductive carrying trays to reduce the chances of cells being dropped, causing shorting or other physical damages

Safe Handling Guidelines

Soldering

- Never touch cell case directly with hot soldering iron
  - Soldering to the battery cell surface could damage the cell
  - Use tab or connector for soldering instead
  - Use heat sinks to spot weld tabs and limit thermal contact

Soldering directly on battery Cell Surface is unacceptable

Safe Handling Guidelines

- Maintain clean work areas
  - Area should be free of sharp objects that could puncture cells
  - Cells should not be left where they may fall or short out
- Avoid unintentional cell shorting
  - Service leads one at a time
  - Keep cells away from conductive materials
  - If shorted, dispose of, cell may have generated dendrites
- Keep terminals protected when putting the pack together or taking it apart using isolation media such as:
  - Protective cap, preferred method
  - Electrical tape
  - **Cell case may be a terminal and not insulated**
- Use only insulated non-conductive equipment and tools or cover all exposed metal on tools with electrical tape or non-conductive heat shrink material to prevent shorts

Pack Handling/Testing Guidelines

Safe Handling Guidelines

- Avoid pack testing, **manual pack charging** and manual pack discharging without BPS functional
  - Protect Pack and cell voltages
  - Protect Pack and cell temperatures
  - Protect Pack and cell currents
  - Protect Pit and your teams equipment
  - **NO Unattended Charging or Discharging** of cells or packs is allowed anytime
- Know the cell pedigree before assembling the pack.
  - Prior history may provide insight into what to expect when testing.
  - Ask Manufacturer upon receipt of cells what prior conditioning occurred.
  - If last team from prior event to use, dis-assemble to module level and characterize before performing any testing in vehicle.

Cell Disposal

Safe Handling Guidelines

Upon observation of weak – defective cell' don't just throw away - discharge cell(s) completely – so they are Spent.

1. Discharge cell in salt water bath at least 20 times the volume of the cell.
2. Ordinary Tap water mixed with ¼ cup salt per gallon water will serve to gradually discharge cell and contain heat.
3. Stand clear when exposing cell to this solution
4. Expect bubbling and possibly boiling (cell should be submerged)
5. Keep activity away from breathable airstream and combustibles
6. Try to use metal container for this activity, plastic may melt.
7. Expect this to take up to 4 hours
8. Confirm fully discharged cell with a voltmeter you trust
9. Dispose the remains according to your University guidelines
10. If cell rupture occurs, expect to address all liquid remains as waste.

Storage and Disposal Guidelines

Safe Handling Guidelines

- Store cells in original containers & label
- Follow the manufacturer's instructions for stacking batteries
- Store the cells in a well ventilated, dry area. The temperature should be as cool as possible to maximize shelf life if between races (>32F)
  - Observe the manufacturers minimum and maximum storage temperatures and SOC's (typically 50%)
- Do Not Store defectives unless they have been drained/spent, otherwise they still retain dangerous charge and they are still prone to failure
- Don't use chargers that you don't have experience with
- Don't apply loads or other that you haven't done before at your shop
- Don't Create a dangerous condition within your pit of garage area

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- Electrical Concerns
  - Safety and Protection
  - Electrical Hazards
- Hazards and Emergency Response
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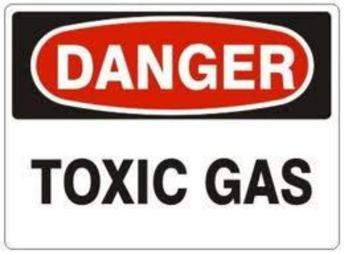
Common Issues

- Hooking things up backwards
- Applying the wrong voltage
- Chaffing or shorting of wires to frame
- Overheating
- Shorting - Conductive tools
- Incorrect Mounting
- Foreign debris
- Mother Nature
- Un-documented or communicated changes
- Human Error
- Other

- It rains! Be sure your systems can handle water
  - Where possible mount open termination on vertical surfaces away from seams in the vehicle or horizontal panels
  - Mount cables and connector away from low points were water might collect
  - Use water-tight connectors and include drip loops
- Provide adequate cooling and heat sinking for systems
- Provide strain relief, grommets, and isolation mounting
- Electrical tape is not really tape when it is **hot** or **wet**
- Keeping things simple and easy to fix on the side of the road
- Use appropriate personal protective equipment (PPE)

Agenda

- ❑ Introduction
- ❑ Lithium Battery Chemistry
- ❑ Failure Mechanism
- ❑ Safe Handling Guidelines
- ❑ Electrical Concerns
- ❑ Hazards and Emergency Response
  - Fire
  - Electrical Shock
  - Chemical Exposure
- ❑ Heat and your Body
- ❑ Summary



Hazards and Emergency Responses

Fire

- If the battery creates a spark, the flammable materials inside the battery can ignite
- If the temperature inside the battery rises rapidly, the battery can explode causing a fire and leaking electrolyte
- If Charging or Discharging Pack is left Unattended, this too can result in a fire

Hazards and Emergency Responses

Fire

- The common ABC fire extinguisher is acceptable for use on Lithium-Ion battery fires
- The BC & D extinguisher is acceptable, also.
- Sand is also recommended
- You should attempt to extinguish the fire only if it can be put out by a hand held fire extinguisher, otherwise get help

Fire Extinguishers (20# Size shown)

~20Kg of extinguisher is required

& 40 Kg of Sand

Fire

- Each Team should have an action plan in the event of an incident
- Those safety persons responsible will be requested to demonstrate their understanding during Support Vehicle Inspections
- Every Plan should contain
  - Who
  - What
  - Where
  - When
  - How

A Scenario for your consideration

Situation: Smoke has been detected in the exhaust from the Battery Box, Open Power Switch

1. Driver and team should visually survey battery pack for an obvious fire/smoke incident.

2. If incident is obvious, follow your process for emergency

3. If incident is not obvious, determine cell/module that has caused the smoke.
   - May require opening pack to see issue: BE CAREFUL Here. Have Observer save seals

4. With caution and added PPE [face shield, gloves], investigate the battery pack to determine the cause of the smoke.

5. If cause is serious or potentially serious, follow FIRE REACTION PLAN.

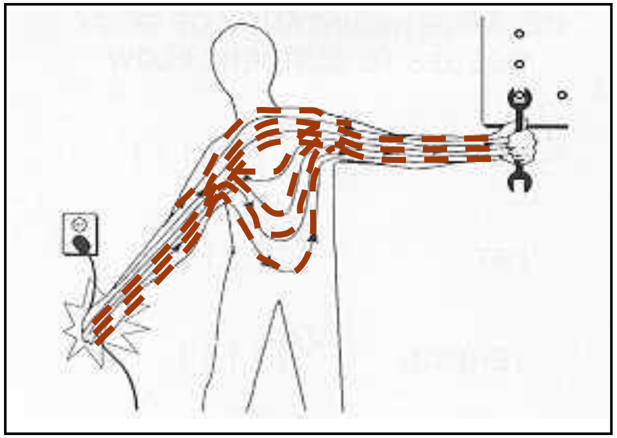
6. If cause is not serious, eliminate it.
   - Notify ASC of the event

- When in doubt: Walk Away and await 911Response !!! Better safe than sorry

Electrical Shock

- Electrical Shock should be avoided
- Every Plan should contain
  - Who
  - What
  - Where
  - When
  - How

- Electricity requires a complete path (circuit) to continuously flow
- Injuries occur if the human body becomes part of the **current path**
- Current paths that directly cross the body through the heart are called the **critical path** which can potentially cause severe injury or death
  - Hand-to-hand
  - Hand-to-opposite foot
  - Head-to-either foot
- Degree of conductivity varies by contact resistance of skin surface



Current lines through body if current passes hand-to-hand

Annuals of the MBC – vol. 4 – n'2 – June 1991

Electrical Concerns

Electrical Hazard

Effect	DC (mA)	AC (60 Hz)
Slight sensation at contact point	0.6	0.3
Perception threshold (when you would feel it)	3.5	0.7
Shock --- not painful, no loss of muscular control	6	1.2
Shock --- painful, no loss of muscular control	41	6
Shock --- painful, *let-go* threshold	51	10.5
Shock --- painful, severe effects: • Muscular contractions, breathing difficulty	60	15
• Shock --- possible ventricular fibrillation (loss of normal heart rhythm)	500	100

- Very little current is required to cause injury
- Your solar vehicle deals with 1,000 times over the threshold which could lead to negative consequences

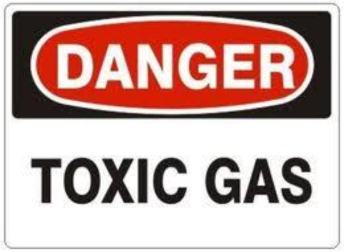
Electrical Shock

- Know your Emergency Contacts
- Know who to call when:
- Know what to do:
- Safety persons responsible will be requested to demonstrate their understanding during Support Vehicle Inspection
- And lastly, know what not to do and when to walk away!!

Hazards and Emergency Responses

Chemical burn

- How does a chemical burn occur?
  - When the skin comes in contact with strong acids or alkaloids such as lithium battery electrolyte
- The chemical will continue to erode the skin in deeper layers until it is washed away
- Extent of damage depends on the duration of exposure to the skin
- $LiPF_6$ [Lithium hexafluorophosphate] is the problem.
  - It is in the Lithiated Salt (caustic) (principal electrolyte component).
  - It is toxic to exposed skin, to inhale or to ingest. Fumes are **BAD**



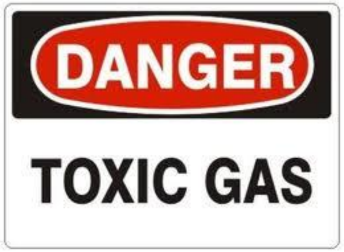
Hazards and Emergency Responses

Chemical Exposure [eye and skin reaction plan]

- *Affected Person*
  - ✓ Wash affected area(s) with running water for at least 30 minutes or as directed by medical personnel
  - ✓ Remove clothing and jewelry that may be contaminated
- *Team Mates*
  - ✓ Contact 911 to request emergency medical assistance. (Tell them it involves lithium battery exposure)
  - ✓ Put on protective gear, face shield, gloves and assist exposed person
  - ✓ Collect contaminated clothing in plastic bag
  - ✓ Cordon off spill area
  - ✓ Contain any liquids if it can be done safely

Chemical Gas Exposure [inhalation]

- Once exposed to air, the reaction of the chemicals may pose a hazard, even at 20 PPM!
- Breathing the gas can irritate lungs, nose and throat
- The gas can cause damage to the skin, mucous membrane or eyes
- Higher exposure to lithium fumes can cause a build-up of fluid in the lungs, leading to pulmonary edema
- So, if you smell peculiar sweet fumes, see cells venting, or hear “gassing” sounds of a battery pack….
  - GO TO FRESH AIR, IMMEDIATELY



Chemical Gas Exposure [inhalation reaction plan]

❑ Affected Person

- Leave area immediately at first sign of irritation
- Get to fresh air --- Notify colleagues if possible

❑ *Team Mates*

- Assist victim(s) only if they are out of exposure area
- Evacuate the area immediately; notify team mates to evacuate;
- Call 911 as soon as safely possible
  - ✓ Identify location
  - ✓ Tell them it involves lithium battery gas
  - ✓ Report any injuries
- Notify ASC and your school

50 50

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Heat Index

HEAT INDEX CHART

TEMPERATURE F°	RELATIVE HUMIDITY								
	10 %	20%	30%	40%	50%	60%	70%	80%	90%
104°	98	104	110	120	>130	>130	>130	>130	>130
102°	97	101	108	117	125	>130	>130	>130	>130
100°	95	99	105	110	120	>130	>130	>130	>130
98°	93	97	101	106	110	125	>130	>130	>130
96°	91	95	98	104	108	120	128	>130	>130
94°	89	93	95	100	105	111	122	128	>130
92°	87	90	92	96	100	106	115	122	128
90°	85	88	90	92	96	100	106	114	122
88°	82	86	87	89	93	95	100	106	115
86°	80	84	85	87	90	92	96	100	109
84°	78	81	83	85	86	89	91	95	99
82°	77	79	80	81	84	86	89	91	95
80°	75	77	78	79	81	83	85	86	89
78°	72	75	77	78	79	80	81	83	85
76°	70	72	75	76	77	77	77	78	79
74°	68	70	73	74	75	75	75	76	77

Directions: Locate the current temperature on the left column and then locate the relative humidity on the top row. Follow the temperature across and the humidity down until they meet; this measurement is the heat index. The heat index will increase 15 degrees in direct sunlight.

The Effect

Severity Stage	Condition	Signs/Symptoms	First Aid
Stage 1	***Heat Cramps***	• Painful muscle spasms • Heavy sweating	• Increase water intake • Rest in a cool environment • Use ice as needed
	Heat Syncope (loss of consciousness)	• Brief fainting • Blurred vision	• Increase water intake • Rest in a cool environment • Use ice as needed
	Dehydration	• Fatigue • Reduced movement	• Increase water intake • Rest in a cool environment • Use ice as needed
Stage 2	***Heat Exhaustion***	• Pale and clammy skin • Possible fainting • Weakness, fatigue • Nausea • Dizziness • Heavy sweating • Blurred vision • Body temp elevated (100°)	• Lie down in a cool environment • Use ice as needed • Water intake if conscious • Loosen clothing • Call ambulance if symptoms continue once in a cool environment.
Stage 3	***Heat Stroke***	• Cessation of sweating • Skin hot and dry • Red face • High body temperature (>104°) • Unconsciousness • Collapse • Convulsions • Confusion or erratic behavior • Life threatening condition	• **Medical Emergency!** • Call ambulance • Move victim to a cool environment and immerse in water or use ice to cool the victim.

Action for Heat

- ***Stage 1*** *can typically return Raycing after an opportunity to cool off and receive adequate re-hydration*

- ***Stage 2*** *will be monitored closely. Body temperature should be maintained between 98.6° and 101.° If body temperature cannot be controlled after a prolong rest period in a cool environment and re-hydration or body temperature re-elevates once the employee is back in the Raycing environment, the employee will not be able to participate further and thorough medical evaluation will be made as necessary.*

- ***Stage 3*** *will receive medical attention immediately. All efforts will be taken to monitor weather conditions to prevent this stage from occurring*

Conditions

- Extreme Danger:
  - Heat Stroke likely to occur when working under these solar conditions.
- Danger:
  - Heat Exhaustion or Heat Cramps likely. Heat Stroke may occur upon prolonged exertion, so take action!!
- Extreme Caution:
  - Heat Cramps or Heat Exhaustion likely to occur. ASC will implement adjusted schedules and procedures. Take action here to!!
- Caution:
  - Heat Fatigue may occur. Normal summer conditions should be observed. Slow down and drink regularly.

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- Lithium-Ion Battery Chemistry
- Failure Mechanism
- Safe Handling Guidelines
- Electrical Concerns
- Hazards and Emergency Response
- Heat and your Body
- Summary

- In review:
  - How batteries work, basic battery cell structure and its electrochemical process
  - Why and how batteries fail
  - The potential hazards associated with working with batteries during product development
  - Safe battery handling standards
  - Electrical Standards and Hazards
  - The types of possible incidents and your responsibility should an incident occur

Pit Review

- ASC Inspectors will be “Auditing” Team Pits for compliance and to observe for issues.
- We expect a Team Safety Officer to take notes and team to deal with the issues
- This will occur at least 2 times during the Formula Sun 2017

- We will identify issues with:
  - Safety
  - Cleanliness
  - Food
  - Other
- Random audits will occur as well.

0% SOC means that there is no charge left in the battery.

A. True

B. False

0% SOC means that there is no charge left in the battery.

A. True

B. False

Even if the SOC is 0%, there still could be a considerable amount of energy remaining in the battery

Name the three main categories of battery failures.

A. Infantile failures
B. Ultimate or End of Life (EOL)
C. Abuse

Which of these should cause us the most concern?

Why?

- What are the 5 “Don’ts” with batteries?

- What are the 5 “Don’ts” with batteries?

1) Don’t overcharge the battery or cell.
2) Don’t over-discharge the battery or cell.
3) Don’t overheat the battery or cell.
4) Don’t short-circuit the battery or cell.
5) Don’t physically abuse the battery or cell.

And Certainly, Don’t Charge or Discharge a Battery unattended!!

Question

- When reacting to chemical exposures per the posted reaction plans, teams must not…..?

- When reacting to chemical or electrical exposures per the reaction plans, team mates must not…..?

  Answer: Become victims of the hazard.

- How is this achieved?

Question

- When reacting to chemical exposures per the posted reaction plans, team mates must not…..?

  Answer: Become victims of the hazard.

- How is this achieved?

  Answer: Put on protective gear before aiding victim.

- Why is it we are so interested in SAFETY?

What's this?

Q & A