Battery Technology for Data Centers and Network Rooms: Fire Safety Codes – USA

By Stephen McCluer

White Paper #31

Revision 6

Executive Summary

Fire safety regulations and their application to UPS battery installations in the USA are reviewed. In some cases, fire codes do not clearly recognize improvements in battery safety resulting from changing battery technology. Valve Regulated Lead Acid (VRLA) batteries are frequently deployed within data centers and network rooms without the need for the elaborate safety systems that are required for Vented (Flooded) Lead Acid batteries. Proper interpretation of the fire codes is essential in the design and implementation of data centers and network rooms.

Introduction

Understanding fire safety codes as they relate to battery installations in data centers is important for the following reasons:

- Knowledgeable individuals allow themselves more flexibility when selecting a battery solution. For example, data center professionals who are unfamiliar with the codes may find themselves paying for and installing safety equipment that is not required by law.
- Knowledge of the code can limit liability should a disaster occur.
- Fundamental knowledge of the code can help buy peace of mind. Data center professionals encounter enough complexity in their jobs without having to harbor doubts as to whether their battery system installations violate local fire codes.

A *code* is law–a mandated ordinance, regulation or statutory requirement enforced by a government or its agencies. Codes are enacted in order to protect public health, safety, and welfare. Codes are enforced by the "Authority Having Jurisdiction" (AHJ). This can be an organization, an office, or a single individual responsible for enforcing the requirements of a code or standard, or for approving equipment, material, an installation, or a procedure.[1] In an environment like a data center, jurisdictions for the enforcement of a code sometimes overlap. For example: the building code may apply to seismic construction and floor loading; the fire code may apply to the use of flammable substances; the mechanical code may apply to ventilation and exhaust; and the electrical code may apply to equipment installation and safety.

This paper will look primarily at fire codes in the USA as they are usually the driver during battery system installations for the application of other codes (such as mechanical and electrical codes). Fire codes for stationary lead acid batteries were originally written to address large systems utilizing vented (also called "flooded" or "wet cell") lead-acid batteries that supported data centers and network rooms. These systems are often located in a separate room away from the servers on the data center floor. These batteries continuously vent hydrogen gas and contain electrolyte in liquid form. Special ventilation and spill containment systems are required when these battery systems are deployed.

Smaller and distributed back-up power systems are typically located much closer to or within the equipment they protect (e.g., they are often located in racks next to servers). They generally use Valve-Regulated Lead-Acid (VRLA) batteries. VRLA batteries are designed to recombine hydrogen and oxygen and emit only extremely small amounts of hydrogen under normal operating conditions. Normal room ventilation is usually sufficient to remove any emitted hydrogen, so special ventilation is typically not required (see APC White Paper #32, "Battery Technology for Data Centers and Network Rooms: Environmental Regulations").[2]

The electrolyte in a VRLA battery is not in liquid form but is immobilized. The most common technology in the USA, termed “Absorbed Glass Mat” (AGM), uses a highly porous, non-woven glass mats that immobilize the electrolyte and prevent it from spilling. Another type, more common in Europe and Asia, uses a gelled electrolyte with a consistency similar to that of tar. A crack or hole in the casing of a VRLA battery will not result in a measurable electrolyte spill. Spill containment systems for installations with VRLA batteries are therefore not needed or necessary.

Code of Federal Regulations

Vented (flooded) batteries must comply with the Occupational Safety and Health Administration (OSHA) Regulation 29 CFR 1926.441, Battery Rooms and Battery Charging. This regulation applies to batteries of the unsealed type installed in new construction. “Unsealed” in this case means vented (flooded) batteries. Under this regulation ventilation, worker protection, acid flushing, and neutralization are required. Users with vented (flooded) batteries, should consult the OSHA web site www.osha.gov >1926.441 “batteries of the unsealed type” [3]. VRLA batteries are considered to be of the “sealed” type so the above referenced OSHA regulation does not apply.

The Environmental Protection Agency (EPA) Emergency Planning and Community Right-to-know Act (EPCRA) requires owners to inform local authorities when their facilities have large volumes (actually reported in weight) of hazardous materials such as sulfuric acid (present in lead-acid battery electrolyte). These laws are spelled out in 42 U.S.C. 9601, also known as Title III of SARA, and 42 U.S.C. 1101. These requirements are explained in detail in White Paper #32, “Battery Technology for Data Centers and Network Rooms: Environmental Regulations”. [4]

Fire Codes

The two main fire codes in the United States relating to battery systems are the Uniform Fire Code (UFC)5, published by the National Fire Protection Association (NFPA - 1) and the International Fire Code (IFC)6 published by International Code Council (ICC). Both are revised and updated on a 3 year cycle.

The IFC and the UFC are referred to as “model” codes. A locality, town, county, or state, can choose which model code (and which version of the code) to adopt and enforce. For example, the entire State of Alaska adopted the IFC, while only certain towns in Arizona have adopted it. Some jurisdictions still use the 1994 or 1997 version of the UFC. Checking with the local safety inspector is the best method to determine which code applies to a specific installation. Local jurisdictions can also modify the codes. Under the codes, battery systems are subject to special installation requirements, depending upon amount of electrolyte and battery technology. The IFC applies to battery systems with more than 50 gallons of electrolyte. The UFC applies to battery systems with more than 50 gallons of electrolyte in a room without sprinklers, or 100 gallons of electrolyte in a room with sprinklers.

Mechanical Codes

Mechanical codes applicable to spaces where batteries are present focus on the circulation of air to prevent the accumulation of either a flammable (i.e., hydrogen) or toxic gas. (Toxic gases could be formed in a battery failure mode such as thermal runaway). Both the UFC and the IFC refer to the mechanical codes for ventilation. The dominant mechanical codes enforced in the USA are the International Mechanical Code (IMC),[7] which is used in 47 states, and the Uniform Mechanical Code (UMC).[8] The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) says that *ventilation* is "the process of supplying or removing air by natural or mechanical means to or from any space. Such air may or may not have been conditioned."[9] All of the above codes say that hydrogen must not be allowed to accumulate in concentrations greater than 1% of the volume of air in a space (the lower flammability level [LEL] for hydrogen is 4%). Neither the UFC nor IFC requires the use of hydrogen detectors.

Because vented batteries continuously release hydrogen, the mechanical codes require that exhaust and / or ducting systems transport the gas to the exterior of the building. Exhaust air from a battery room cannot pass into or through another room. Because VRLA batteries recombine hydrogen and oxygen internally and release little or no gas under normal conditions of use, special ventilation for VRLAs is almost never needed. The minimum ventilation standards for information technology equipment or for human occupancy are normally more than adequate for VLRA battery systems sharing the same spaces.

Application of the Codes to Battery Technologies

To understand how a code applies to a particular situation in a data center a series of important questions needs to be answered:

1. What is a battery system?
2. How many gallons of electrolyte are in this battery system?
3. Is the electrolyte free-flowing liquid or is it immobilized?
4. At what electrolyte volume does the code begin to apply?

What is a battery system?

Under the UFC definition,[10] a "battery system" consists of three interconnected subsystems:

- A lead-acid battery
- A battery charger
- A collection of rectifiers, inverters, converters and associated electrical equipment as required for a particular application.

From this definition both individual UPSs and DC plants are examples of battery systems.

How many gallons of electrolyte are in a battery system?

Gallons are a liquid measure and the fire codes seek to determine the amount of liquid electrolyte in the battery system. In a flooded battery system 100% of the electrolyte is in liquid form. The amount of liquid electrolyte in a VRLA battery solution is very small, about 3% of the electrolyte used in production of the battery. These values are provided by the battery manufacturer. The liquid electrolyte value in each battery container or string within the battery system would be added together to arrive at the total for a "system." Smaller, separately installed UPS are independent and do not have an additive effect on the electrolyte capacity. A fault in one system will not propagate to the others, as they are independent of each other. The threshold triggers are defined per battery system and not by facility. The code does not specifically instruct the summation of independent battery systems.

Is the electrolyte free-flowing liquid or is it immobilized?

The International Fire Code was modified in 2001 to create different rules for VRLA batteries. It recognized that VRLA batteries have different properties versus flooded batteries. IFC (Section 609) applied to VRLA battery systems having an electrolyte capacity of more than 50 gallons. In subsequent editions, all stationary batteries have been covered under a single Chapter (608). This chapter includes vented lead-acid, VRLA, nickel-cadmium (Ni-Cd), and Lithium Ion. The IFC specifically states for VRLA batteries, "The battery systems are permitted to be in the same room with the equipment they support." [6] The IFC also has requirements for thermal runaway, neutralization, and ventilation.

The Uniform Fire Code has also been modified over time to account for the differences between flooded and VRLA batteries. Certain requirements, such as spill containment, apply only to battery systems having *free-flowing* electrolyte in excess of 1000 gallons. The intent was to exempt batteries with *immobilized* electrolyte (e.g., VRLA batteries) from such rules. Neither the IFC nor the UFC require spill containment for VRLA batteries.

What is the electrolyte volume at which the code applies?

For a "flooded" battery system the IFC (Section 608) and UFC (Article 64 in the old code and Article 52 in the updated code) use 50 gallons of electrolyte capacity criteria for when compliance is required. Below 50 gallons the code is not applied. For a room with sprinklers the UFC threshold increases to 100 gallons. In data centers or network rooms using an alternative method of fire protection (for example, Halon or FM200), the 50-gallon level applies.

It is safe to assume that any UPS application using flooded batteries has to comply with the fire codes. Both codes specify requirements for occupancy separation, spill control, neutralization, and ventilation.

Year 2000 and earlier editions of the UFC, Article 64 requires VRLA battery systems exceeding the liquid electrolyte volume threshold values listed above to meet special protection requirements. Compliance required occupancy separation, spill control, neutralization, and ventilation. In 2003 the code was revised to apply spill containment requirement only to flooded battery systems (i.e., batteries with free-flowing electrolyte) with a minimum of 1,000 gallons. The purpose of the change was to hold batteries to no higher standard than applies for hazardous material covered elsewhere in the code. Requirements other than spill control still apply at the 50 and 100 gallon limits.

Both the UFC and the IFC require an approved method to prevent thermal runaway in VRLA battery systems.

Interpretation

The purpose of codes is to provide a clear direction of when and how the “rule” should be enforced. However, interpretation is often up to the local inspector. This can result in substantial variance when it comes to application of a code. A common misinterpretation of the older UFC has sometimes been to sum the quantity of electrolyte in different battery systems. Such an interpretation, if enforced, could lead to the absurd situation where every item in a facility containing a VRLA battery first needs to be identified and then a separate spill containment and occupancy separation needs to be provided for each.

The UFC now offers clear guidance in this area by providing a definition of a “battery system.” [Exception: This distinction should not be confused with Emergency Planning & Community Right to Know Act (EPCRA) reporting requirements. EPCRA requires a building owner to declare when the aggregate amount of sulfuric acid in batteries throughout the entire facility exceeds 500 pounds. Because electrolyte is approximately 2/3 water and 1/3 acid, some inspectors have recently taken a broader (and incorrect) interpretation that requires owners to report when the total amount of electrolyte exceeds 500 pounds.] For full details on reporting requirements, see White Paper #32: "Battery Technology in Data Centers and Network Rooms: Environmental Issues."

Conclusion

Flooded batteries require special containment and ventilation due to the risks posed by their liquid electrolyte and their continual hydrogen generation. VRLA batteries have miniscule amounts of liquid electrolyte and generate much lower amounts of hydrogen. The latest codes specifically recognize the technology differences between flooded and VRLA batteries and exempt VRLA batteries from spill containment and occupational separation.

However, older codes might still be in use in many jurisdictions. The older codes were not as clear in making the distinction, and an inspector might take a very narrow interpretation. Since VRLA batteries contain miniscule amounts of liquid electrolyte, most practical installations of VRLA batteries do not trigger the spill containment and occupancy separation requirements. Battery systems based on VRLA batteries can be deployed, and are routinely deployed, within data centers, network rooms and work environments in compliance with fire codes.

References

[1] NFPA 70, *2008 National Electrical Code*, Article 100 (National Fire Protections Association)
[2] APC White Paper #32, "Battery Technology for Data Centers and Network Rooms: Environmental Regulations
[3] APC White Paper #32, "Battery Technology for Data Centers and Network Rooms: Environmental Regulations
[4] APC White Paper #32, "Battery Technology for Data Centers and Network Rooms: Environmental Regulations
[5] NFPA 1, *Uniform Fire Code, 2006* (National Fire Protections Association)
[6] International Fire Code, 2008 (International Code Council), Chapter 608
[7] *International Mechanical Code* [IMC] 2008 (International Code Council)
[8] *Uniform Mechanical Code* [UMC] 2006 (International Association of Plumbing & Mechanical Officials)
[9] *ASHRAE Terminology of Heating, Ventilation, Air Conditioning, & Refrigeration,* 1991 (American Society of Heating, Refrigeration and Air-conditioning Engineers
[10] NFPA 1- 2006, Uniform Fire Code, Section 3.3.22,´"Definitions"

About the Author

Stephen McCluer is Senior Manager for External Codes and Standards at APC by Schneider Electric. He has over 25 years of experience in the power protection and power quality industries. He serves on NFPA Technical Committees 75 (Information Technology Equipment), 110 (Emergency & Standby Power) and 111 (Stored Electrical Energy). He chairs several task groups within the IEEE Stationary Battery Committee, and he serves on two BICSI standards technical committees for bonding/grounding and for data center design. He is a frequent speaker and has authored many articles, white papers, and technical papers on batteries and power quality / protection. He holds a Master's degree in International Management.