

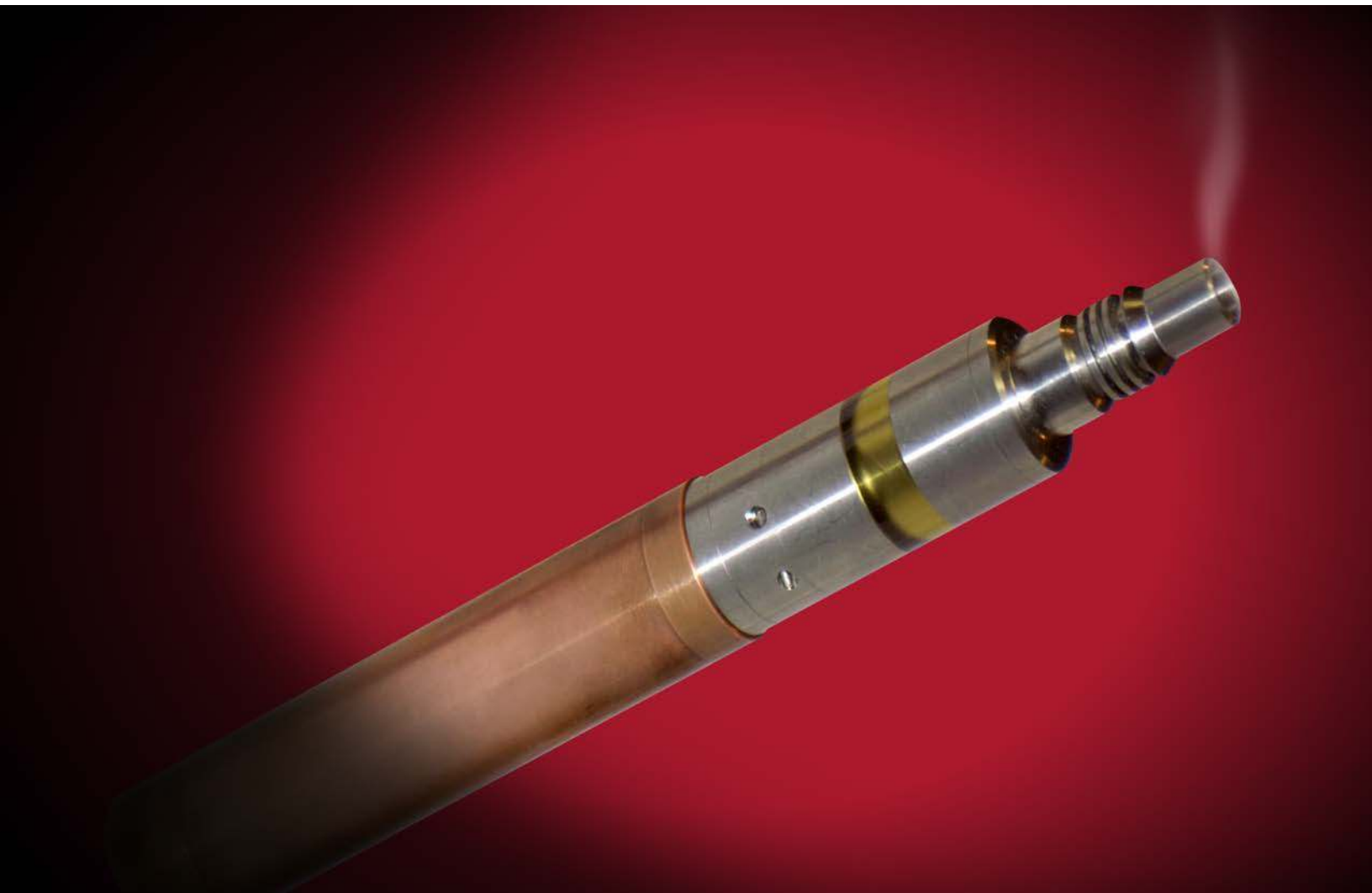
U.S. Fire Administration

Electronic Cigarette Fires and Explosions

October 2014



FEMA



U.S. Fire Administration

Mission Statement

We provide national leadership to foster a solid foundation for our fire and emergency services stakeholders in prevention, preparedness, and response.



FEMA



Electronic Cigarette Fires and Explosions

Key Points

- More than 2.5 million Americans are using electronic cigarettes (e-cigs or e-cigarettes), and this number is growing rapidly.
- Fires or explosions caused by e-cigarettes are rare.
- Twenty-five separate incidents of explosion and fire involving an e-cigarette were reported in the United States media between 2009 and August 2014.
- Nine injuries and no deaths were associated with these 25 incidents. Two of the injuries were serious burns.
- Most of the incidents occurred while the battery was charging.
- The shape and construction of e-cigarettes can make them more likely than other products with lithium-ion batteries to behave like “flaming rockets” when a battery fails.
- Lithium-ion batteries must be charged in accordance with the manufacturer’s instructions.
- Using power sources not approved by the manufacturer to recharge a lithium-ion battery can result in an explosion and fire.

What is an E-Cigarette?

The e-cigarette, also called a personal vaporizer (PV) or electronic nicotine delivery system, is a battery-powered device that simulates tobacco smoking by producing a heated vapor, which resembles smoke. These devices have become very popular as an alternative to smoking, including among a growing number of individuals who have never been smokers but who enjoy the many flavors and/or the experience of using e-cigarettes.

Development

E-cigarettes were first patented in 2003 and have been available for sale in the U.S. since 2007. E-cigs have been rapidly growing in popularity as the number and selection of products expand at an extremely rapid rate. Zhu, et al. (2014) report that by January 2014, there were 466 brands of e-cigarettes and 7,764 unique flavors available for sale. They also state that the number of products has been increasing at a rate of 10.5 brands and 242 new flavors per month. Richtel (2014) reported that annual e-cigarette sales have reached 2.5 billion dollars in the U.S. StatisticBrain¹ reports that as of July 13, 2014, there were 2.5 million e-cigarette smokers in America. Indicators point to continued dynamic growth in the industry.

What do they look like? How much do they cost?

E-cigarette designs vary greatly. Some resemble a traditional cigarette, cigar or pipe, while others resemble a

flashlight or a small pack of cigarettes with a protruding tube. Cellphone cases with built-in e-cigarettes are also available. Figure 1 shows three common commercially available devices.

Prices for the devices range from \$30 to over \$300, with a corresponding range in battery size, liquid capacity and vapor output. The most basic device is an e-cigarette, which looks like a traditional cigarette. Moving up the line, devices designed to make larger quantities of vapor are called PVs or Mods. Users can purchase a wide variety of commercially available products or make their own. Homemade vaporizers and e-liquids are common.



Figure 1. Three of the many e-cig styles available.

¹ <http://www.statisticbrain.com/electronic-cigarette-statistics>.

How do they work?

The devices have a heating element (an atomizer or caratomizer) to vaporize a liquid solution. Solutions (also called juice) usually contain a mixture of propylene glycol (PG), which increases flavor; vegetable glycerin (VG), which increases vapor; nicotine; and flavorings. Some juices provide flavored vapor without nicotine. Figure 2 shows the principal parts that are found in every e-cigarette or vaporizer.

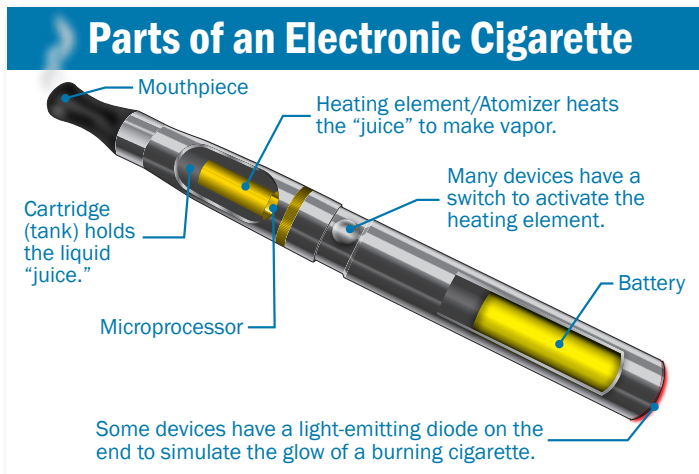


Figure 2. Parts of an electronic cigarette.

“Automatic” e-cigarettes activate the heating coil when a user takes a drag from the device. Manual e-cigarettes have a switch that the user depresses to energize the heating element to make the heated vapor. Most manufactured devices have built-in timeout features that prevent overheating, and many have locking features to prevent the switch from being activated in a pocket or purse. A light-emitting diode to simulate a cigarette’s glow on the end is common among e-cigarettes, but not common in PVs or Mods.

Alternate Uses

E-cigarettes are sometimes used to smoke hash oil or “honey oil,” a cannabis product derived by separating the resins from marijuana. Separating hash oil from marijuana is a hazardous process that is often done illegally in hotels and homes. First responders should be aware of this practice and the hazards that it presents.²

² For more information, see <http://www.rmhidta.org/default.aspx/MenuItemID/691/MenuGroup/RMHIDTAHome.htm>.

Health and Safety

The health effects of the vapor and the danger of nicotine overdose by ingestion or dermal contact with the juice are the subject of ongoing review by various agencies (Cressey, 2014; World Health Organization (WHO), 2014). The regulatory situation related to e-cigarettes varies by jurisdiction. At the time of publication of this report, the following facts were known:

- The U.S. Food and Drug Administration (FDA) recently proposed regulations for e-cigarettes. These proposed FDA regulations do not include consideration of the battery or electronics used in/with the devices — the FDA is proposing to address only the health effects of inhaling the vapors (FDA, 2014; Ledford, 2014).
- WHO has recently proposed that member states adopt stringent controls on e-cigarettes (WHO, 2014). The proposal is limited to the potential health effects of e-cigarettes and does not include language addressing the electronics.
- The U.S. Consumer Product Safety Commission has advised that e-cigarettes do not fall under its jurisdiction.
- Gourdet, et al. (2014) report that 34 states’ laws address e-cigarettes either explicitly or as part of language applying to tobacco-derived or nicotine-containing products. Laws explicitly addressing e-cigarettes primarily focus on youth access (22 states) or smoke-free air (12 states).
- Underwriters Laboratories (UL) has developed standards that relate to lithium-ion battery safety. These standards are applied to products containing batteries that undergo UL safety testing.
- No regulation, code or law applies to the safety of the electronics or batteries in e-cigarettes. While many consumer products are required to be tested by a nationally recognized test laboratory, such as UL, there are no requirements that e-cigarettes be subjected to product safety testing.

Do You Mind If I Vape?

The world of cigarette alternatives has a vocabulary of its own.

The term **vape** is a contracted form of the word **vapor**, which has its origins in the Latin “vaporem” meaning “steam” or “exhalation.” The word vape mirrors the path of word formation that the term **smoking** followed; for instance, there are **nonvapers** as well as **vapers**, and those who oppose the habit talk about **antivaping** campaigns.

Vaporize is what the e-cigarette does. **Vapor** is what the e-cigarette produces. **Vaping** is what users do. **No-nic vapers** are vapers who vape using juice that does not contain nicotine.

Other common terms used within the vaping community include **analog** (slang for a traditional cigarette), **juice**, **e-juice**, **e-liquid**, **tanks**, **atomizers**, **cartomizers**, **clearomizers**, **drippers**, **vape pens**, **twists**, **Mods**, **subohm coils**, **mechanical Mod**, **PG**, **VG**, and **blast**.

Incidents

Why did we look at e-cigarettes?

A number of recent fires have been attributed to e-cigarettes, causing some concern within the fire service community. In response, a review of incidents involving e-cigarettes was initiated.

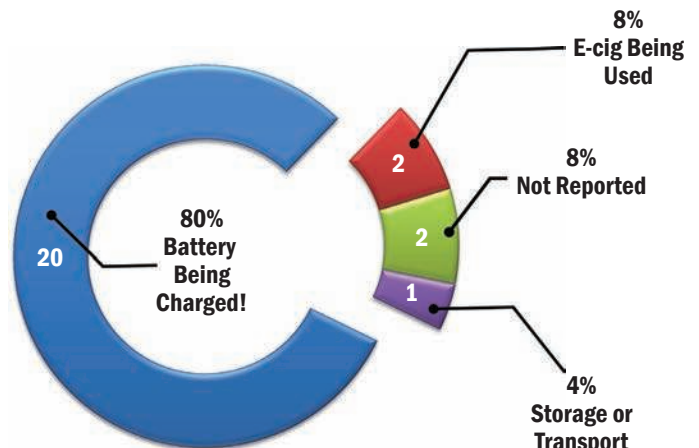
The National Fire Incident Reporting System (NFIRS) does not collect information that is specific enough to provide accurate analysis of the frequency or impact of e-cigarette fires. Lacking NFIRS data to use, media reports were selected as an available, albeit less reliable, information source. The results cited herein should be viewed in this light — as qualitative information rather than as a quantitative analysis.

What we found

Media reports of 25 separate incidents in the U.S. dating from 2009 to the present were found during an Internet search. This list is not thought to be all-inclusive since it is likely that there were incidents that were not reported to the fire department and/or reported in the media. The media reports were reviewed, and key information was extracted and summarized. The information contained in many reports was brief and often inconsistent with other media reports covering the same incident. The photographs or video segments included in some of the reports provided more useful information for this study than the body of the article. A summary spreadsheet of the reports was prepared and is included in Appendix 1 for reference.

- Twenty incidents occurred while the battery in the device was being charged.
- Two incidents occurred during use.
- In two incidents, it is not clear whether the e-cigarette was in use, idle or being charged.
- One incident occurred during transportation on a cargo aircraft.
- Ten injuries and zero deaths were reported by the media.³
- Several burn injuries were reported. Two serious injuries occurred when devices exploded in users' mouths.

Status of E-cigarette at Time of Fire



³ Press in the United Kingdom has reported one death in an August 2014 incident where an e-cigarette that was being charged in a nonmanufacturer-approved device exploded and ignited nearby oxygen equipment.

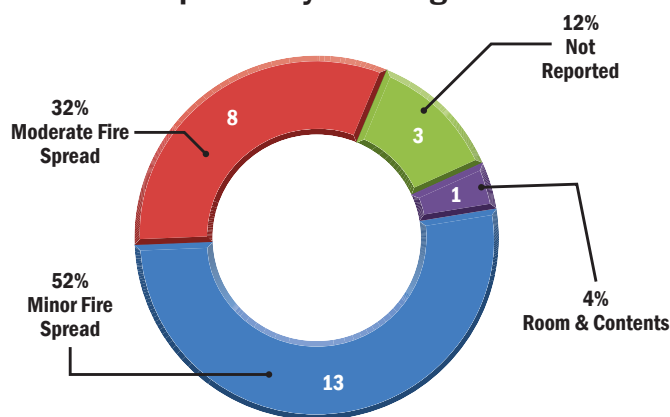
Media reports generally characterize these incidents as explosions. The event occurs suddenly and is accompanied by a loud noise, a flash of light, smoke, flames, and often vigorous ejection of the battery and other parts. Many of the media reports state that the battery or other components of the device were ejected under pressure and “flew across the room,” often igniting combustible items where they landed. An incident that reportedly occurred in a U.K. pub was captured on a security camera and subsequently posted on YouTube.⁴

Did the fires spread?

Most of the incidents resulted in ignition of nearby contents, such as carpets, drapes, bedding, couches or vehicle seats. Fortunately, users were generally nearby when the incident occurred (most were alerted by the sound of the explosion), and they were able to take action to extinguish the fires while they were still small. One incident resulted in the loss of a bedroom.

In the chart below and in the listing in Appendix 1, the term “minor fire spread” describes incidents where scorching or flames either self-extinguished or were extinguished by occupants very quickly; typically, the burned areas appeared to be less than 6 inches in diameter. The term “moderate fire spread” is used to describe those incidents where the flames grew larger but were extinguished by occupants before fire department arrival.

Fire Spread Beyond E-Cigarette



Charging

Eighty percent of the incidents reported occurred while charging. A variety of charging sources were reported — laptop USB ports, auto USB adapters, desktop computer USB ports, and wall adapter USB ports.

⁴ See <https://www.youtube.com/watch?v=mXgFk7RMjL4>.

None of the incidents reported in the media involved the larger PVs. All of the incidents reviewed involved “vape pens” or “twists,” which more closely resemble traditional cigarettes in appearance. These twists are intended to be recharged using a USB port built into the e-cigarette and a power adapter supplied with the device. Most of the PVs and Mods use larger batteries that are removed from the vaporizer and placed in an external charging unit. This helps to ensure that a proper power supply is used to charge the batteries.

USB Ports

Many e-cigarettes have a USB port for connecting the device to the power adapter that is provided by the manufacturer of the e-cigarette. The use of ordinary USB port charging connections allows users to connect the e-cigarette to power adapters that are not provided by the manufacturer of the device. The use of such non-approved power adapters appears to be responsible for most of the incidents involving e-cigarettes.

Few, if any, consumers understand that not all USB ports are “created equal.” The voltage and current provided by USB ports can vary significantly. Appendix 2 shows the current specifications for the various **standard** USB port definitions. (There are also nonstandard ports in use that do not match these specifications.) Without consulting the technical specifications for the USB power source, it is difficult or impossible for a consumer to determine the power supplied by any particular USB port and even more difficult to determine whether it is safe to use with a particular e-cigarette.

As a result, plugging an e-cigarette into a USB port or power adapter not supplied by the manufacturer may subject the battery to higher current than is safe, leading to thermal runaway that results in an explosion and/or fire.

ALWAYS USE THE CHARGING APPLIANCE THAT COMES WITH THE UNIT AND FOLLOW THE MANUFACTURER'S INSTRUCTIONS.

PLUGGING AN E-CIGARETTE INTO A “STANDARD” USB PORT TO RECHARGE MAY RESULT IN AN EXPLOSION AND/OR FIRE.

Overheating

Although we saw no evidence that this can be a problem, concern has been raised that the heating element inside the e-cigarette could become an ignition source. Manufactured PVs typically have built-in circuits to limit the time that the heating element can be turned on, which prevents overheating and possible fires or injuries. In the absence of independent safety testing of the e-cigarettes, no assurance that these circuits will reliably perform their safety function is available. Homemade Mods may not have overheat protection built in.

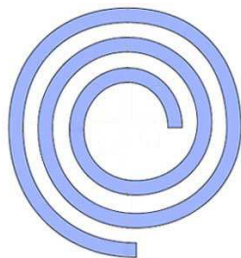
Lithium-Ion Battery Failure

Lithium-ion polymer batteries are excellent power supplies for portable devices and are widely used by consumers, industries and the emergency services. Lithium-ion batteries are known to experience statistically rare failure events, including fire and explosions. Indeed, there are multiple reports of fires caused by failures of lithium-ion batteries in cellphones, laptop computers, medical devices, electric cars, and myriad other portable electronic devices.

The descriptions and photographs in the media reports reviewed are entirely consistent with known failure modes of lithium-ion batteries.

Why do Lithium-ion batteries catch fire?

A cylindrical lithium-ion battery is made by winding alternating layers of metallic anode and cathode material separated by a porous film. The porous separator film holds a liquid electrolyte made of an organic solvent and dissolved lithium salts. This core is placed into a cylindrical metal can through the open end, and the can is then sealed closed tightly so that the liquid electrolyte cannot escape or evaporate.



All of the electrolytes currently used in lithium-ion batteries are either flammable or combustible liquids. It is this flammable electrolyte that causes the fire and explosion when the lithium-ion battery overheats.⁵ Scientists are working to develop nonflammable electrolytes

⁵ A variety of organic solvents are used, either alone or in combinations. The boiling points of the electrolytes range from 200 F to 500 F, and autoignition temperatures range from 60 F to 300 F.

for lithium-ion batteries, but these are not yet available in the market.

During the typical failure mode for a lithium-ion battery, the electrolyte is heated to its boiling point,⁶ the internal pressure in the battery builds to a point where the seal at the end of the battery ruptures, and the pressure is abruptly released through the sealed end of the battery case. Usually, the electrolyte then ignites, and expanding gas from the rapid combustion will further increase the pressure. The fire is sustained briefly after initial ignition by the porous separator film, which is made of plastic. Mikolajczak, et al. (2011) provide detailed descriptions and explanations of the various failure modes that lithium-ion batteries can experience.

Why is the impact of battery failure different in e-cigarettes?

E-cigarettes are different from other electronic consumer devices because the battery is installed in a cylindrical device that has its weakest (structural) point at the ends. When the battery seal (at the end of the battery) ruptures, the pressure within the e-cigarette cylinder builds quickly and instantly ruptures, usually at the end. As a result of the battery and container failure, one or the other, or both, can be propelled across the room like a bullet or small rocket.


In contrast to e-cigarettes, the cylindrical lithium-ion batteries used in laptop computers and portable tools are contained in rigid plastic cases that are generally strong enough to prevent the failing battery from “rocketing” away. Fires do occur as a result of battery failure, but most fires initially involve only the device that the battery pack is installed in.⁷

Cellphones, tablets and other devices use pouch-type batteries that are flat rather than cylindrical in shape, and they are encased in a sealed flexible plastic pouch or thin rigid plastic case instead of a metal can.



⁶ Overheating of the battery (thermal runaway) can be caused by puncture, overcharge, external heat, short circuit or internal cell fault.

⁷ A laboratory experiment showing worst-case lithium-ion battery failures in a laptop computer can be seen at <https://www.youtube.com/watch?v=pizFsY0yjs#t=250>.



These pouch-type batteries will not build up much pressure when they overheat and do not explode violently when they fail. But pouch batteries can, and have, overheated to the point where the pouch bursts, the electrolyte ignites, and a fire spreads beyond the device.⁸

What safeguards are used to prevent fires in Lithium-ion batteries?

Several different approaches to protecting lithium-ion batteries against explosion or fire have been developed. Protection can be built into the battery, the charging appliance, or the electronics that control the charging cycle. Often, a combination of these approaches is used in a product. Amon, et al. (2012) conclude that the risk of fire depends heavily on the type and effectiveness of the protection system used.

The protection appropriate for a particular device or appliance is determined by the manufacturer and/or by regulations or standards that apply to that product. Since there are no apparent standards directly applicable to e-cigarettes, the selection of protection for the lithium-ion battery is left to the manufacturers' best judgment. The fact that, statistically, so few of these devices are failing in the ways described by the media reports suggests strongly that e-cigarette manufacturers have been largely successful in preventing battery fires.

Conclusions

E-cigarettes are increasingly common; sales are growing rapidly.

The lithium-ion batteries used to power the devices can fail. Battery failures, manifested as small explosions and fires, have occurred. Considering the vast number of products in the field that use lithium-ion batteries, however, it is clear that the failure rates are low.

⁸ Failure of an intentionally overloaded pouch-type lithium-ion battery can be seen at https://www.youtube.com/watch?v=SMY2_qNO2Y0&index=8&list=PLkLKD6x5giq2LyjhKbjt-OYR8kiAN8_UW.

It is reasonable to expect that the number of battery failure incidents will increase as the number of lithium-ion batteries in use continues to grow, even as the failure rate per device remains constant or declines. Continuing improvements in battery safety designs by the industry could offset this expected increase.

Not all battery failures can be prevented by end-users. However, the media reports strongly suggest that many of the failures occurred while the battery was charging with power supplies that were not provided by the manufacturer. This fact highlights a need for user education.

E-cigarette manufacturers should consider changing to a different style of electrical connection. The elimination of USB-type electrical connections on e-cigarettes will make it more difficult (but not impossible) for users to overcharge the batteries. The inclusion of protection circuits into the e-cigarette device would improve battery safety.

Suppliers, industry associations, user groups, and fire prevention educators should all stress the importance of proper charging practices to reduce the number of incidents. Most e-cigarette manufacturers already mention the importance of proper charging practices in their literature. Stronger warnings in the literature and user manuals may be helpful.



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Appendix 1

E-Cigarette Incidents Reported in News Media*

Date	Location	Charging?	Charging Source	Fire Beyond E-Cig?	Injuries?	Notes	Source URL
Aug-09	Minneapolis, MN	NO	NA	Moderate	None	Fire in a cargo container on a FedEx jet discovered during approach to landing. Fire suppression system activated. Fire was linked to Li-ion batteries in box of Ruyan Inhalers, model RappE-Mystick.	
Nov-11	Greeley, CO	NO	NA	No	Severe	A man was hospitalized for eight days after an electronic cigarette exploded in his face, sending burning debris and battery acid into his mouth, face, and eyes. Prodigy V3.1 e-cig cited, as well as Radio Shack Energcell battery.	https://www.consumeraffairs.com/news04/2012/04/e-cigarette-exploded-in-mans-face-suit-charges.html
Feb-12	Niceville, FL	NO	NA	No	Severe	E-cigarette explodes in mouth causing severe burns, lost teeth and part of tongue. Lots of press coverage on this one. Some stories report that the device may have been modified by the user.	http://www.cbsnews.com/news/electronic-cigarette-explodes-in-mans-mouth-causes-serious-injuries/
Apr-13	Glendale, AZ	Y	USB-Car	Moderate	None	Exploded while charging from USB adaptor in car. Hot fragments ignited back seat upholstery.	http://www.kpho.com/story/22066822/unattended-electronic-cigarette-charger-explodes-car-catches-fire
Apr-13	Oklahoma City, OK	Not Reported	Not Reported	Moderate	Minor	Explosion of Li-ion battery in e-cig in office. Occupant treated for inhalation.	http://www.koco.com/news/oklahomanews/okc/Police-Explosion-at-apartment-complex-came-from-e-cigarette/19768650#!T8hDI
Jun-13	Sherman, TX	Y	USB-Macbook	No	Moderate	Battery into 2-hour charge exploded in user's hand. 2nd & 3rd degree burns on hand and smoke inhalation.	http://www.kxii.com/news/headlines/E-cigarette-explodes-in-Texoma-mans-home-215771641.html
Jul-13	Corona, CA	Y	USB-car	Minor	Moderate	Charging in car led to 'blowtorch' fire and explosion. Debris flew into occupant's lap, resulting in 2nd degree burns on upper thighs and lower buttocks. VapCig brand is cited.	http://losangeles.cbslocal.com/2013/07/11/corona-couple-sues-after-e-cigarette-battery-explodes-in-car/
Jul-13	Tulsa, OK	Y	USB-Laptop	Minor		Fire while charging off laptop.	http://www.newson6.com/story/22536957/tulsa-mans-e-cig-catches-fire-while-charging

* This listing is confined to incidents reported in the US. Internet search reveals many incidents in UK and other countries.

Date	Location	Charging?	Charging Source	Fire Beyond E-Cig?	Injuries?	Notes	Source URL
Aug-13	Phoenix, AZ	Y	USB-Macbook	Minor	None	This one ignited carpet, was put out by resident. Video shows plugging into white laptop for charge.	http://www.azfamily.com/news/consumer/Exploding-electronic-cigarette-blamed-for-fire-231499581.html
Aug-13	Phoenix, AZ	Y	Not Reported	Major	Minor	Resident states in article that e-cig started TWO fires in their bedroom in recent days. They just exploded... Charging for about 20 minutes. First incident scorched carpet, second gutted the bedroom. Resident treated for smoke inhalation. Smokin' T Smokin Time brand is cited.	http://www.kptv.com/story/23785774/phoenix-fd http://www.kpho.com/story/23273275/e-cigarette-nearly-sparks-fire-at-phoenix-apartment
Sep-13	Binghamton, AL	Y	Not Reported	Moderate	None	Fire in home caused by charging e-cig.	http://www.wbng.com/news/local/Fire-Marshall-Charging-electronic-cigarette-sparked-fire-222081441.html
Sep-13	Grant Park, GA	Y	USB-Desktop	Moderate	None	Unattended charging via USB port on computer. Spread to couch and rug.	http://www.wsbtv.com/news/news/local/woman-says-e-cigarette-exploded-shot-flames-4-feet/nZkCX/
Sep-13	Provo, UT	Y	USB-Car	Moderate	Moderate	Explosion while charging in car. Hot fragments ignited baby's car seat in back seat resulting in 1st and 2nd degree burns to 3 yr old.	http://newsone.com/2724915/e-cigarette-fire-utah-kinzie-barlow/
Oct-13	LaCrosse, WI	Y	Wall	Minor		Story highlights several incidents during charging. Lack of overcurrent/overheat circuitry implicated.	http://www.dailymail.co.uk/news/article-2442715/E-cigarette-explosion-causes-Wisconsin-home.html
Oct-13	Valparaiso, FL	Y	USB-Wall adaptor	Moderate	None	Explosion while charging from USB port, igniting curtains. Occurred after 10 minutes charging.	http://www.nwfdailynews.com/local/electronic-cigarette-explodes-catches-curtains-on-fire-1.214335
Oct-13	Blaine, MN	Y	USB-Desktop	Minor	None	Exploded while charging on USB plugged into computer.	http://www.myfoxtwincities.com/story/23584719/minnesota-e-cig-explosion-charging#ixzz2gh7xFIF
Nov-13	Kootenay County, ID	Y	USB-Laptop	Moderate	None	Explosion while charging from USB port of laptop. Ignited couch. Smoke alarm alerted the sleeping family of four.	http://www.wptv.com/news/local-news/water-cooler/e-cigarette-blamed-for-house-fire-in-idaho-electronic-cigarette-battery-overcharged-and-exploded http://www.nwcn.com/news/230720191.html

Date	Location	Charging?	Charging Source	Fire Beyond E-Cig?	Injuries?	Notes	Source URL
Nov-13	Warren, MI	Y	Wall	Minor	None	Device blew out of wall socket in ball of fire. Scorched hardwood flooring before occupant extinguished it. TV video report shows a USB wall charger that does not match those supplied by the manufacturer (Bulldog).	http://www.wxyz.com/news/warren-woman-says-electronic-cigarette-caused-small-explosion-and-fire
Nov-13	Eugene, OR	Y	Auto	Moderate	None	Device failed after about 2 hours charging. Fragments flew to back seat, igniting seat of truck.	http://www.kval.com/news/local/E-cig-explodes-damaging-truck-231482791.html?tab=video&c=y
Nov-13	Colorado Springs, CO	Y	Not Reported	Moderate	Moderate	Unattended while charging on floor. Ignited bed. Home occupant burned arms, hands & face while using blanket to smother flames.	http://www.krdo.com/news/ecigarette-blamed-for-mattress-fire/23206306
Dec-13	Springfield, MO	Y	USB-Laptop	Moderate	Moderate	Failure while charging on laptop USB port. Ignited bedding, 2nd degree burns on leg and foot. User quoted as saying he likely used the wrong charger.	http://www.ky3.com/news/local/man-experiences-explosive-consequence-from-using-electronic-cigarette/21048998_24083270
Mar-14	Medford, OR	Y	Not Reported	Minor	None	Exploded while being charged, sending bits of burning battery flying into the ceiling and walls. One hot piece of battery landed on a pillow, causing it to smolder and filling the house with smoke.	http://www.katu.com/news/local/Fire-marshall-E-cigarette-batteries-cause-fires-in-Medford-248274331.html
Mar-14	Medford, OR	Y	Not Reported	Minor	None	The lithium batteries that power the vaporizers in electronic cigarettes caused two recent fires in Medford. In this second case, a mattress caught fire but a resident put it out.	http://www.katu.com/news/local/Fire-marshall-E-cigarette-batteries-cause-fires-in-Medford-248274331.html
Mar-14	Lompac, CA	Y	Wall	Moderate	None	Started kitchen fire while charging unattended.	http://www.ksby.com/news/e-cigarette-blamed-for-kitchen-fire/
Mar-14	Syracuse, NY	Not Reported	Not Reported	Moderate	Moderate	Patient on oxygen in a hospital suffered 1st and 2nd degree burns. Patient had e-cig, but investigation has not yet tied e-cig to the ignition. Hospital has banned e-cigs out of caution.	http://www.foxnews.com/us/2014/04/22/ny-hospital-reinforces-ban-after-e-cigarette-fire/

Appendix 2

USB Variations

The following information and tables were extracted from Wikipedia.*

Universal Serial Bus (USB) is an electronics industry standard developed in the mid-1990s that defines the cables, connectors and communications protocols used in a bus for connection, communication, and power supply between computers and electronic devices.

USB was designed to standardize the connection of computer peripherals (including keyboards, pointing devices, digital cameras, printers, portable media players, disk drives and network adapters) to personal computers, both to communicate and to supply electric power. It has become commonplace on other devices, such as smartphones, PDAs and video game consoles. USB has effectively replaced a variety of earlier interfaces, such as serial and parallel ports, as well as separate power chargers for portable devices.

In general, there are four basic kinds or sizes related to the USB connectors and types of established connections:

- The older “standard” size, in its USB 1.1/2.0 and USB 3.0 variants (for example, on USB flash drives),
- The “mini” size (primarily for the B connector end, such as on many cameras),
- The “micro” size, in its USB 1.1/2.0 and USB 3.0 variants (for example, on most modern cellphones), and
- The versatile “USB On-The-Go” scheme, in both mini and micro sizes.

In general, each end of a USB cable uses a different kind of connector; an A-type or a B-type. This kind of design was chosen to prevent electrical overloads and damaged equipment, as only the A-type socket provides power.

USB connections also come in four data transfer speeds: Low Speed, Full Speed, High Speed and SuperSpeed. High Speed is only supported by specifically designed USB 2.0 High Speed interfaces (that is, USB 2.0 controllers without the High Speed designation do not support it), as well as by USB 3.0 interfaces. SuperSpeed is supported only by USB 3.0 interfaces.

* USB, (n.d.). In Wikipedia. Retrieved August 13, 2014, from http://en.wikipedia.org/wiki/Universal_Serial_Bus

The tables that follow illustrate the differences among several principal characteristics of USB ports and connecting cables. While the majority of device manufacturers adhere to the industry standards, it is important to note that this is a rapidly changing field and that there are a number of non-standard ports and connectors in the marketplace, which further illustrates the need to follow the manufacturers’ guidance when charging a device.

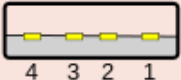
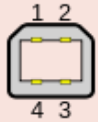
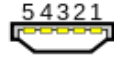
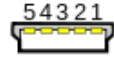
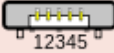
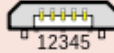

Power Output*

USB Power Standards			
Specification	Current	Voltage	Power
USB 1.0	150 mA	5 V	0.75 W
USB 2.0	500 mA	5 V	2.5 W
USB 3.0	900 mA	5 V	4.5 W
USB 3.1	2 A	5 V	10 W
	5 A	12 V	60 W
	5 A	20 V	100 W
USB Battery Charging	0.5–1.5 A	5 V	2.5–7.5 W
USB Power Delivery	2 A	5 V	10 W
	3 A	12 V	36 W
	3 A	20 V	60 W
	5 A	20 V	100 W

Color Coding*

Color	Description
Black or white	USB 1.x or USB 2.0
Blue	USB 3.0
Yellow or red (ports only)	High current and/or sleep-and-charge

USB Connector/Plug Configurations*

Standard USB Plug/Connector Designs	
 <p>Type A</p>	 <p>Type B</p>
 <p>Mini-A</p>	 <p>Mini-B</p>
 <p>Micro-A</p>	 <p>Micro-B</p>
 <p>Micro-B USB 3.0</p>	