



Personal Mobility Device Fires

Personal Electric Mobility Devices (also known as personal transport) are becoming a big part in the future of urban transportation. These electric adult and children mobility devices will challenge first responders at many levels, and we must prepare ourselves with knowledge and training.

Electric-driven mobility devices are not only convenient to use but they are also eco-friendly. These mobility devices are cost-effective and low power consuming. Given growing worldwide pollution, and traffic congested on inner-city streets, the pressing demand for mobility devices are constantly on the rise. Some leading manufacturers like Tesla, Segway and Rivian are already reaping their benefits. So, what are personal electric-driven mobility devices:



MOPED



BIKE



SCOOTER



HOVERBOARD

We will also include the items below because of their energy source:



4 WHEEL MOBILITY SCOOTER



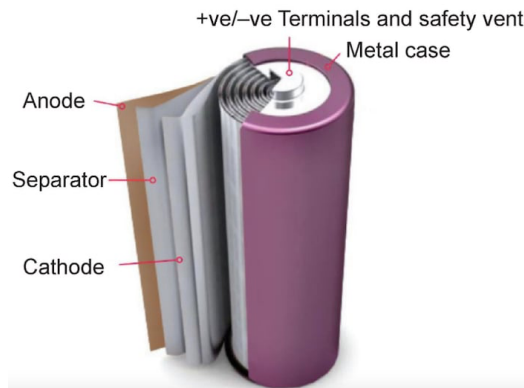
WHEELCHAIR



KIDS ELECTRIC RIDING TOYS

Note: many of these electric mobility devices use lithium-ion batteries as their energy source.

Lithium-ion Batteries as The Energy Source



A full battery pack consists of a number of cells, which is the shaped of standard AA battery. The cell consists of a cathode (positive electrode), an anode (negative electrode), a separator, and a safety vent hole. The separator is a thin plastic filter that only allows ions to pass through. The direction of movement of the cathode (+) and anode (-) electrodes moving back and forth determine if the battery cell is charging or discharging.

Most Lithium-Ion batteries use a liquid or a solid electrolyte to cool the battery which is flammable. If a battery reaches temperatures above 460 degrees, the battery will start to decompose and will rapidly increase the battery's temperature up to 1,472 degrees or higher. This rapid heating and a chemical reaction within the battery will cause the cathode (+) electrode to release oxygen and assist with igniting the flammable electrolytes.

When a lithium-ion battery cell self-heats due to uncontrolled chemical reactions on the Anode (-) or cathode (+) initiated by abuse or defect, it is called **Thermal Runaway**. Thermal runaway can result in explosion or fire due to the rapid release of the battery's stored energy as well as energy produced when the heating starts breaking down the battery cell's components.

The heat generated during Thermal Runaway can heat nearby cells causing the same process to repeat with those cells as well. That may happen quickly or over several hours depending on many factors. If the battery pack includes dividers between cells this may significantly slow or even stop the cascading failure of the cells.



Why are these batteries going on fire?



Battery Failures

One of the leading causes of e-scooter fires is battery failures. Most battery failures emanate from poor design, manufacturing flaws, and physical abuse causing electrical, thermal, and mechanical damage.

Poor quality construction and design flaws

Some battery manufacturers make their batteries using low- quality materials and fail to participate in proper quality control inspections. During the manufacturing stage, metal debris or welding burns may find their way into the battery's electrolyte. As the lithium-ion cells expand and contract when energized and deenergized, the debris can damage the separator. This often leads to a short circuit that causes a chemical reaction that can produce more heat and gas pressure than the battery cells can dissipate, causing what is known as thermal runaway.

Physical damage

Another common cause of fire in electric scooters is physical damage to the battery. Physical damage such as dropping, impact, crushing or puncturing the battery can lead to a short circuit. This, in turn, causes heat and gas build-up triggering a thermal runaway in battery cells.

Riders should understand that physical damage to the battery may immediately trigger a fire or cause a defect that ignites a fire later. Manufacturers encourage users to change their batteries regularly, especially if they display signs of physical damage.

Overcharging

Overcharging may occur when using the wrong charger or not following the manufacturer's instructions, causing the cell voltage to be incorrectly determined by the control system. An overcharge can cause the anode (-) material to accumulate lithium

metal deposits. These deposits may continue to grow until they penetrate the separator, leading to an internal short circuit. This, in turn, trigger thermal reactions that cause the battery to explode or ignite the nearby materials.

Rapid charging or overcharging may cause the battery to go past its charging limit, thereby degrading the cells performance or rendering them useless. Important to remove the lithium-ion device and batteries from the charger once they are fully charged.

Discharge

When lithium-ion batteries are discharging, lithium-ions flow from the anode (-) current collector to the cathode (+) current collector. When there is too much discharge, the negative current collector made of copper starts to dissolve causing the chance of an internal short circuit, which may cause a fire. It can also lead to chemical reactions that produce hydrogen and oxygen, two highly flammable gases.

Exposure to high or low Temperatures

High temperatures (e.g., above 130 deg.s) from an external heat source (open flame, heaters, etc..) can degrade and accelerate failure of the battery cells causing an exothermic reactions that may cause battery defect that can ignite the battery or even explode. To be safe, avoid keeping your machine in places with extreme temperatures.

Increasing internal temperatures can initiate a thermal runaway event, high temperatures can make a cell fail and spread heat further within the lithium-ion battery pack. This may lead to the formation of flammable gases that cause the battery to swell and even ignite.

Charging temperatures below freezing (32 deg. s) can lead to permanent metallic lithium buildup (i.e., plating) on the anode, increasing the risk of failure.

- Store batteries and devices in a dry, cool location. If practical, batteries should be stored in a metal storage cabinet or in their original packaging. Used batteries should be stored at room temperature and in well vented area. The recommended storage temperature for most lithium-ion batteries is 59°F.

What are the hazards of a lithium-ion battery fire?

Many highly populated cities in USA and other countries around the world as starting to experience a rash of fires involving personal electric mobility devices.

Due to the lack of storage area or security reasons many people are storing and charging their personal device in their residential homes, apartments, work office, place of business or common hallways. On a few occasions these devices are being transported in elevators and catch fire while inside the elevator car causing serious injuries to the occupants inside the elevator car. Fires involving lithium-ion batteries are quick, intense, toxic, and fast spreading fire.



Toxic gases and Smoke include:

- **Nitrogen (Ni)**
- **Carbon monoxide (CO)**
- **Carbon Dioxide (CO₂)**
- **Hydrogen (H₂)**
- **Cobalt Oxide (CoO)**
- **Nickle Oxide (NiO)**
- **Manganese Oxide (MnO₃)**

What is the best fire strategy for lithium-ion battery fires?

A small lithium-ion fire can be handled like any other combustible fire. For best result use a foam extinguisher, CO₂, ABC dry chemical, powdered graphite, copper powder, or soda (sodium carbonate). Water-based products are most readily available and are appropriate since lithium-ion contains very little lithium metal that reacts with water. Water also cools the adjacent area and prevents the fire from spreading. Research laboratories and factories also use water to extinguish Lithium-ion battery fires.

When thermal runaway happens, it produces toxic smoke, arc flashing flames and even explosions of the battery cells. The heated off-gassing and fire will spread to surrounding battery cells, then to the other battery cell modules until the entire battery is consumed in fire if you cannot stop this chemical reaction by cooling down the battery.

Using water to cool a damaged battery in a thermal runaway phase is currently the recommended strategy for responders to use while operating at lithium-ion battery fires. It is recommended that firefighters apply “copious amounts of water” directly on the area of the battery case and use a thermal imaging camera to periodically look for signs of heat from the ongoing chemical reaction inside the battery.

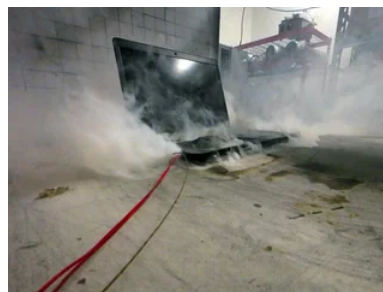
Do not puncture or cut holes into the battery casing to expose the battery cells!

It is very dangerous and may cause the spread of fire quicker to the other modules in the battery!

The risk of electric shock and battery re-ignition/fire can arise from the stranded (stored) energy that remains in a damaged battery. Stranded energy is any scenario where electrical energy remains in a battery without an effective means to remove it. This typically happens when the battery is damaged – by impact, electrolyte (coolant) leakage, excessive heat, water intrusion, or normal component failure. It can also lead to thermal runaway. How much energy that remains in the battery when it is damaged can affect the severity and duration of the reaction. Past incidents have shown that the lithium-ion batteries can re-ignite several hours or several days later depending on remaining energy stored in the damaged battery. The tell-tall sign of thermal runaway phase has begun is the popping and hissing noises coming from the battery. A damaged high-voltage battery is very difficult to de-energize and it must be handled by a manufacturer’s technician.

Signs of failure and fire include:

- **Leaking electrolyte stains**
- **Increasing temperatures**
- **Gurgling/bubbling sounds**
- **Popping or hissing noises**
- **Odor of smoke or off gassing**
- **Swelling or bulging**
- **Flames and sparks**



Safety tips to prevent lithium-ion battery fires.

- Purchase and use devices and batteries that are listed by a qualified testing laboratory. Avoid unauthorized or third-party batteries.
- Only charge your e-bike battery with the charger provided by the manufacturer. Follow the manufacturer's instructions for charging and storage.
- Do not leave a charging e-bike battery unattended or on the charger overnight while you are sleeping.
- Batteries can get warm during use and should be allowed to cool down, before attempting to re-charge.
- If a battery overheats or you notice an odor, change in shape/color, leaking, or odd noises from a device discontinue use immediately.
- Do not use aftermarket, low cost, counterfeit, or refurbished e-bike batteries.
- Do not use or attempt to charge a damaged or malfunctioning e-bike battery. Remove them from service.
- Keep batteries/devices at room temperature. Avoid cold temperatures, humidity, or direct sunlight.
- If possible, store your e-bike battery in a fire-resistant cabinet or container when not in use. Store batteries away from anything flammable.
- Store damaged e-bike batteries outside and contact your local fire department to ask about safe disposal.
- Do not store electric devices and batteries in common hallways or near exits and entrance ways.
- And of course, have a fire extinguisher located nearby.