

Demand for e-bikes fuels an alarming rise in lithium-ion battery fires

By Assistant Chief Fred Schaaf



Pictured is an example of the cramped interior of many e-bike (battery-powered mobility device) stores. When the store is closed, the center aisle is usually filled with the e-bikes that inhabited the front sidewalk during business hours. This creates a large fire load and a heavy clutter condition. The reach of the stream should be utilized and full PPE maintained during overhaul due to the possibility of reignition of damaged batteries. No sprinkler protection is provided.

On Sept. 1, 2021, FDNY members operated at a fatal fire in Ozone Park, Queens, that resulted in the death of a 9-year-old boy. The cause of the fire was a charging electric bike (e-bike) battery. On Dec. 19, 2021, a Manhattan man who repaired e-bikes perished while charging nine batteries in his East Village apartment. One of the batteries exploded with such force that it blew out windows and knocked out an interior wall. This second-alarm fire also critically injured a 46-year-old woman, whose two children only escaped by climbing down an electric conduit near their apartment window.

In yet another case on Jan. 8, a four-alarm fire at 2230 Grand Concourse in the Bronx ravaged a six-story New Law tenement. The fire, which was reported just after 0200 hours, started in the Caridad restaurant on the ground floor of the building and spread to the apartments above, displacing dozens of residents. Food-delivery workers employed by the restaurant had been storing and charging e-bikes inside at night when one

caught fire, extending to the multiple dwelling above.

Electric bikes have become enormously popular in the United States. Over the past year alone, e-bike sales have increased by 240 percent nationally, according to Consumer Reports. Their use is especially prevalent among the estimated 65,000 food-delivery workers in NYC, who now rely on powered mobility devices to navigate the City. But this trend comes with a troubling externality: As e-bike sales have increased, so have the number of fires.

Over the past few years, NYC has experienced an alarming rise in the number of lithium-ion battery fires involving powered mobility devices, including e-bikes. In 2019, there were 30 e-bike fires in the City. In 2020, that number jumped to 44 fires, yielding 23 injuries. In 2021, the number of fires soared to 104, causing 79 injuries and four deaths. And in the first month of 2022, 22 fires were recorded, setting the City on pace to eclipse the statistics of previous years.



This e-bike store is located on the ground floor of a multiple dwelling under the fire escape; a CIDS card should be submitted. Responding units will have to quickly search the floors above for life and extension. The previously mentioned four-alarm fire in the Bronx was caused by e-bikes stored overnight in a restaurant, with fire extending to the apartments above. A store presents an even greater potential.

This trend presents a serious problem for NYC residents and government officials. Electronic-bike fires are a threat to the public, requiring a public-policy response to ensure that technological advances can coexist with public safety. For its part, the FDNY has been forced to adjust, altering its operational tactics and implementing a new set of procedures to fight these fires and mitigate the threat of battery reignitions.

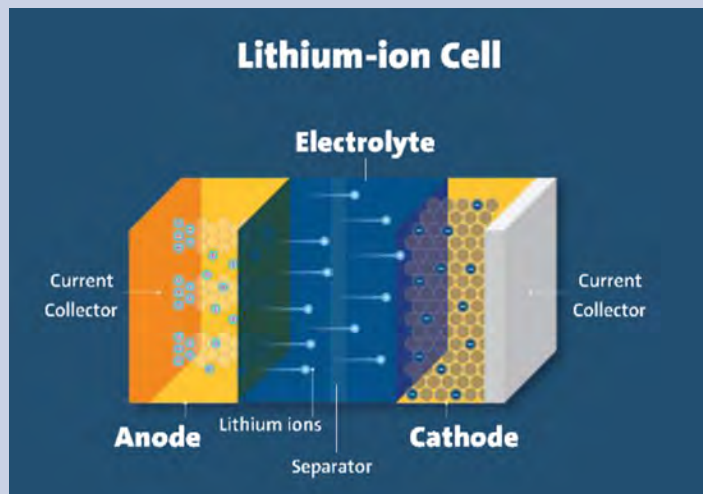
Lithium-ion batteries have been used in commercial products for more than 25 years. They are used to power many modern devices we are all familiar with, such as power tools, laptops, appliances and automobiles. In recent years, lithium-ion batteries have become a good energy solution for e-bike manufacturers, as the technology has evolved to store ever-greater amounts of energy in smaller, sleeker cases. Lithium-ion batteries also operate efficiently over a wide range of outdoor temperatures.

There is a serious problem with these batteries, however: Damage to their casing, or to the cells inside, can cause the batteries to fail quickly and violently, resulting in fires that grow with stunning speed and intensity. Because e-bikes and their batteries are often stored and charged indoors in residential buildings, they can ignite combustible goods and furnishings in their immediate areas, causing major fires with serious life hazards. To make matters worse, they are more difficult to extinguish than ordinary structural fires. The technology used in lithium-ion batteries requires exceptionally large amounts of water to ex-

Lithium-ion batteries: understanding the hazards

By Lieutenant John Cassidy and Battalion Chief Mike Maiz

The technical discussion starts with understanding how a lithium-ion (Li-ion) battery is built and how it functions. Lithium-ion batteries store and release energy through electrochemical reactions. The battery has two electrodes—the anode and the cathode—that are isolated from each other by a separator (see Figure 1). The components are submerged in a liquid electrolyte composed of a lithium salt and a flammable organic solvent. Electrons will move through the electrolyte to and from the electrodes based on whether the battery is charging or discharging.



Lithium-ion batteries or cells come in three basic forms: the ridged wall cylindrical cell, the flexible wall pouch cell and the prismatic block cell. The cells are the building blocks found in items as small as cell phones, mobility devices or power tools and as large as utility scale energy storage systems. Battery cells are arranged in modules to make the desired application.

The fire service becomes involved when the cells fail within a given device. Cell failure can result in fires, as well as the release of toxic/flammable gases that can ultimately lead to an explosion. This failure process is called *thermal runaway*, or the uncontrolled, self-heating state of a cell failure. Exothermic decomposition of the cell materials leads to extremely high temperatures and/or violent venting of toxic/flammable gases that result in fires and sometimes explosions. It is important that thermal runaway happens so quickly absence of an elevated thermal signature in the thermal imaging camera does not indicate a stable condition. Thermal runaway and cell failure can be caused by a number of factors, including factory defects, thermal abuse, electrical abuse and mechanical abuse.

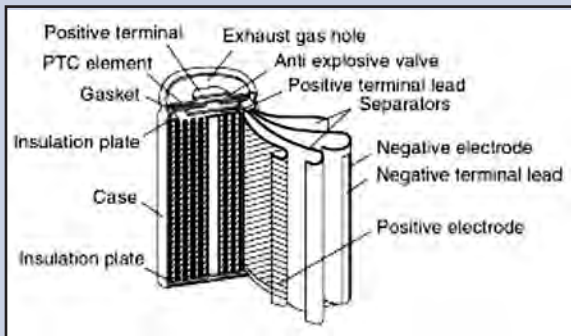
Construction of a lithium-ion battery cell requires a highly precise process. Factory defects can result in the breakdown of the separator, which can cause an internal short circuit. The percentage of defective cells is small, but with an exponentially increasing number of cells being manufactured, defects cannot be ruled out as a potential cause of cell failure.

Thermal abuse is a common cause of cell failure, especially with mobility devices. Heat is generated as part of the normal charging process, and insulating items placed on batteries/

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charges can lead to fires. External heat sources, including proximity to radiators or boilers, have been factors in mobility-device fires. Radiant heat and/or direct flame contact from a fire can result in battery failure as well.



In New York City, it is common for mobility devices to be stored and charged in the living areas of apartments or residences.

There are a number of factors that can be considered electrical abuse. Incorrect, defective or damaged charging systems can result in cell failure. Battery modules/systems will have a battery management system to maintain the health of the battery module. Failure of the module can also be considered electrical abuse.

Mechanical abuse is also a primary factor in the failure of batteries in mobility devices. Mobility devices are subject to impact trauma, vibration and water ingress. Mechanical abuse can lead to a breach of the individual cells or damage to the electrical system of the device.

There is another cause not listed above: do it yourself (DIY). FDNY has responded to fires caused by individuals who repaired or modified battery modules. DIY attempts can trigger a number of failure modes.

Mobility devices were tailor-made for New York City; low cost of ownership compared to motor vehicles, ease of storage versus parking and overall convenience will ensure their increased use in NYC. Lithium-ion batteries in the fire apartment pose a threat to firefighters. When a cell fails, it releases gases that are toxic and flammable and that, when ignited, can result in an explosive atmosphere. If a cell fails during a fire, it can dramatically increase the volume of fire present. Cell failure after exposure to fires is unpredictable and can result in reignition hours to days later. The volume of gas released from cell failure can quickly fill any room.

Firefighters operating around heat-impacted batteries/devices must use full PPE, including SCBA. A hazardous materials response will ensure that impacted batteries are safely removed from the incident. The impact of lithium-ion batteries on the fireground is a new reality for the fire service; however, we have the tools to safely deal with this new challenge. ■



About the authors

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Electric bike retailers may stockpile discount batteries not certified by a rating agency to save on cost and increase profit margins.

tinguish, and experience has shown that they can spontaneously reignite minutes—and sometimes even hours—after an initial fire has been extinguished.

This is what occurred on Dec. 9, 2021, when a fire destroyed an e-bike store at 41-12 Junction Blvd. in Corona, Queens. Units of Battalion 46 arrived to find the store—which was filled with e-bikes and lithium-ion batteries—fully involved in fire. FDNY members extinguished the fire, bringing it under control in just less than an hour. Since lithium-ion batteries were involved, the incident commander (IC) followed current Department policy by transmitting a 10-80 Code 1 and notifying the Bureau of Fire Investigation (BFI). The 10-80 Code 1 signal initiated a Hazmat response, summoning the Hazmat Battalion and Hazmat Company 1 to the scene. Department policy requires Hazmat units to overpack lithium-ion batteries involved in fire and contact the Sanitation Department's environmental police for removal.

But the number of batteries at the Junction Boulevard fire, estimated at 1,000 pounds, far exceeded the FDNY's overpacking and removal capacity, making the normal procedure impossible to carry out. Instead, representatives of the NYC Department of Environmental Protection (DEP) responded, issuing an order for the owner of the e-bike store to hire a licensed contractor to remove the batteries. This is similar to current procedures for commercial establishments when removing propane or other bottled flammable gasses. It was not until around 1900 hours—13 hours after the fire was placed un-

der control—when the owner had a removal contractor on the scene. The affected batteries were removed, and the incident was considered mitigated.

Approximately 30 hours after the original fire, at 0511 hours on Dec. 11, 2021, Queens Box 7977 was transmitted again, reporting a store fire at 41-12 Junction Blvd. For a second time, Battalion 46 units responded to find the e-bike store fully involved with fire, with fire venting from the front entrance. Once again, the fire was extinguished and placed under control in less than an hour, leaving an incredulous group of FDNY members wondering how the e-bike store had erupted in fire for a second time in two days.

The store owner, DEP representatives and the removal contractor had left the scene the previous day believing they had mitigated the incident. Upon their return, DEP representatives explained that they had required the contractor to remove only the batteries that were in storage, not the batteries on the e-bikes themselves. A new order was issued requiring the removal of all lithium-ion batteries. Again, Battalion 46 ordered a watch-line engine to remain on the scene and monitor the dozens of burnt and charged e-bikes now covering the sidewalk in front of the store. This time, to be sure that the threat of reignition was properly mitigated, Battalion 46 requested to be notified when the work was completed so they could evaluate conditions before DEP and the removal contractor left the scene.

In subsequent conversations since the incident, DEP inspectors have acknowledged that lithium-ion battery fires and the threat of reignition are new and growing issues that require agencies to rethink how to safely mitigate similar incidents moving forward. For FDNY members, time is of the essence in requiring overpacking and removal to mitigate the reignition hazard from damaged batteries.

At the time of this writing, there are no laws regulating how e-bikes are transported or stored, but some building owners and property-management companies have banned or limited their use. Still, they can be found in trains, elevators, apartments and stores, where they can create a serious life hazard if involved in fire.

There are several potential policy solutions that could diminish the severity of lithium-ion battery fires. One is to require e-bike stores to be sprinklered. Owners could also be required to carry enough insurance to meet disposal costs. Further, battery-disposal contractors should be licensed and required to provide 24-hour-a-day service every day of the year. Also, food establishments could be required to safely store e-bikes when not in use.

In addition to the FDNY's fire operations, Hazmat operations and BFI investigations, part of the mechanism for addressing lithium-ion battery fires requires thorough documentation. By diligently tracking these fires, the fire service can push for changes, including new legislation, to try to reduce the dangerous increase in battery fires. Fire marshals will respond to conduct a cause and origin investigation as they normally do. If it is determined that battery ignition occurred secondary to an original fire, this will also be documented.

The new 2022 New York City Fire Code, effective as of April 15, contains requirements regulating stationary energy storage systems (ESS) and powered mobility devices. While not the focus of this article, ESS installations have seen an increase in construction. This is due to a societal shift toward cleaner energy that requires energy storage in batteries to maintain reliability in power supply. The requirements for ESS are detailed



When overpacking lithium ion batteries, Hazmat uses CellBlock, a fire, heat and smoke suppressant that will not interfere with the recycling process as other methods might. The pail to the right is an overpack container; Hazmat carries containers of multiple sizes, depending on what is required.

in Fire Code Section FC608, and in Fire Department Rule 3 in the Rules of the City of New York, (RCNY) 608-01 (which refers to them by the 2014 Fire Code terminology, stationary storage battery systems).

Powered mobility devices, including the storage and charging of e-bikes, can be found in Fire Code Section FC309.3, which sets forth new fire-safety regulations for indoor rooms and outdoor locations in which six or more powered mobility devices are being charged or stored while not charging. The section exempts storage and charging in a Group R-3 occupancy or in a dwelling unit in a Group R-2 occupancy of not more than five powered mobility devices—provided that such devices are for personal use—as well as charging of a single powered mobility device by and in the presence of its owner or user.

I'm sure anyone reading this article, including myself, has lithium-ion batteries powering some of their devices. Public education is critical so that NYC residents can safely use, charge and dispose of these batteries, especially as related to e-bikes and mobility devices. Owners of e-bikes should follow some basic safety practices, including only using batteries that are certified by a qualified testing laboratory such as Underwriters Laboratories (UL). They should also perform a visual inspection of the battery for any physical damage before charging, following the manufacturer's recommendation for charging and stor-

¡ su seguridad, abroche el
cinturón de seguridad de su hijo



End of life care: How many of these batteries will be properly disposed of, as opposed to discarded with regular refuse? Will some of them end up in dumpsters and sanitation trucks, failing and igniting combustibles within?



ing while also using their supplied charging cords and stations. If e-bikes must be stored or charged indoors, it must be done away from any flammable material and in a well-ventilated area. E-bikes should also be kept away from any paths of egress out of your home or apartment.



A 41-12 Junction Blvd., the remediation company took only the batteries that were extinguished from the first fire. These scooters were subjected to high heat but not taken away. Their batteries later failed, causing an even heavier fire with fewer contents. The gases escaping from the batteries fueled this second fire.

Lessons learned/reinforced

- Lithium-ion batteries can reignite hours after they appear to be extinguished and dormant. A watch line must be initiated until they are declared safely mitigated by Hazmat, or removed by Sanitation or a licensed contractor.
- Even if they are not the cause and origin of a fire, lithium-ion batteries can still be damaged and ignite, adding to the fuel load and intensity of the fire. This can occur while members are advancing a hoseline and have passed the location of the batteries. In commercial occupancies or garages where there might be multiple batteries in storage, the reach of the stream should be utilized. During overhaul operations, members should be protected by a charged hoseline and full PPE.
- Critical Information Dispatch System (CIDS) entries should be generated for all e-bike occupancies. This will give responding members valuable situational awareness to operate safely. ■

I would like to thank the many people who contributed their expertise to this article, especially Lieutenant John Cassidy, Hazmat 1; Chief Fire Marshal Daniel Flynn; AC Kevin Brennan; Inspector Andrew Dushynskiy; and the code development unit of the Bureau of Fire Prevention.



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