Network Advisory:
Fire Risk Management

Updated Q2 2025

Presentation by Chris Brown,
Chief Technical Officer, Uptime Institute

Readout produced by Michael O'Neil,
Contributing Analyst

uptime INSTITUTE

Smarter Together

The Uptime Network is a community of data center owners and operators under mutual NDA. No member organizations or individuals are named.

This readout is based on a Tutorial led by Uptime Institute Chief Technical Officer Chris Brown, and over 50 members of the Uptime Network on Feb 13, 2025.

These readouts are designed to capture the iterative, collaborative knowledge-shared between Network members and Uptime technical SMEs. These documents do not necessarily represent the opinions of Uptime's technical leadership or members but instead provide members resources to track our community's ongoing discussions. These readouts are intended for Uptime Network internal use.

Email suggestions for future topics to Matt Stansberry: mstansberry@uptimeinstitute.com.

uptime® INSTITUTE

Member Questions Submitted in Advance

- What approaches are members using to manage tape library fire risk?
- Is anyone researching/doing NFPA fire system checks, or are members simply working from vendor recommendations?
- Are members doing annual AHJ facility tours?
- Are members having problems getting VESDA parts?
- Are members being pressured by insurers to protect RFs with clean agent fire suppression above and below?
- Has anyone calculated the cost of reversion back to VRLA? Or investigated recycling options for different battery types?
- Hygiene issues: combustibles, abandoned cables (under floor, overhead), inadequate fire stopping materials…

Key Points From Uptime Institute

- Fires are uncommon in data centers. They are somewhat more common in support areas than in the data hall, where industry practices have reduced the likelihood and impact of fire.
- Data center fires can be caused by malfunctioning electronics, water leaks, or overheated batteries. Fires involving lithium-ion batteries are a particular concern.
- The trend towards much greater rack density in the data center, and extensive use of li-ion batteries, is expected to increase data center fire risk in the future.
- Uptime urges members to address fire risk by ensuring that combustibles (including batteries) are not present within the data hall, by compartmentalizing fire risks to protect facilities, and through regular maintenance of key electrical and fire suppression systems.

uptime® INSTITUTE

Fire Starters: Electrical Malfunction and Batteries

- All data centers contain complex electrical systems whose malfunction could cause a fire.
  - However, these systems are designed to high specifications and with multiple fail-safe checks, which reduces the likelihood of a malfunction and the probability that an event might ignite and feed a fire.
  - Different levels of risk – and impact – apply in data halls and gray space.
  - Water can cause dangerous conditions, but most water reservoirs used in data center systems (cooling towers, double interlock pre-action sprinklers) physically separate water from data halls, and risks can be managed with regular maintenance.

- Batteries, especially li-ion batteries, pose a different level of threat.
  - If batteries catch fire, they burn until all stored energy is exhausted or until they are brought below their auto-ignition temperature.
  - It is possible to cool lead acid and nickel cadmium (NiCad) batteries enough to stop them from continuing to burn. Li-ion batteries, however, burn so hot that they are very unlikely to be extinguished by cooling; current practice calls for misting to prevent fire spread, and for use of breathing equipment to avoid inhalation of toxic chemicals released by burning li-ion batteries.
  - To avoid fire events, some operators eschew li-ion altogether. Uptime advises those that do deploy li-ion to physically isolate the batteries.

Three Pillars of Fire Risk Management

- Reduce the Risk
- Prevent the Spread
- Limit the Impact

uptime® INSTITUTE

Uptime Institute's Three Pillars

1. Reduce risk:

- Ensure your organization deploys electrical systems that incorporate fail-safe circuit breakers which eliminate power flow in the event of a short circuit, so electricity is not fed to a flash point. *Proper electrical system design is a critical first step.*
- Eliminate combustible materials in the data hall, including wood, paper, *batteries,* and other materials that ignite easily.
- Perform careful maintenance on systems containing liquid, such as cooling and sprinkler systems, to avoid corrosion or malfunctions that could cause a fire by bringing water into contact with live circuits.

2. Prevent the spread:

- Use plenum-rated cabling (rather than PVC cabling) in the data hall, so that cables don't act as a conduit for spreading fires or toxic gasses across data center zones.
- Separating batteries (especially Li-Ion) into rooms or containers designed to contain fire.
- Construct separate battery rooms to contain fire and limit its spread to complementary systems,
- Equipping battery rooms with systems that are designed to reduce the likelihood or spread of battery fires.

3. Limit the impact:

- Use fire suppression systems that are appropriate to room requirements, and which will react immediately to an actual fire.

Note: Careful attention to reducing risk and preventing spread is critical to limiting impact. Investments made to reduce fire risk should tie to the potential cost associated with a fire-related outage.

uptime® INSTITUTE

Network Member Challenges

- One member mentioned (and Uptime site visits confirm) many organizations struggle to remove combustibles (e.g., cardboard and pallets) stored in IT and support spaces
- Some organizations have inadequate or missing fire stopping materials at penetrations throughout the facility, and abandoned cables underneath raised access floors or in overhead trays.
- Many noted use of li-ion batteries for UPS systems located in IT areas.

Chris Brown highlighted the cable issue, noting that cabling removal can be risky, expensive, time consuming, and potentially outside existing change budgets – but that it is important to protecting against fire risk. He also mentioned that addressing penetrations – e.g., installing fire-retardant putty around openings – may not be viewed be important, but is beneficial in preventing fire spread.

Additional Member Questions

- Q: Are nickel-cadmium and nickel-zinc batteries less risky than li-ion?
  - A: There isn't as much, but it appears so – true of sodium-ion, too, though those are very new..
- Q: Is a regular two-hour rated wall adequate for containment/isolation of a li-ion battery room?
  - A: Fire wall ratings are not all created the same. Actual containment depends on multiple factors – for example, fire suppression methods. If you heat the concrete too much, the fire will sprawl, but if (using water mist) you can keep the temperature down, a two-hour fire rated wall should be fine.
  - One related factor– if you are misting for hours, where is the water going? It could infiltrate complementary systems in other rooms if it spreads through the building. That issue needs to be understood and addressed.
- Q: Are you familiar with emerging li-ion fire suppression systems like Li-ion Tamer and Fike Blue?
  - A: No direct experience with these – they're new. It will take time before we understand efficacy.
  - Worth noting: An issue with li-ion thermal runaway has been manufacturing defects – the separation between cells breaks down, they short across, and the battery goes into thermal runaway…
- Q: Firefighting for li-ion in cars has involved use of (suppression) blankets. Has there been any movement towards using similar approaches in the data center?
  - A: Haven't seen it yet. In thermal runaway scenarios, by the time the fire department arrives at the scene, the fire is advanced… and not aware of an automated system that could deploy them.

Higher density deployments increase fire risk

- Racks housing powerful GPUs may require liquid cooling when they surpass 40-60 kw. Liquid cooling is not fully established in many data centers; operators will need to contend with a lack of standards and experience (on the part of both staff and suppliers), increasing the possibility of missteps that could result in unwanted outcomes, including fire.
- High density racks can incorporate in-rack UPS systems, which in turn may include li-ion batteries. These batteries are relatively small, so good fire suppression equipment can probably prevent in-rack or in-row fires from spreading throughout the zone or facility. However, it is likely that these fires will disable closely-proximate IT gear and negatively impact other systems that ingest smoke from a nearby fire.
- Increased power demand within a data hall means that UPS systems need expanded capacity. As a result, data center operators are deploying more battery capacity – and this means that battery rooms become a bigger fire risk. All batteries have the potential for thermal runaway, and popular li-ion batteries are a significant fire threat. Increased battery capacity will increase the potential for data center fires.

Li-Ion Thermal Runaway Example

In a recent incident (location redacted) a data center fire originated in a site's lithium-ion batteries.

The batteries were installed in two battery rooms adjacent to UPS rooms. The battery capacity was approximately 2800 kW per room, providing 30 minutes of runtime for a 5,600 kW UPS.

Batteries were installed in specialty cabinets from battery manufacturer, paired with a battery monitoring system. Battery rooms were air cooled and fire suppression was provided by a clean agent gaseous fire suppression system. The same fire suppression was used for rest of critical rooms in the site.

Despite these measures, the Li-Ion-fueled fire burned down the entire facility.

Uptime Commentary: "They did everything right, but the suppression agent did not reduce the temperature. Long term misting might have changed the outcome."

uptime® INSTITUTE

“Infrequent but potentially catastrophic”

- While there are recent and high-profile examples of data center fires (Global Switch in Paris in April 2023, Digital Reality in Singapore in September 2024), Uptime’s Annual Outage Analysis 2024 found that fire and fire suppression systems were cited as the cause by only 3% of firms that have experienced an outage over the past three years.
- Motivated in part by insurance underwriters, there has been a decades-long, industry-wide **focus on removing combustibles from the data halls**. This has reduced fire risk in the data hall, as the IT equipment doesn’t support combustion without an energy source, and electrical systems are designed to cut power in an emergency.
- **Fires in data center support areas are somewhat more common**. It isn’t possible to remove all combustibles from service areas: batteries are combustible, and necessary to UPS functions; diesel fuel is combustible, and necessary for generator operation. Electrical fail-safes and fire suppression systems manage most (but not all) of these fires.

Recommendations for data center management

uptime® INSTITUTE

Uptime Guidance

- Isolate Li-ion installations with adequate distance from main data center building.
- Consider additional measures such as fire rated walls in the main data center building as an additional line of defense.
- Compartmentalize complementary electrical systems to allow the data hall to operate if one system does experience a battery fire.
- When selecting a fire suppression system for lithium-ion batteries, consider the size and configuration of the battery installation, the specific fire risks involved, and any regulatory requirements or industry standards that apply.
- Consulting with fire protection experts and conducting thorough risk assessments can help ensure that the chosen suppression system is effective and appropriate for the application.
- Ensure that personnel handling such incidents are adequately trained in these systems. Additionally, comprehensive risk assessments should be conducted to identify potential hazards and implement appropriate safety measures.

uptime® INSTITUTE

Uptime Network Commentary and Questions

- **Member Comment:** Batteries and electrical systems are a common source of fire. A separate li-ion building is sometimes used; this has its own challenges, but at a minimum, batteries and electrical systems need to be in their own fire-rated rooms with appropriately-rated fire suppression systems. Also, complementary systems should be separated: A from B, or A from B from C.
- **Member Question:** We have a legacy data center that is 30 years old, with an average rack density of 5-8 kw. New servers from Dell and HPE seem to incorporate lithium-ion batteries by default. As I start to refresh, I could end up with hundreds of li-ion batteries in a data center that has VESDA and a pre-action system that was designed for servers that were common 30 years ago. What should we look to do? Upgrade the fire systems? Ensure that we don't have li-ion in servers because that isn't what our building is designed for?
  - **A:** It is an ever-present risk – a lot of batteries have made their way into racks. Hyperscale organizations pushed to deploy battery backups into racks with a rectifier feeding the DC bus – in effect, an in-rack UPS. Those units don't use high-density batteries and haven't caused a lot of problems…but that's because rack loads are low (10 kw). As rack density increases, you will have to increase the density of batteries and the power in each cell to provide meaningful ride through time. And that will increase risk.
  - Why have batteries in the data hall? The server is backed up by UPS that have batteries, it's better to rely on them.
- **Member commentary:** Fire in a single rack has impact across the data hall. Data halls are high-volume airflow rooms. Anytime something burns, hydrocarbons are released. Some of those hydrocarbons are acidic. They are typically not liquid at the time of the fire, but smoke is pulled into other servers through cooling fans. Some hydrocarbons settle on electronics; over time, they mix with humidity, turn into an acid, and reduce the lifespan of the equipment.

Prevention checklist

- ✓ *Minimize combustibles in the data center.* Most data center operators have policies prohibiting wood, paper, and other flammable substances from being stored within the IT environment.
- ✓ *Ensure effective containment of battery risk.* This includes placing batteries in structures that are designed to resist high heat.
- ✓ *Follow best practices for fluid system separation and maintenance.* These include regular maintenance and mechanical systems, such as double interlocked sprinkler systems, designed to prevent inadvertent fluid releases.
- ✓ *Use plenum rated cables in the data center.* Some jurisdictions have regulations that will permit use of PVC cables. These offer near-term cost savings but are flammable and release toxic gasses.
- ✓ *Utilize a fire alarm monitoring vendor* to monitor status of detection and suppression systems; notify site personnel of alarm conditions; and dispatch local fire department response upon initiation of building horns and strobes.

First Responder Guidance

- Life safety is always the primary mission during response.
- Knox boxes containing master keys and/or access badges to facilitate fire department access should be installed on all gates and entry doors, to allow ready access for authorized personnel but still maintain security of keys, access badges and entry points.
- Security Officer should post orders to allow immediate access to marked vehicles – both law enforcement and fire department.
- Fire department incident command will want an accounting of all personnel on site and anyone still in the building needing help. If there are victims inside, fire fighters will move with utmost urgency.
- Fire fighters need location of fire in the building, information on the incident, additional dangers (electrical gear, batteries, fuel), and ability to cut power.
- Sprinklers should not be turned off until fire fighters assess the situation and determine there is no additional danger.
- Fire department suggests sending two technicians to investigate alarms or fire incidents to support each other.
- Site teams should create laminated building maps and binders to provide to fire department incident command upon arrival. Maps can be used to markup dangers, site of fire, route to fire, and potential victims.
- Local police suggest identifying a first responder primary and secondary incident command location.
- For fire fighter safety, sites should have signs on UPS room doors identifying the presence of Li-ion batteries.
- Arrange annual facility tours for the local fire department so that first responders are aware of the layout and potential hazards if they need to respond in an emergency.

First Responder Guidance: Have a Plan

Uptime: How is the fire department going to get in? If there's a fire, everybody focuses on responding and nobody will be focused on the gate or the front door. Somebody has to have that as a job; somebody has to let the fire department in, tell them what's going on, direct them to where they need to be.

At that point, the fire department takes over. No one should be silencing alarms or turning off sprinklers until they're told to do so.

Member Advice: "Bring the local fire department into the facility on a regular basis – show them around, give them lunch or dinner or something. Treat them well…explain how the facility is designed, how things operate, where the risks are, what the risks are." You can engage in Q&A: "if there's a fire in this room, what are you going to want us to do? If you want us to shut off power, how long do we have to do that? Can we cut power just to a specific area? You need to know all of these things, because you have to have procedures and training to support orderly operations."

Member addition: We've had many training sessions with the fire department. It was very advantageous: they know where the UPS is, where the disconnects are – and know that there are lots of ways to put out a fire without bringing water into the data center.

Key Takeaways

- Separation is important: Separate electrical systems from IT gear in fire-rated compartments where reasonable, so that if or when a fire happens, it doesn't affect IT.
- Don't rely on a single battery room – deploy A and B side batteries in separate enclosures.
- Don't deploy rack or row mounted UPS systems (and their batteries) in the data hall. Rack or row-mounted UPS are efficient but pose an avoidable fire risk. Assess alternative approaches, such as increased UPS capacity outside the data hall.
- Constant vigilance is essential: Data halls are combustible-free by design, but combustibles are introduced over time – as palettes used to deliver equipment, as boxes housing replacement components, as cards used to track regular maintenance, as trashcans or other containers. Data center managers need to be vigilant to ensure that these potential hazards are cleared promptly.
- Effective maintenance reduces latent risk: Circuit protection devices should be tested regularly. These are both protection against electrical fire (if they perform correctly) or potential sources of fire (if they malfunction).
- Use dry nitrogen rather than air in pre-action systems. Some moisture leakage (or post-discharge moisture) in sprinkler pipes should be expected. Moist air can support microbe-induced corrosion (MIC) in sprinkler system pipes – which can eventually lead to a rupture, water damage, and fire hazard.

Special Consideration

Lithium-Ion Adoption, Fire Suppression Challenges, and Risk Analysis

uptime® INSTITUTE

Lithium-Ion Adoption

Within the last five years, data center owners have started installing Lithium-Ion (Li-Ion) instead of lead acid batteries for new builds, and to a lesser extent have replaced lead acid batteries with Li-Ion in existing operational sites.

Lithium-ion batteries offer several advantages over lead-acid batteries in data center applications. They boast higher energy density, longer lifespan, more charge-discharge cycles, faster recharging capabilities, and higher efficiency, resulting in reduced maintenance requirements and smaller physical footprints.

While Li-Ion installations come with higher initial costs, their long-term benefits in terms of performance, reliability, and longer lifespans make them a compelling choice for UPS applications in data centers where space, efficiency, and performance are critical considerations.

Use of Li-Ion batteries for large energy storage is relatively new and adoption preceded a full evaluation of the fire and safety risk.

Recent fire incidents in data centers caused by lithium-ion batteries suggest many organizations have implemented insufficient fire-suppression measures.

Problem Statement

Ineffective fire suppression of lithium-ion batteries can pose several risks due to their unique characteristics:

- **Thermal Runaway:** Li-ion batteries are prone to thermal runaway, a self-perpetuating reaction that can occur when the battery overheats. Introducing certain fire suppression agents can potentially exacerbate this reaction, leading to increased heat generation and the release of flammable gases.
- **Toxic Gas Emission:** When Li-ion batteries undergo thermal runaway, they can release toxic gases such as carbon monoxide and hydrogen fluoride. Fire suppression systems that involve water or certain chemical agents may cause these gases to disperse, posing health risks to individuals nearby.
- **Chemical Reaction:** Some fire suppression agents may react chemically with the components of lithium-ion batteries, leading to unpredictable outcomes. For instance, water can react with lithium, potentially producing flammable hydrogen gas or causing the battery to explode.
- **Battery Re-Ignition:** Inadequate suppression of the initial fire or incomplete extinguishing of the battery can lead to re-ignition. Li-ion batteries can reignite even after being seemingly extinguished, especially if internal components remain hot or reactive.
- **Corrosive Residues:** Residues left behind by some fire suppression agents may be corrosive and can damage surrounding equipment, infrastructure, or electronics, potentially exacerbating the damage caused by the battery fire itself.

Methods

Fire suppression systems for Li-ion batteries typically involve a combination of active and passive (preventive) measures designed to mitigate the unique risks associated with these batteries. Commonly used fire suppression systems include:

- **Specialized Fire Suppression Agents:** Certain fire suppression agents have been specifically formulated to suppress Li-ion battery fires. These agents can rapidly cool the battery and suppress the release of flammable gases. Examples include fluorinated gases like FM-200 and Novec, as well as dry chemical agents such as potassium bicarbonate-based powders.
- **Water Mist Systems:** Water mist systems use fine droplets of water to cool the battery and suppress the fire. Unlike traditional water-based systems, water mist systems generate smaller droplets that are less likely to cause thermal shock or react with the lithium in the battery. Water mist systems can be particularly effective for enclosed spaces or areas where other suppression agents may not be suitable.
- **Heat Detection and Suppression Systems:** These systems use sensors to detect temperature increases in the battery and trigger the release of suppression agents automatically. They can provide rapid response to lithium-ion battery fires, minimizing the spread of fire and reducing the risk of thermal runaway.
- **Enclosure and Containment Systems:** Enclosures and containment systems can help isolate Li-ion battery fires, preventing them from spreading to adjacent areas. These systems may include fire-resistant enclosures or barriers designed to contain the fire and direct heat and gases away from sensitive equipment or personnel.
- **Thermal Management Systems:** Proper thermal management of Li-ion batteries can help prevent overheating and reduce the risk of thermal runaway. This can include measures such as active cooling systems, thermal insulation, and temperature monitoring and control systems.
- **Emergency Response Protocols:** Effective emergency response protocols are essential for minimizing the impact of Li-ion battery fires. This includes clear procedures for evacuating personnel, isolating affected areas, and coordinating with emergency responders. Training personnel in the proper use of fire suppression equipment and response procedures is also critical.

Uptime Analysis

While most data center owners with Li-Ion installations have deployed a combination of two or more of the fire suppression methods mentioned on the previous slide…

None of those methods or any combination, has proven to be reliably effective to suppress the fire once lithium-ion batteries have entered thermal runaway mode.

When the fire starts and batteries enter thermal runaway, it will not stop until all combustible material is consumed. Li-ion battery installations for data centers measured in megawatts. Such a large volume of flammable material will burn for hours, causing severe damage to life and property.

This risk can be mitigated by isolating installations of Li-ion batteries away from main data center building.

uptime® INSTITUTE

Recommended Solutions

- Isolate Li-Ion installations with adequate distance from main data center building.
- Consider additional measures such as fire rated walls in the main data center building as an additional line of defense.
- When selecting a fire suppression system for lithium-ion batteries, consider the size and configuration of the battery installation, the specific fire risks involved, and any regulatory requirements or industry standards that apply.
- Consulting with fire protection experts and conducting thorough risk assessments can help ensure that the chosen suppression system is effective and appropriate for the application.
- Ensure that personnel handling such incidents are adequately trained in these systems. Additionally, comprehensive risk assessments should be conducted to identify potential hazards and implement appropriate safety measures.

uptime® INSTITUTE

About this document: This redout was prompted by an interaction with an Uptime Network member in the second half of 2024. Contributing Uptime experts included Chris Brown, Naveed Saeed, Daniel Bizo, and Jacqueline Davis.

Please contact Matt Stansberry at mstansberry@uptimeinstitute.com if you would like to schedule a discussion with an Uptime expert on fire risk or related topics or have other inquiry topics for future roundtables.

uptime® INSTITUTE