NFPA and IFC Stationary Battery Code Changes for 2018

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Abstract

National Fire Protection Association (NFPA) and International Fire Code (IFC) regulations concerning stationary batteries underwent major changes in 2016 with incorporation of several proposals for additional restrictions and limitations on battery systems. The changes were driven in part by fire officials and insurance companies concerns with the growing deployment of lithium ion batteries within city buildings along with an unfamiliarity with safety aspects associated with battery chemistries from a fire-fighting perspective. The IFC Fire Code Action Committee internally re-wrote Section 608 of the IFC and NFPA-1 Fire Code Technical Committee developed similar changes to Chapter 52 of NFPA-1 with limited user or manufacturer input. Some areas that may have a major impact for battery users include criteria for; maximum allowable quantities (MAQ), array size and location restrictions, and mandated risk analysis. In addition to these code actions, a new NFPA committee "Energy Storage Systems" NFPA-855 was organized to develop new comprehensive stationary battery regulations. There are additional battery criteria codified through the NEC in Articles 480 and 706. Finally, NFPA-111 will likely apply to smaller deployments of energy storage systems such as hospitals or smaller enterprise or IT organizations. The purpose of this report is to inform battery users and manufacturers of the battery aspects of fire codes that may impact their products and operations, and to encourage more participation in these code groups from the industry. Industry participation is essential to ensure basic criteria regarding safety are properly documented to help code officials accurately develop and implement appropriate codes and regulations.

Introduction

Most municipal and state building and fire regulations originate within one of the two established model code making bodies; International Code Council (ICC) and/or the National Fire Protection Association (NFPA). The international building code (IBC), fire code (IFC), and mechanical code (IMC) all are developed and facilitated through the ICC. Both the IFC and NFPA-1 have substantial criteria for stationary battery systems. The NFPA publishes additional fire related codes for a host of applications that include flammable liquid codes, sprinkler codes, and fire detection and alarming codes. The National Electrical Code (NFPA-70) is a national mandated electrical code that has 2 sections covering stationary storage batteries in Articles 480 and 706. Stationary battery systems, both bulk and distributed architecture, are widely deployed in telecommunications facilities, commercial power utilities, load shedding applications, solar applications, and data centers. For several decades, lead-acid batteries have generally been well understood and accepted by code officials and fire departments. Recent newer technologies and different electrolyte chemistries, and the possible interactions between different types of batteries has become a major area of concern for fire officials. Fighting a fire or entering a power room with mixed types presents challenges for first responders. The need to protect life and property and a full understanding on response methodologies for different types of batteries is a critical endeavor. However, the codes place numerous restrictions for batteries that may create challenges for end-users as well as battery manufacturers. These include:

- Maximum Allowable Quantities
- Permitting
- Location of Battery Rooms
- Battery Array Size and Placement Limitations
- Energy Management System
- Signage
- Spill Control and Neutralization
- Failure Mode and Effects Analysis
- Gas Detection
- Fire Suppression

Both NFPA-1 and the IFC provide a threshold for the quantity of batteries where the codes will apply for enforcement. In past editions of the fire code documents, battery systems were frequently described by volume of electrolyte, weight of electrolyte, or in the case of lithium, weight of the battery. To achieve consistency for comparing the relative size of existing and newer technologies, both the NFPA and IFC codes are now using kilowatt-hours (KWh) to describe and compare the size of a battery systems. The new 2018 NFPA-1 and IFC codes will apply to battery systems exceeding the values below.

Figure 1. Battery Capacity Threshold Covered by Codes	
Technology	**Capacity Threshold (kilowatt hours)**
Lead Acid (all types)	70 KWh (252 Mega joules)
Nickel Cadmium (Ni-Cd)	70 KWh (252 Mega joules)
Lithium (all types)	20 KWh (72 Mega joules)
Sodium (all types)	20 KWh (72 Mega joules)
Flow Batteries	20 KWh (72 Mega joules)
Other Battery Technologies	10 KWh (36 Mega joules)

Stationary storage battery systems having capacities exceeding the values shown in Figure 1 are required to comply with the IFC as applicable. The same values have been incorporated into NFPA-1 Chapter 52.

Kilowatt-hours for a single string (array) are simply the rated amp-hours (at an 8-hour rate) multiplied by the battery string voltage and divided by 1000. As an example of a system that is covered by the code, the photograph below shows strings of VLA batteries that are rated at approximately 4000 amp-hours. So even a single string would be subject to the codes. 48V x 4000 amp-hours / 1000 = 192 KWh. As shown in Figure 1, newer technology batteries have substantially lower threshold to be subject to the code so the vast majority of new technology battery installations, even small UPS systems, would be mandated to follow the code.

Figure 2. The -48V VLA battery strings are approximately 190 KWh each.

Specific IFC and NFPA-1 Code Changes and Impact

Maximum Allowable Quantities (MAQs)

Maximum allowable quantities for different types of batteries are defined in IFC chapter 12 and NFPA-1 chapter 52. For the 2018 editions, both codes plan to be harmonized with the values shown in Figure 3. If a user or site exceeds or is planned to exceed these maximum allowable quantities, the facility will need to be classified as a high hazard occupancy and be subjected to increased physical and operational criteria as described in the occupancy sections of the IFC/IBC or NFPA-1. The high hazard designation has consequences in allowed uses for the building, fire protection measures, and construction.

Figure 3. IFC and NFPA-1 MAXIMUM ALLOWABLE QUANTITIES (MAQ)

BATTERY TECHNOLOGY	MAXIMUM ALLOWABLE Quantities	GROUP H OCCUPANCY
Lead acid, all types	unlimited	Not Applicable
Nickel cadmium (Ni-Cd),	unlimited	Not Applicable
Lithium, all types	600 KWh	Group H-2
Sodium, all types	600 KWh	Group H-2
Flow batteries [b]	600 KWh	Group H-2
Other battery technologies	200 KWh	Group H-2 [c]
a. For batteries rated in Amp-Hours, Watt-hours (KWh) shall equal rated battery voltage times the Amp-hour rating divided by 1000		
b. Shall include vanadium, zinc-bromine, polysulfide-bromide, and other flowing electrolyte type technologies		
c. Shall be a Group H-4 occupancy if the fire code official determines that a fire or thermal runaway involving the battery technology does not represent a significant fire hazard		

Figure 4. Battery room with more than 1400 KWh capacity. For these lead-acid batteries, it is allowable (unlimited), but other technologies have 200 KWh or 600 KWh limits before the facility is regulated as high hazard occupancy.

Hazardous occupancies are categorized into one of five subgroups. The most severe occupancy is H-1. The occupancies gradually become less severe through H-5 as described in the list below.

- *Group H-1* includes occupancies containing materials with a detonation potential.
- *Group H-2* includes occupancies containing materials that have a deflagration potential or that create a hazard from accelerated burning.
- *Group H-3* includes occupancies containing materials that are easily combustible or pose a "physical hazard."
- *Group H-4* includes occupancies containing materials that pose a "health hazard." The IBC defines a *health hazard* to include toxic, highly toxic, and corrosive chemicals.
- *Group H-5* includes occupancies containing *hazardous production materials* (HPM) used in semiconductor fabrication and research and development laboratories.

A building designated a group H occupancy will have construction, layout, and operational criteria corresponding with the hazard group H-1 through H-5. These criteria are outlined in IBC Section 415.6 through 415.10 and are described in the IBC as well as the IFC. They require increased regulations and training as well as limitations for uses for the facility. Large mixed use buildings may be subjected to conflicts if designations are changed to high hazard occupancy. The category “other battery technologies” reflects fire code officials’ uneasiness over new technologies and therefore this category poses the most severe restriction on those battery types not directly listed in the table. This may have an adverse impact for users or manufacturers of new unlisted battery types. Even if the new unlisted battery types are more safe than those explicitly listed in the table, their deployment will be highly regulated. The language may allow (depending on permission of local AHJ) to exceed the MAQs, provided a detailed hazard mitigation and risk analysis is approved by the AHJ. The content of the hazard mitigation and risk analysis is not presently defined.

Battery Room Location Restrictions

A new addition to both NFPA-1 Chapter 52 and IFC Section 1206 imposes a restriction prohibiting a battery installation more than 75 feet above street level fire department vehicle access. Additionally, battery spaces cannot be placed more than 30 feet below the lowest finish floor access point. While this requirement is intended to facilitate fire department response and access to battery rooms, many larger cities have high-rise buildings with power rooms on floors that exceed 75 feet above the street. Typically, the battery room should be reasonably close to the equipment it supports due to voltage drop and cabling issues. Furthermore, the fire risks of traditional lead-acid batteries have been proven to be low. An exception is planned for lead-acid and nickel-cadmium batteries to this criterion, however it is the prerogative of local AHJ on whether to grant these exceptions. While some exemptions may be in place in the codes to allow certain installations, this restriction could have an impact especially if other types of batteries are placed with equipment in higher floor data centers.

Battery Array (String) Size and Separation Criteria

Storage batteries, prepackaged stationary storage battery systems and pre-engineered stationary storage battery systems are required to be segregated into stationary battery arrays (strings) not exceeding 50 KWh (180 Mega joules) each. Each stationary battery array shall be spaced a minimum three feet (914 mm) from other stationary battery arrays and from walls in the battery room or area.

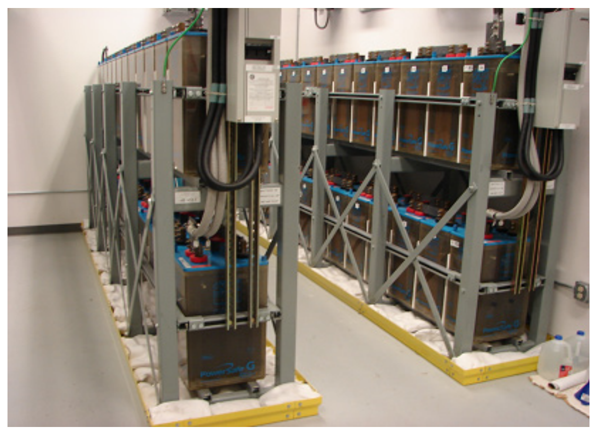

Figure 5. Planned exemptions for lead-acid batteries to be closer than 3 feet from walls or other obstructions would make the installations above permissible. Separation criteria for other technologies must be followed.

The maximum allowable array (string) size may drive system designs to utilize a larger number of smaller strings of stationary storage batteries, although there is a planned exception that may allow listed pre-packaged and pre-engineered battery systems up to 250 KWh. The definition of these systems with respect to array size needs clarification in the code. The required 3-foot separation between individual battery strings, walls and obstructions, or other battery strings raises some concerns in small facilities. It is common to position a battery string with one side along a wall, provided servicing can be performed from the front as shown with the VRLA modules and VLA string in Figure 5. Similarly, individual strings of VLA cells are frequently arranged in parallel line-ups, affording access to the longer sides and front of each string, but with a far side along a wall. Figure 3 violates the spacing criteria along the right side wall and the rear side of each string is too close to the back wall. Due to the large number of existing lead-acid and nickel-cadmium installations, there are planned exceptions for these and certain pre-packaged systems for both spacing and array size. However, there is no such exception for new technology battery systems and a risk remains that local code officials may not recognize the lead acid exceptions as it is prerogative of the municipality. The 2017 National Electrical Code Article 480.10 Battery Locations, clause C allows battery string racks to be installed along and contacting adjacent walls or structures provided there is free air space for 90% or more of its length.

Outdoor stationary battery systems were not addressed in prior editions of the codes, but are an increasing concern. In the next editions, outdoor stationary battery systems require separation of a minimum five feet (1524 mm) from lot lines, public ways, buildings, stored combustible materials, hazardous materials, high piled stock and other exposure hazards. There is an additional criterion that outdoor stationary storage battery systems must be separated from any means of egress as required by the fire code official to ensure safe egress under fire conditions, but in no case less than 10 feet (3048 mm). There is an exception permitting an AHJ to approve smaller separation distances but it would require large scale fire testing data by an approved laboratory to show that a fire will have no adverse impact on egress. A clause on security of outside batteries has been added to the codes as well.

Energy Management System

Both codes have added criterion for an approved energy management system to be provided for battery technologies other than lead acid and nickel cadmium. The energy management system monitors and balances cell voltages, current, and temperatures within the manufacturer's specifications. The system must transmit an alarm signal to an approved location if potentially hazardous temperatures or other conditions such as short circuits, overvoltage (overcharge) or under voltage (over discharge) are detected. This criterion serves to enhance safety and performance as well as providing alarming functionality. The definition of energy management system is somewhat broad so it is likely the newer technology systems that incorporate battery management systems (BMS) integrated with the battery may meet the intent of the code. The mechanism by which a battery BMS would have appropriate alarming parameters and indicators activated and routed to an acceptable alarm management system would be the prerogative of the AHJ.

Hazard Mitigation Analysis

In cases where battery systems exceed the MAQs or in facilities where different battery types or chemistries are collocated within one space, AHJs will likely require risk mitigation and failure mode analysis studies. At the discretion of the local AHJ, this analysis may be used to justify exceeding the MAQ without classifying the installation as a hazardous occupancy. These studies also are required in cases where a battery type other than those listed in Figure 1 and directly denoted in the code are installed. Material compatibility and reactivity issues are emphasized when battery types are mixed in a single space. There is merit to these regulations given that electrolytes with notably different water reactivity, and potential interactions with electrolytes or fire suppressing agents can make the strategies for fire suppression or spill control more complicated. The code changes provide details on what is required to perform a hazard mitigation or failure mode analysis as shown below.

- The hazard mitigation analysis shall evaluate the consequences of the following failure modes, and others deemed necessary by the fire code official. Only single failure modes shall be considered.
    - Thermal runaway condition in a single battery storage rack, module, or array.
    - Failure of any energy management system.
    - Failure of any required ventilation system.
    - Voltage surges on the primary electric supply.
    - Short circuits on the load side of the stationary battery storage system.
    - Failure of the smoke detection, fire suppression, or gas detection system.
    - Spill neutralization not being provided or failure of the secondary containment system.
- Construction equipment and systems that are required for the stationary storage battery system to comply with the hazardous mitigation analysis, including but not limited to those specifically described in Section 1206.2 shall be installed, maintained, and tested in accordance with nationally recognized standards and specified design parameters.

- The fire code official is authorized to approve the hazardous mitigation analysis provided the consequences of the hazard mitigation analysis demonstrate:
    - Fires or explosions will be contained within unoccupied battery storage rooms for the minimum duration of the fire resistance rated walls identified in IBC table 509.1.
    - Fires and explosions in battery cabinets in occupied work centers will be detected in time to allow occupants within the room to safely evacuate.
    - Toxic and highly toxic gases released during fires and other fault conditions shall not reach concentrations exceeding the IDLH (Immediate Danger to Life & Health) level in the building or adjacent means of egress routes during the time deemed necessary to evacuate from that area.
    - Flammable gases released from batteries during charging, discharging and normal operation shall not exceed 25% of their LFL (lower flammability limit).
    - Flammable gases released from batteries during fire, overcharging and other abnormal conditions shall not create an explosion hazard that will injure occupants or emergency responders.

End users should strongly consider these regulations and the safety impacts of mixing different battery chemistries within a power room. Required building systems such as ventilation and types of suppression also should be considered.

Permitting

NFPA-1 requirements for both installation and operational permits for battery systems will continue and are emphasized in the introductory section that covers lead-acid and nickel-cadmium, as well as emerging battery technologies. The previous 2015 edition of the IFC had installation permits only, but the 2018 edition will include operational permits as well. Some municipalities add their own operational permit requirements such as the NYC certificate of fitness for operating stationary battery systems.

Suppression

The 2015 editions of both the IFC and NFPA-1 did not explicitly require suppression for certain lead-acid batteries. The 2018 codes require suppression for all battery spaces however exceptions are present for batteries used exclusively for telecommunications spaces. While this exemption is consistent with NFPA-76, Standard for the Fire Protection of Telecommunications Facilities, 2015 which specifies conditions where telecommunications equipment including batteries do not require suppression, local AHJs may at their discretion require suppression.

Gas Detection Systems

The new codes have additional criteria for gas detection that include alarming for 25% of the lower flammability level of gas as well as 50% of the IDLH for toxic or highly toxic gases. The gas detection system must be designed with the following features; initiation of distinct audible and visible alarms in the battery storage room, transmission of an alarm to an approved location, de-energizing of the battery charger, and activation of the mechanical ventilation system, where the system is interlocked with the gas detection system.

Spill Control & Neutralization

Spill control and neutralization criteria are consistent with the 2015 editions of the code. For battery systems with free flowing electrolyte the method and materials shall be capable of neutralizing a spill of the total capacity from the largest cell or block to a pH between 5.0 and 9.0. For batteries with immobilized electrolyte, the method and material shall be capable of neutralizing a spill of 3.0 percent of the capacity of the largest cell or block in the room to a pH between 5.0 and 9.0.

Signage Criteria

Both NFPA-1 and IFC explicitly describe the wording for signage in battery spaces and buildings containing batteries. These are designed to alert first responders or other officials as to the unique criteria associated with the type of battery and chemistry within a facility. Previous versions of the code signage were limited to energized electrical circuits, energized battery systems, and corrosive liquids.

To summarize the pending codes changes, the 2018 editions of NFPA-1 and the IFC are planned to be generally harmonized with respect to stationary battery systems. They are likely to be structured differently with the IFC using exceptions for several categories for traditional lead-acid or nickel-cadmium batteries whereas NFPA-1 will retain the existing lead-acid and nickel-cadmium sections and adding a section for other battery technologies. Although they may be split an introductory section requires the same MAQ and Capacity definitions as the IFC and includes permit requirements for both sections. The IFC will likely move the stationary battery section from Section 608 in the 2015 code to a new chapter covering energy storage systems.

NFPA-855 Energy Storage

While the IFC and NFPA-1 fire codes contain stationary battery regulations that have been adopted in most jurisdictions in the United States, development of a new energy storage code, NFPA-855, commenced late in 2016 with the first working meeting held in January in 2017 in San Diego. This standard is intended to be a comprehensive guideline for safety for all energy storage systems. Some expected content includes:

- Fire protection
- Placement and Siting
- Thermal Management & Ventilation
- Interconnection
- General Battery Requirements

There is some uncertainty on the overlap between NFPA-855, existing fire codes, NEC, and NFPA-111. NFPA-855 may reference existing codes and standards or may eventually be referenced by other codes. An additional point of concern is whether NFPA-70, the National Electric Code may reference NFPA-855 within Articles 480 and 706. A reference in article 480 would make the criteria mandatory as part of the NEC whereas a reference in 706 may make it mandatory for certain voltage levels. There are notable differences in defining what is covered in the various codes from a battery perspective. At the time of this writing, the NFPA-855 technical committee is considered full and not accepting new members. However, a listing of current members is heavily weighted to fire code officials and insurance industry with very limited user or battery manufacturer participation. Since NFPA guidelines strive for a balance of interests for the code development process, any interested parties should consider applying. The goal of the NFPA-855 committee is to complete a first draft standard for public review by end of 2017.

NFPA-111 Standard on Stored Electrical Energy Emergency and Stand-by Power Systems

This code provides guidelines for safe deployment and operation of stationary battery systems in stand-by applications – that is, in times when the normal electrical power source fails. NFPA-111 is not currently used as basis for existing code enforcement but is referenced as industry best practices and may be included in various regulations to certify and/or review battery installations. The Emergency power systems that operate at less than 24 volts and/or less than 500 VA are not subjected to these requirements.

While NFPA-1 and the IFC have more detail on the fire safety aspects of batteries in the context of the building envelope, NFPA-111 is more of a guideline that details installation, maintenance, operations, and testing of energy storage systems. It covers power sources, converters, inverters, transfer equipment, controls, supervisory equipment, and accessory equipment needed to supply electrical energy to selected circuits. A sister document NFPA-110 focuses more on generators and associated back-up power,

The overlap and/or intended demarcation between NFPA-111 and the new NFPA-855 is not yet understood. While the application of NFPA-111 is usually restricted to the user side of the utility meter, NFPA-855 seems to seek to address both the utility side and user side applications. The NFPA-110/111 technical committee is currently completing its first draft and the second draft meeting. The NFPA-110/111 and NFPA-855 technical committees are comprised of completely different players so essentially these documents are being developed in parallel without significant collaboration. The consensus of NFPA-111 is that the committee must wait until the first draft of NFPA-855 is available for comment and then submit input to differentiate the two documents.

Code Development Process

The code development process is a public process, however, knowing when and where meetings are, when and where to make public comments, and how to participate in technical committees is not always obvious. Both IFC and NFPA do accept formal public input that can be entered online using their websites for both a first and second draft revision.

- **ICC:** http://www.iccsafe.org/ (to provide public input use link for code development process access from the ICC site: https://cdpaccess.com/login)
- **NFPA:** http://www.nfpa.org/codes-and-standards

These comments may or may not be entertained and experience has shown that submitted comments frequently require vocal “in-person” support to make their case. In addition to formal public comments; the public has final recourse after second draft publication in submitting a NITMAM (Notice of Intent to Make a Motion). NITMAMS delay release of the code or standard so are generally used sparingly for serious issues that one believes were not properly addressed by the technical committee. The NITMAM process provides a mechanism for one last opportunity to formally lobby for a change. One caveat is that NITMAMs can only be entered relative to comments that were previously submitted, so new items cannot be grounds to issue a NITMAM. There have been recent experiences where a public or special interest group was not satisfied with these avenues and filed a legal appeal to the standards board or council. These extreme methods can cause further ill feelings within the standards community. The best way to affect change is direct involvement first as interested public user, and once relationships are developed, to apply for membership on one of the technical committees. These applications may be denied initially, but persistence and volunteering to help on a task group may convince a code body of the merits of your future membership. The table in Figure 6 provides dates for current and planned editions of several relevant fire and building codes that have sections pertaining to stationary battery systems.

Figure 6. Codes Development Status

Code	Title	Current Edition	Next Edition
NFPA-1	Fire Code	2015	2018
IFC	Fire Code	2015	2018
NFPA-855	Energy Storage Code “New “	New	2018 (tentative)
NFPA-70	National Electric Code	2017	2020
NFPA-101	Life Safety Code	2015	2018
IBC	International Building Code	2015	2018
IMC	International Mechanical Code	2015	2018
NFPA-111	Standard on Stored Electrical Energy Emergency and Standby Power Systems	2016	2019

Summary

The introduction of newer battery technologies into existing facilities, or as a compliment to new energy storage applications (green energy, load shedding) is an area of concern for public safety officials, fire departments, and building inspectors. These concerns have led to increasing regulations and criteria as proposed and developed in the 2018 IFC and 2018 NFPA 1. Battery manufacturers should be aware of the increased interest in requests for test data, fault data, and fire simulation work to satisfy code officials and meet the new code additions. End users must have a thorough understanding of these codes to determine types of technologies that can be readily deployed in existing structures, and installation and design issues for newer installations and facilities. It is also encouraged that users, manufacturers, and researchers participate in the various code development bodies to help provide the best and most up to date information available to ensure codes are appropriate given the technologies that are employed.

References

The following references consist of existing editions of the fire, electrical, and building codes, as well as drafts of next editions. In cases where drafts are available for comment they can be accessed online at the appropriate ICC or NFPA websites.

1. NFPA-1 Fire Code, 2015
2. NFPA-1 Fire Code, 2018 Draft
3. IFC International Fire Code, 2015
4. IFC International Fire Code, 2018 Draft
5. NFPA-855, 2017 Pre-Draft Discussions
6. NFPA-111, 2014
7. NFPA-111, 2017 First Draft
8. NEC-70 National Electric Code, 2017
9. International Building Code, 2015
10. International Mechanical Code, 2015
11. NFPA-76, Standard for the Fire Protection of Telecommunications Facilities, 2015