Explosions & Fires in Electronic Cigarettes

Scope and Causes

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Do You Mind if I *VAPE*?

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 ***non-vapers*** as well as **vapers**, and those who oppose the habit talk about ***anti-vaping*** *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*, *sub-ohm coils*, *mechanical Mod*, *PG* (propylene glycol), *VG* (vegetable glycerin), and *blast*.

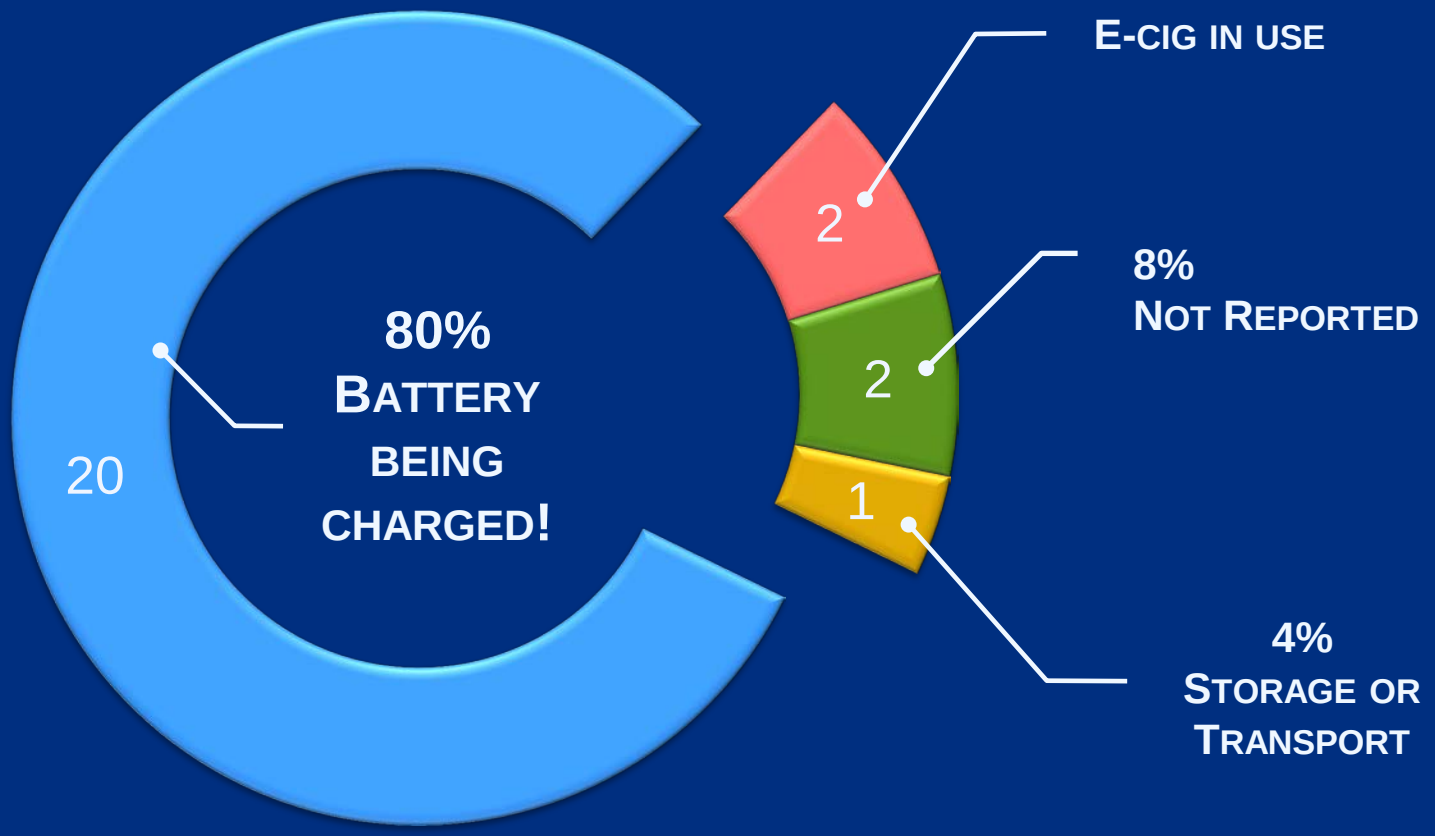
Media Reports

- Readily available
- Inaccurate, Incomplete
- Not all-inclusive
- Often contain data that the author/reported is not aware of

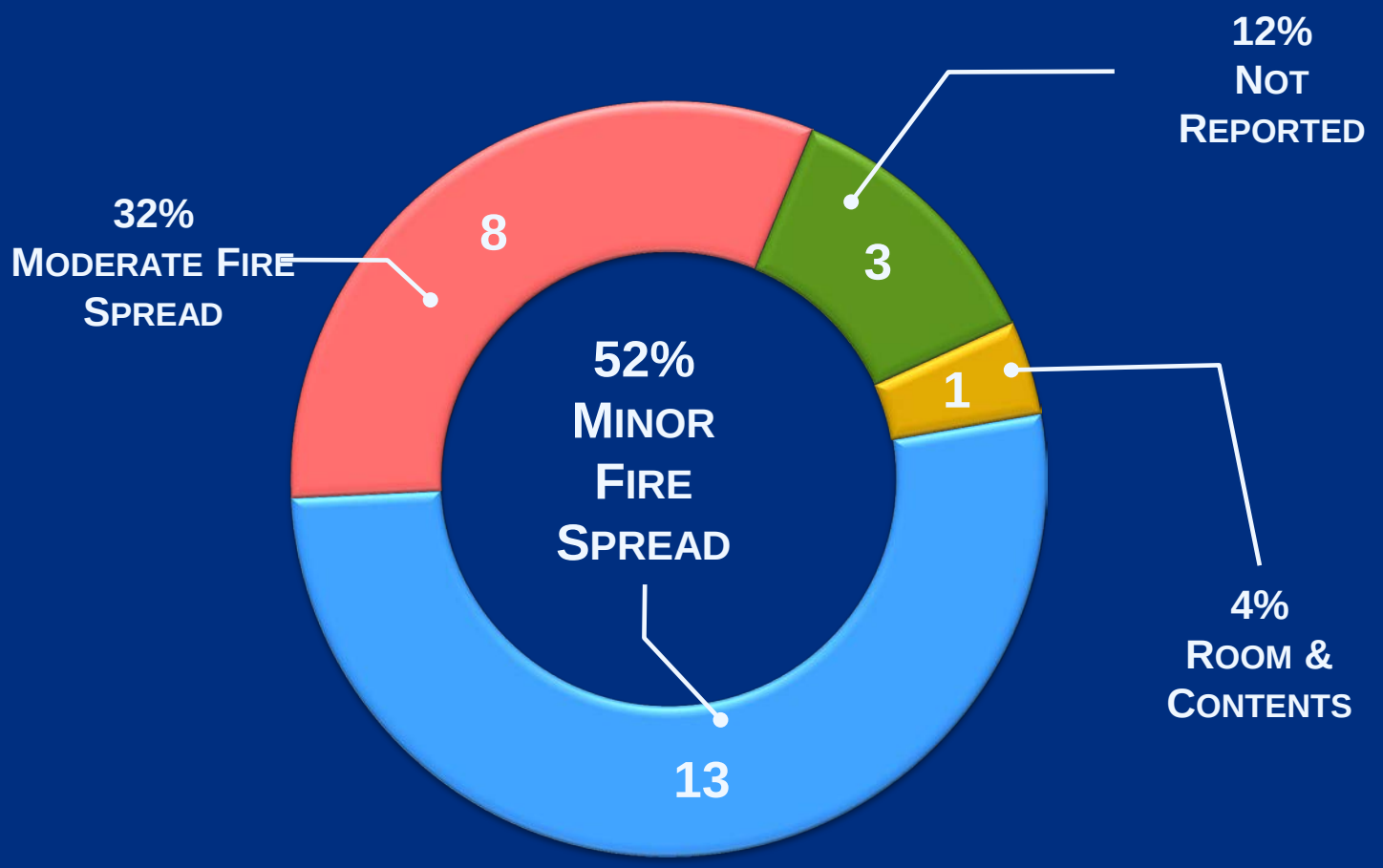
Findings

- Twenty-five separate incidents of explosion and/or fire involving an electronic cigarette were reported in U.S. media between 2009 and the August 2014.
- Nine injuries and no deaths were associated with these 25 incidents.
- Two serious burn injuries.

Status of E-Cig



Fire Spread


12%
Not
Reported
32%
Moderate Fire
Spread
8
3
52%
Minor
Fire
Spread
1
4%
Room &
Contents
13

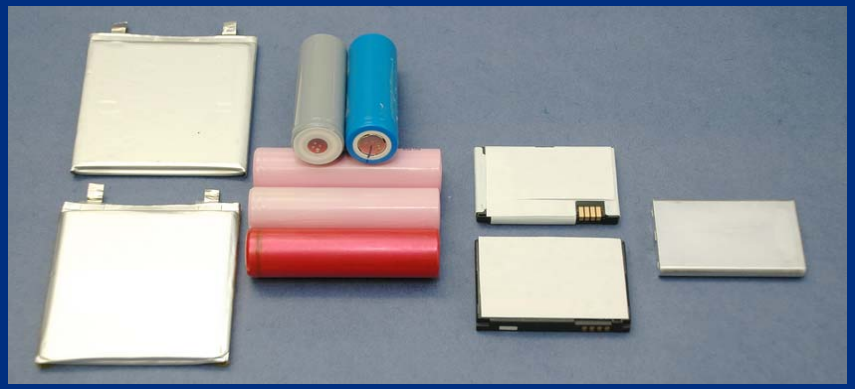
Conclusions

- Fires or explosions caused by e-cigarettes are rare events
- Factors contributing to the apparent higher incidence rates in e-cigarettes vs. other battery-powered consumer products include:
  - Known failure modes of lithium-ion polymer batteries
  - Geometry
  - Charging
    - Manufactured product
    - Misuse

Lithium Ion Polymer Batteries

- Widely used in consumer products – laptop computers, portable power tools, cell phones, tablets, players, medical devices, electric cars, etc.
- Hundreds of millions of batteries in use
- Several hundred reported fires, in use and in storage

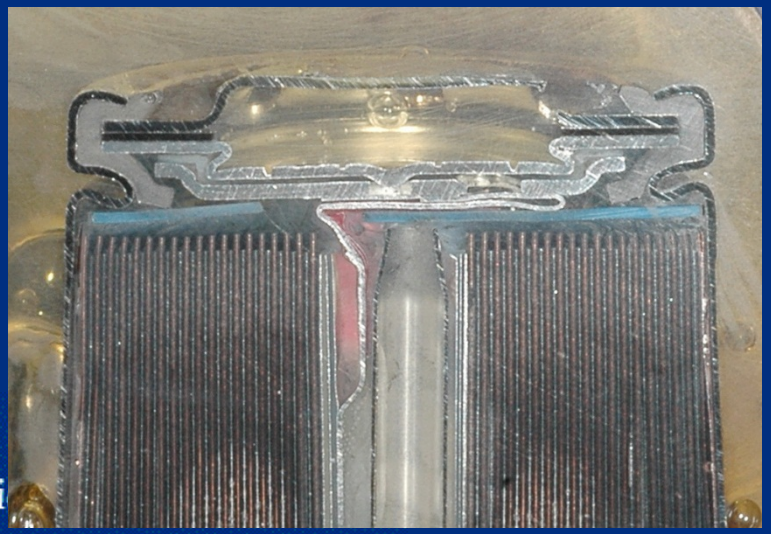
Battery packs



Cells inside battery packs

Why are Li-ion Batteries Different?

- Chemistry
  - Liquid electrolyte
  - Flammable or combustible
- Physics
  - Form factor dictates close tolerances
  - Conductive components
  - Polymer separator
  - Sealed can



Video

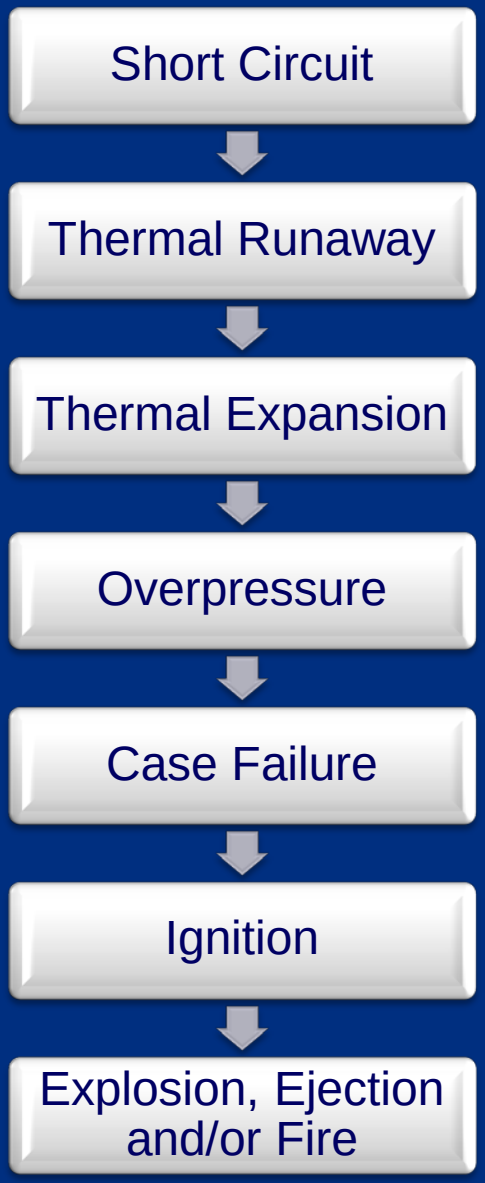
YouTube video of an 18650 Li-ion battery intentionally overcharged to induce failure and speed up the process. This video is one of many on YouTube that illustrate how Li-ion polymer batteries behave/react during thermal runaway.

Other types of Li-ion battery exhibit the same behavior. Pouch-type batteries won't generally rocket around the room due to the lack of rigid containment that can focus the expanding gas into a jet.

https://www.youtube.com/watch?v=mZ9vIy2dYDU

Li-Ion Failure Mode

- Reasonably well established phenomena initiated by:
- Overcharge
- Overheat
- Mechanical damage
  - Crush
  - Puncture
- Manufacturing defect
  - Microscopic contaminant



Geometry

- The form factor of the e-cig differs substantially from that of other common consumer products.
- Contributes to ‘rocketing’ effect during battery failure.

Charging

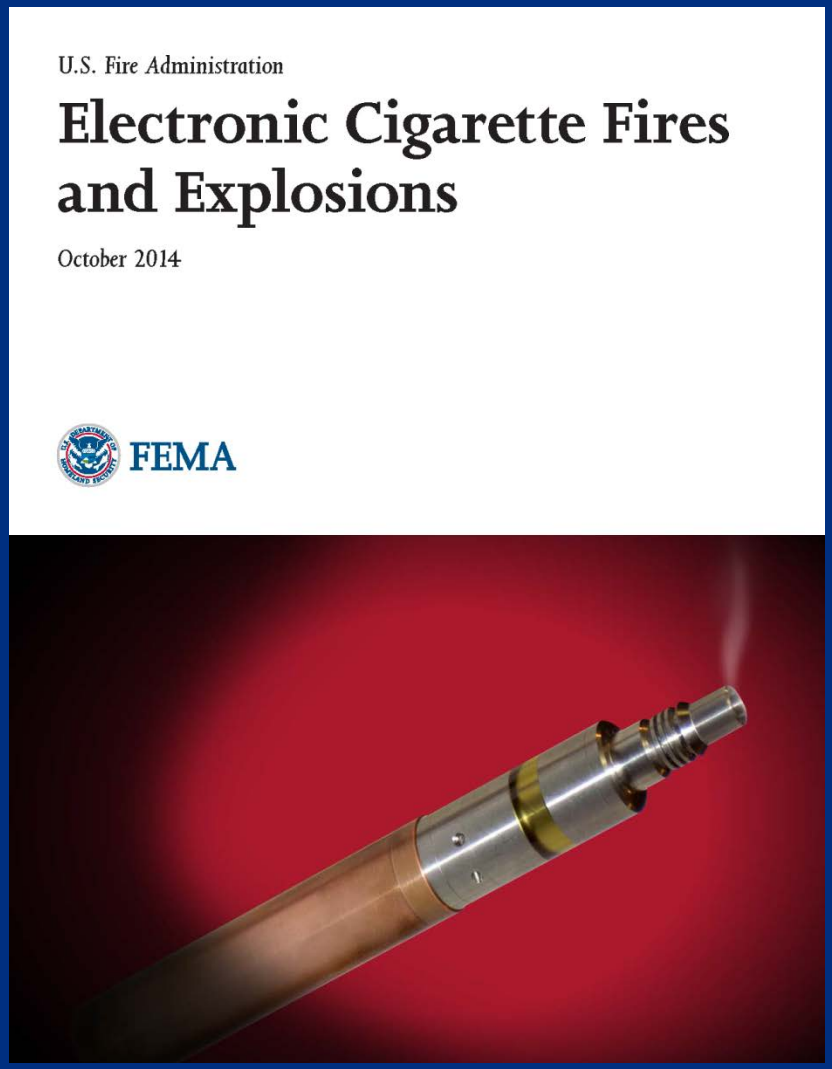
- Many e-cigs use USB style connections for charging
- Power from USB ports can vary from 1.5A to 5A. Most USB ports are not labeled.
- Low-end products typically have overcharge protection in the charger, not the battery (high-end products typically have both)
- Many of the incidents reviewed occurred during recharge using power sources not provided by the e-cig manufacturer

Summary

- Fires or explosions caused by e-cigarettes are rare.
- While Li-ion battery failure rates are low, the growing number of e-cigs in use is likely to result in more incidents. Improvements in battery/charger safety features may offset this likely increase.
- The shape and construction of e-cigarettes can make them more likely than other products with Li-ion batteries to behave like “flaming rockets” when a battery fails.
- Li-ion batteries must be charged in accordance with the manufacturer’s instructions.
- Using power sources not approved by the manufacturer to recharge a Li-ion battery can result in an explosion and fire.

Recommendations

- 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 e-cigarettes should improve 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.

More Information

http://www.usfa.fema.gov/downloads/pdf/publications/electronic_cigarettes.pdf