NFPA®

855

Standard for the Installation of Stationary Energy Storage Systems

2020

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NFPA® 855

Standard for the

Installation of Stationary Energy Storage Systems

2020 Edition

This edition of NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, was prepared by the Technical Committee on Energy Storage Systems and acted on by NFPA at its Association Technical Meeting held June 17–20, 2019, in San Antonio, TX. It was issued by the Standards Council on August 5, 2019, with an effective date of August 25, 2019.

This document has been amended by one or more Tentative Interim Amendments (TIAs) and/or Errata. See "Codes & Standards" at www.nfpa.org for more information.

This edition of NFPA 855 was approved as an American National Standard on August 25, 2019.

Origin and Development of NFPA 855

The energy storage system project that led to this first edition of NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, was approved by the NFPA Standards Council in April of 2016, after which a call for members was posted. The original request was submitted by an individual on behalf of the California Energy Storage Alliance in order to address gaps in regulation identified in workshops held by the U.S. Department of Energy and the Fire Protection Research Foundation. In August of that same year, the Standards Council appointed the first NFPA Technical Committee on Energy Storage Systems. The initial draft was developed over the course of three meetings by the technical committee and was released to the public in 2017. Over the past 2 years, the technical committee has met several times to review feedback from the public and to make improvements to the standard.

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NOTE: Membership on a committee shall not in and of itself constitute an endorsement of the Association or any document developed by the committee on which the member serves.

Committee Scope: This committee shall have primary responsibility for documents on the fire prevention, fire protection, design, construction, installation, commissioning, operation, maintenance, and decommissioning of stationary, mobile, and temporary energy storage systems.

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NFPA 855

Standard for the

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NOTICE: An asterisk (*) following the number or letter designating a paragraph indicates that explanatory material on the paragraph can be found in Annex A.

A reference in brackets [ ] following a section or paragraph indicates material that has been extracted from another NFPA document. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced and extracted publications can be found in Chapter 2 and Annex G.

Chapter 1 Administration

1.1 Scope. (Reserved)

1.2 Purpose. This standard provides the minimum requirements for mitigating the hazards associated with ESS.

1.3* Application. This standard applies to ESS exceeding the values shown in Table 1.3.

Table 1.3 Threshold Quantities

ESS Technology	Aggregate Capacity[a] kWh	Aggregate Capacity[a] MJ
Battery ESS		
Lead-acid, all types	70	252
Nickel including Ni-Cad, Ni-MH, and Ni-Zn[b]	70	252
Lithium-ion, all types	20	72
Sodium nickel chloride	20	72
Flow batteries[c]	20	72
Other battery technologies	10	36
Batteries in one- and two-family dwellings and townhouse units	1	3.6
Capacitor ESS		
Electrochemical double layer capacitors[d]	3	10.8
Other ESS		
All other ESS	70	252

[a]For ESS units rated in amp-hrs, kWh equals maximum rated voltage multiplied by amp-hr rating divided by 1000.
[b]Nickel battery technologies include nickel cadmium (Ni-Cad), nickel metal hydride (Ni-MH), and nickel zinc (Ni-Zn).
[c]Includes vanadium, zinc-bromine, polysulfide-bromide, and other flowing electrolyte-type technologies.
[d]Capacitors used for power factor correction, filtering, and reactive power flow are exempt.

1.3.1 ESS shall comply with the requirements of this standard as applicable.

1.3.2 ESS installed in one- and two-family dwellings and townhouse units shall only comply with Chapter 15.

1.3.3 Mobile ESS deployed at an electric utility substation or generation facility for 90 days or less shall not add to the threshold values in Table 1.3 for the stationary ESS installation if both of the following conditions apply:

(1) The mobile ESS complies with Section 4.5.
(2) The mobile ESS is only being used during periods in which facility's stationary ESS is being tested, repaired, retrofitted, or replaced.

1.4 Retroactivity.

1.4.1 Unless otherwise specified, the provisions of this standard shall not apply to ESS installations that existed or were approved for construction or installation prior to the effective date of this standard.

1.4.2* In those cases where the authority having jurisdiction (AHJ) determines that an existing situation presents an unacceptable degree of risk, the AHJ shall be permitted to apply retroactively any portions of this standard deemed appropriate.

1.5* Equivalency. Nothing in this standard is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, reliability, and safety over those prescribed in this standard.

1.6 Units and Formulas. Metric units in this standard shall be in accordance with the International System of Units, which is officially abbreviated SI in all languages.

Chapter 2 Referenced Publications

2.1 General. The documents or portions thereof listed in this chapter are referenced within this standard and shall be considered part of the requirements of this document.

2.2 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2018 edition.

NFPA 2, *Hydrogen Technologies Code,* 2016 edition.

NFPA 12, *Standard on Carbon Dioxide Extinguishing Systems,* 2018 edition.

NFPA 13, *Standard for the Installation of Sprinkler Systems*, 2019 edition.

NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection*, 2017 edition.

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, 2019 edition.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 52, *Vehicular Natural Gas Fuel Systems Code*, 2019 edition.

NFPA 54, *National Fuel Gas Code*, 2018 edition.

NFPA 58, *Liquefied Petroleum Gas Code*, 2017 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, National Electrical Code®, 2017 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

NFPA 76, *Standard for the Fire Protection of Telecommunications Facilities*, 2016 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2015 edition.

NFPA 1142, *Standard on Water Supplies for Suburban and Rural Fire Fighting*, 2017 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

NFPA 2010, *Standard for Fixed Aerosol Fire-Extinguishing Systems*, 2015 edition.

2.3 Other Publications.

2.3.1 ANSI Publications. American National Standards Institute, Inc., 25 West 43rd Street, 4th Floor, New York, NY 10036.

ANSI Z535.1, *American National Standard for Safety Colors*, 2011.

ANSI Z535.2, *American National Standard for Environmental and Facility Safety Signs*, 2011.

ANSI Z535.3, *American National Standard for Criteria for Safety Symbols*, 2011.

ANSI Z535.4, *American National Standard for Product Safety Signs and Labels*, 2011.

ANSI Z535.5, *American National Standard for Safety Tags and Barricade Tapes*, 2011.

ANSI Z535.6, *American National Standard for Product Safety Information in Product Manuals, Instructions and Other Collateral Materials*, 2011.

2.3.2 ASTM Publications. ASTM International, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA 19428-2959.

ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings*, 2017.

ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, 2016.

2.3.3 IAPMO Publications. International Association of Plumbing and Mechanical Officials, 4755 E. Philadelphia Street, Ontario, CA 91761.

Uniform Plumbing Code, 2015.

2.3.4 ICC Publications. International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001.

International Plumbing Code, 2015.

2.3.5 IEEE Publications. IEEE, 3 Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE C2, *National Electrical Safety Code*, 2017.

2.3.6 NERC Publications. North American Electric Reliability Corporation, 1325 G Street, NW, Suite 600, Washington, DC 20005.

PRC-005, *Protection System, Automatic Reclosing, and Sudden Pressure Relaying Maintenance*, 2016.

2.3.7 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 263, *Standard for Fire Tests of Building Construction and Materials*, 2018.

UL 790, *Standard Test Methods for Fire Tests of Roof Coverings*, 2014.

UL 1564, *Standard for Industrial Battery Chargers*, 2013.

UL 1741, *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*, 2016.

UL 1778, *Uninterruptible Power Systems*, 2014, revised 2017.

UL 1973, *Standard for Batteries for Use in Light Electric Rail (LER) Applications and Stationary Applications*, 2016.

UL 1974, *Evaluation for Repurposing Batteries*, 2018.

UL 9540, *Safety of Energy Storage Systems and Equipment*, 2016.

UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2018.

2.3.8 Other Publications.

Merriam-Webster's Collegiate Dictionary, 11th edition, Merriam-Webster, Inc., Springfield, MA, 2003.

2.4 References for Extracts in Mandatory Sections.

NFPA 30, *Flammable and Combustible Liquids Code*, 2018 edition.

NFPA 70®, National Electrical Code®, 2017 edition.

NFPA 72®, National Fire Alarm and Signaling Code®, 2019 edition.

NFPA *101®, Life Safety Code®*, 2018 edition.

Chapter 3 Definitions

3.1 General. The definitions contained in this chapter shall apply to the terms used in this standard. Where terms are not defined in this chapter or within another chapter, they shall be defined using their ordinarily accepted meanings within the context in which they are used. *Merriam-Webster's Collegiate Dictionary*, 11th edition, shall be the source for the ordinarily accepted meaning.

3.2 NFPA Official Definitions.

3.2.1* Approved. Acceptable to the authority having jurisdiction.

3.2.2* Authority Having Jurisdiction (AHJ). An organization, office, or individual responsible for enforcing the requirements of a code or standard, or for approving equipment, materials, an installation, or a procedure.

3.2.3 Labeled. Equipment or materials to which has been attached a label, symbol, or other identifying mark of an organization that is acceptable to the authority having jurisdiction and concerned with product evaluation, that maintains periodic inspection of production of labeled equipment or materials, and by whose labeling the manufacturer indicates compliance with appropriate standards or performance in a specified manner.

3.2.4* Listed. Equipment, materials, or services included in a list published by an organization that is acceptable to the authority having jurisdiction and concerned with evaluation of products or services, that maintains periodic inspection of production of listed equipment or materials or periodic evaluation of services, and whose listing states that either the equipment, material, or service meets appropriate designated standards or has been tested and found suitable for a specified purpose.

3.2.5 Shall. Indicates a mandatory requirement.

3.2.6 Standard. An NFPA Standard, the main text of which contains only mandatory provisions using the word "shall" to indicate requirements and that is in a form generally suitable for mandatory reference by another standard or code or for adoption into law. Nonmandatory provisions are not to be considered a part of the requirements of a standard and shall be located in an appendix, annex, footnote, informational note, or other means as permitted in the NFPA Manuals of Style. When used in a generic sense, such as in the phrase "standards development process" or "standards development activities," the term "standards" includes all NFPA Standards, including Codes, Standards, Recommended Practices, and Guides.

3.3 General Definitions.

3.3.1* Apartment Building. A building or portion thereof containing three or more dwelling units with independent cooking and bathroom facilities. (SAF-RES) [***101*****,** 2018]

3.3.2 Battery. A single cell or a group of cells connected together electrically in series, in parallel, or a combination of both.

3.3.2.1* ***Flow Battery.*** A type of storage battery that includes chemical components dissolved in liquids where the liquid flows through a reaction zone and stored chemical energy is converted to electrical energy.

3.3.3 Battery Management System (BMS). A system that monitors, controls, and optimizes performance of an individual or multiple battery modules in an energy storage system and has the ability to control the disconnection of the module(s) from the system in the event of abnormal conditions. This system can be completely independent of the ESMS.

3.3.4 Cell. The basic electrochemical unit, characterized by an anode and a cathode, used to receive, store, and deliver electrical energy. [**70:**706.2]

3.3.5 Dwelling Unit. One or more rooms arranged for complete, independent housekeeping purposes with space for eating, living, and sleeping; facilities for cooking; and provisions for sanitation. (SAF-RES) [***101*****,** 2018]

3.3.5.1* ***One- and Two-Family Dwelling Unit.*** A building that contains not more than two dwelling units with independent cooking and bathroom facilities. (SAF-RES) [***101*****,** 2018]

3.3.5.2 ***One-Family Dwelling Unit.*** A building that consists solely of one dwelling unit with independent cooking and bathroom facilities. (SAF-RES) [***101*****,** 2018]

3.3.5.3 ***Two-Family Dwelling Unit.*** A building that consists solely of two dwelling units with independent cooking and bathroom facilities. (SAF-RES) [***101*****,** 2018]

3.3.6 Electric Utilities. All enterprises engaged in the production and/or distribution of electricity for public use including those that are typically designated or recognized by governmental law or regulation by public service/utility commissions and that install, operate, and maintain electric supply such as generation, transmission, or distribution systems.

3.3.7* Electrochemical Double Layer Capacitor (EDLC). A capacitor that has liquid electrolyte (e.g., acetonitrile) and electrodes with a highly porous surface that increases the surface area for holding charge resulting in much larger capacitance and energy density.

3.3.8* Energy Storage Management System (ESMS). A system that monitors, controls, and optimizes the performance of an energy storage system and has the ability to control the disconnection of the energy storage system in the event of abnormal conditions.

3.3.9* Energy Storage Systems (ESS). One or more devices, assembled together, capable of storing energy in order to supply electrical energy at a future time to the local power loads, to the utility grid, or for grid support.

3.3.9.1 ***Capacitor Energy Storage System.*** An electrical energy storage system using capacitors as a storage media.

3.3.9.1.1* ***Electrochemical Energy Storage System.*** An energy storage system that converts and stores chemical energy to electrical energy and vice versa.

3.3.9.1.2* ***Mechanical Energy Storage System.*** An energy storage system that converts and stores mechanical energy to electrical energy and vice versa.

3.3.9.2 ***Energy Storage System Cabinet.*** A cabinet containing components of the energy storage system that is included in the UL 9540 listing for the system where personnel cannot enter the enclosure other than reaching in to access components for maintenance purposes.

3.3.9.3 ***Energy Storage System Dedicated-Use Building.*** A building constructed on-site that is only used for energy storage, energy generation, or electrical grid-related operations.

3.3.9.4 ***Energy Storage System Walk-In Unit.*** A prefabricated structure containing energy storage systems that includes doors that provide walk-in access for personnel to maintain, test, and service the equipment and is typically used in outdoor and mobile energy storage system applications.

3.3.9.5 ***Mobile Energy Storage System.*** An energy storage system capable of being moved and utilized as a temporary source of power.

3.3.9.6 ***Portable Energy Storage System.*** An energy storage system suitable to be lifted and moved by a single person without mechanical aids and not permanently connected to an electrical system.

3.3.9.7 ***Stationary Energy Storage System.*** An energy storage system that is permanently installed as fixed equipment.

3.3.10 Fire Area. An area of a building separated from the remainder of the building by construction having a fire resistance of at least 1 hour and having all communicating openings properly protected by an assembly having a fire resistance rating of at least 1 hour. [**30,** 2018]

3.3.11 Fire Command Center. The principal attended or unattended room or area where the status of the detection, alarm communications, control systems, and other emergency systems is displayed and from which the system(s) can be manually controlled. (SIG-ECS) [**72,** 2019]

3.3.12 Hazard Mitigation Analysis. An evaluation of potential energy storage system failure modes and the safety-related consequences attributed to the failures.

3.3.13 Large-Scale Fire Testing. Testing of a representative energy storage system that induces a significant fire into the device under test and evaluates whether the fire will spread to adjacent energy storage system units, surrounding equipment, or through an adjacent fire-resistance-rated barrier.

3.3.14 Living Area. Any normally occupiable space in a residential occupancy, other than sleeping rooms or rooms that are intended for combination sleeping/living, bathrooms, toilet compartments, kitchens, closets, halls, storage or utility spaces, and similar areas. (SAF-RES) [***101,*** 2018]

3.3.15 Maximum Stored Energy. The quantity of energy storage permitted in a fire area prior to the area being considered a high hazard occupancy.

3.3.16 Off-Gassing. The event in which the cell case vents due to a rise in internal pressure of the cell.

3.3.17 Off-Specification Battery or Cell. A cell or battery that has been tested during the manufacturing quality control process and found not to be within the manufacturer's designed set of criteria for its intended use.

3.3.18 Open Parking Garage. A structure or portion of a structure with the openings on two or more sides that is used for the parking or storage of motor vehicles.

3.3.19 Qualified Person. One who has skills and knowledge related to the construction and operation of the electrical equipment and installations and has received safety training to recognize and avoid the hazards involved. (CMP-1) [**70:**Article 100]

3.3.20 Thermal Runaway. The condition when an electrochemical cell increases its temperature through self-heating in an uncontrollable fashion and progresses when the cell's heat generation is at a higher rate than it can dissipate, potentially leading to off-gassing, fire, or explosion.

3.3.21 Utility Interactive. An energy storage system intended for use in parallel with an electric utility to supply common loads that can deliver power to the utility.

Chapter 4 General

4.1* General. The design, construction, and installation of ESS and related equipment shall comply with Chapter 4 and as supplemented or modified by the technology-specific provisions in Chapters 9 through 13.

4.1.1* ESS Gas Release. ESS shall not release toxic or highly toxic gas creating conditions in excess of the permissible exposure limit (PEL) in the room or space in which they are located during normal charging, discharging, and use.

4.1.2 Construction Documents.

4.1.2.1 General.

4.1.2.1.1 The plans and specifications associated with an ESS and its intended installation, replacement or renewal, commissioning, and use shall be submitted to the AHJ for approval and include the following:

(1) Location and layout diagram of the room or area in which the ESS is to be installed
(2) Details on hourly fire-resistant-rated assemblies provided or relied upon in relation to the ESS
(3) The quantities and types of ESS units
(4) Manufacturer's specifications, ratings, and listings of ESS
(5) Description of energy storage management systems and their operation
(6) Location and content of required signage
(7) Details on fire suppression, smoke or fire detection, gas detection, thermal management, ventilation, exhaust, and deflagration venting systems, if provided
(8) Support arrangement associated with the installation, including any required seismic support

4.1.2.1.2 Plans and specifications associated with energy storage systems owned and operated by utilities as a component of the electric grid that are considered critical infrastructure documents, in accordance with the provisions of North American Electric Reliability Corporation and other applicable governmental laws and regulations shall be made available to the AHJ for viewing based on the requirements of the applicable governmental laws and regulations.

4.1.2.1.3 The following test data, evaluation information, and calculations shall be provided in addition to the plans and specifications in 4.1.2.1.1 where required elsewhere in this standard:

(1) Large-scale fire test data in accordance with 4.1.5
(2) Hazard mitigation analysis in accordance with 4.1.4
(3) Calculations or modeling data to determine compliance with NFPA 68 and NFPA 69 in accordance with Section 4.12
(4) Other test data, evaluation information, or calculations as required elsewhere in this standard

4.1.2.1.4 If modeling data is provided, validation of the modeling results shall also be included.

4.1.2.2 Building Owner. The construction documents described in this section shall be provided to the building owner or the owner's authorized agent prior to the system being put in service.

4.1.2.3 Manuals. An operations and maintenance manual shall be provided to both the ESS owner or their authorized agent and system operator before the system is put into operation and includes the following:

(1) Submittal data stating the ESS size and selected options for each component of the system
(2) Manufacturer's operation manuals and maintenance manuals for the entire ESS or for each component of the system requiring maintenance that clearly identify the required routine maintenance actions
(3)* Contact information for a contracted service agency or responsible in-house personnel
(4) A narrative of how the ESS and its components and controls are intended to operate, including recommended operational set points
(5) A service record log that lists the schedule for all required service and maintenance actions with space for logging such actions that can be completed over time

4.1.2.3.1 The operations and maintenance manual shall be prepared prior to final approval of the ESS and be readily accessible to personnel responsible for the ESS.

4.1.2.3.2 A copy of the operations and maintenance manual shall be placed in an approved location to be accessible to AHJs and emergency responders.

4.1.2.4 Commissioning Plan. A commissioning plan meeting the provisions of Chapter 6 shall be provided to the building owner or their authorized agent and the AHJ.

4.1.3 Emergency Planning and Training.

4.1.3.1* General. Emergency planning and training shall be provided by the owner of the ESS or their authorized representative so that ESS facility operations and maintenance personnel and emergency responders can effectively address foreseeable hazards associated with the on-site systems.

4.1.3.2 Facility Staff Planning and Training. An emergency operations plan and associated training shall be established, maintained, and conducted by ESS facility operations and maintenance personnel.

4.1.3.2.1 Emergency Operations Plan.

4.1.3.2.1.1 An emergency operations plan shall be readily available for use by facility operations and maintenance personnel.

4.1.3.2.1.2 For normally occupied facilities, the emergency operations plan shall be on site.

4.1.3.2.1.3 The plan shall be updated when conditions that affect the response considerations and procedures change.

4.1.3.2.1.4 The emergency operations plan shall include the following:

(1) Procedures for safe shutdown, de-energizing, or isolation of equipment and systems under emergency conditions to reduce the risk of fire, electric shock, and personal injuries, and for safe start-up following cessation of emergency conditions
(2) Procedures for inspection and testing of associated alarms, interlocks, and controls
(3)* Procedures to be followed in response to notifications from the energy storage management system (ESMS), when provided, that could signify potentially dangerous conditions, including shutting down equipment, summoning service and repair personnel, and providing agreed upon notification to fire department personnel for off-normal potentially hazardous conditions
(4)* Emergency procedures to be followed in case of fire, explosion, release of liquids or vapors, damage to critical moving parts, or other potentially dangerous conditions
(5) Response considerations similar to a safety data sheet (SDS) that will address response safety concerns and extinguishment when an SDS is not required
(6) Procedures for dealing with ESS equipment damaged in a fire or other emergency event, including contact information for personnel qualified to safely remove damaged ESS equipment from the facility
(7) Other procedures as determined necessary by the AHJ to provide for the safety of occupants and emergency responders
(8) Procedures and schedules for conducting drills of these procedures

4.1.3.2.1.5 The emergency operations plan in 4.1.3.2.1 shall not be required for electric utility facilities under the exclusive control of the electric utility located outdoors or in building spaces used exclusively for such installations.

4.1.3.2.2 Facility Staff Training.

4.1.3.2.2.1 Personnel responsible for the operation, maintenance, repair, servicing, and response of the ESS shall be trained in the procedures included in the emergency operations plan in 4.1.3.2.1.

4.1.3.2.2.2 Refresher training shall be conducted at least annually and records of such training retained in an approved manner.

4.1.4 Hazard Mitigation Analysis.

4.1.4.1* A hazard mitigation analysis shall be provided to the AHJ for review and approval when any of the following conditions are present:

(1) When technologies not specifically addressed in Table 1.3 are provided.
(2) More than one ESS technology is provided in a room or indoor area where adverse interaction between the technologies is possible.
(3) When allowed as a basis for increasing maximum stored energy as specified in 4.8.1 and 4.8.2.

4.1.4.2 The analysis shall evaluate the consequences of the following failure modes and others deemed necessary by the AHJ:

(1) Thermal runaway condition in a single module, array, or unit
(2) Failure of an energy storage management system
(3) Failure of a required ventilation or exhaust system
(4) Failure of a required smoke detection, fire detection, fire suppression, or gas detection system

4.1.4.2.1 Only single failure modes shall be considered for each mode given in 4.1.4.2.

4.1.4.3 The AHJ shall be permitted to approve the hazardous mitigation analysis as documentation of the safety of the ESS installation provided the consequences of the analysis demonstrate the following:

(1) Fires will be contained within unoccupied ESS rooms for the minimum duration of the fire resistance rating specified in 4.3.6.
(2) Suitable deflagration protection is provided where required.
(3) ESS cabinets in occupied work centers allow occupants to safely evacuate in fire conditions.
(4) Toxic and highly toxic gases released during normal charging, discharging, and operation will not exceed the PEL in the area where the ESS is contained.
(5) Toxic and highly toxic gases released during fires and other fault conditions will not reach concentrations in excess of immediately dangerous to life or health (IDLH) level in the building or adjacent means of egress routes during the time deemed necessary to evacuate from that area.
(6) Flammable gases released during charging, discharging, and normal operation will not exceed 25 percent of the LFL.

4.1.4.4 The hazard mitigation analysis shall be documented and made available to the AHJ and those authorized to design and operate the system.

4.1.4.5* Construction, equipment, and systems that are required for the ESS to comply with the hazardous mitigation analysis shall be installed, tested, and maintained in accordance with this standard and the manufacturer's instructions.

4.1.5 Large-Scale Fire Test.

4.1.5.1* Where required elsewhere in this standard, large-scale fire testing in accordance with 4.1.5 shall be conducted on a representative ESS in accordance with UL 9540A or equivalent test standard.

4.1.5.2 The testing shall be conducted or witnessed and reported by an approved testing laboratory and show that a fire involving one ESS unit will not propagate to an adjacent unit.

4.1.5.3 Where installed within buildings, the fire during the test shall be contained within the room or enclosed area for a duration equal to the fire resistance rating of the room separation specified in 4.3.6.

4.1.5.4* The test report shall be provided to the AHJ for review and approval.

4.1.6 Combustible Storage.

4.1.6.1 Combustible materials not related to the ESS shall not be stored in rooms, cabinets, or enclosures containing ESS equipment.

4.1.6.2 Combustible materials related to the ESS shall not be stored within 3 ft (914 mm) from ESS equipment.

4.1.6.3 Combustible materials in occupied work centers shall not be stored within 3 ft (914 mm) of ESS equipment.

4.1.6.4 Combustible materials in occupied work centers shall comply with Section 10.18 of NFPA 1 or other applicable fire codes.

4.1.6.5 Subsection 4.1.6 shall not apply to dwelling units.

4.2 Equipment.

4.2.1* Listings. ESS shall be listed in accordance with UL 9540, unless specifically exempted in other sections of this standard.

4.2.1.1 Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76 are not required to be listed in accordance with UL 9540.

4.2.1.2* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to be listed in accordance with UL 9540.

4.2.1.3 Lead-acid battery systems in uninterruptable power supplies listed and labeled in accordance with UL 1778 and utilized for standby power applications shall not be required to be listed in accordance with UL 9540.

4.2.2 Repairs.

4.2.2.1 Repairs of ESS shall only be done by qualified persons and documented in the maintenance, testing, and events log required in 4.1.2.3.

4.2.2.2 Repairs with other than identical or equivalent parts shall be considered a retrofit and comply with 4.2.3.

4.2.3 Retrofits.

4.2.3.1 Retrofitting of ESS shall comply with the following:

(1) Battery systems and modules and capacitor systems and modules shall be listed in accordance with UL 1973.

(2) Battery management and other monitoring systems shall be connected and installed in accordance with the manufacturer's instructions.
(3) The overall installation shall continue to comply with UL 9540 listing requirements, where applicable.
(4) Retrofits shall be documented in the maintenance, testing, and events log required in 4.1.2.3.

4.2.3.2 Changing out or retrofitting existing lead-acid or nickel-cadmium battery systems with other lead-acid or nickel-cadmium battery systems less than 50 V ac, 60 V dc in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76 shall be considered repairs when there is no increase in system size or capacity greater than 10 percent from the original design.

4.2.3.3* Changing out or retrofitting existing lead-acid or nickel-cadmium battery systems with other lead-acid or nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall be considered repairs when there is no increase in system size or capacity greater than 10 percent from the original design.

4.2.3.4 Changing out or retrofitting existing lead-acid battery systems with other lead-acid battery systems in uninterruptable power supplies listed and labeled in accordance with UL 1778 and utilized for standby power applications shall be considered repairs where there is no increase in system size or capacity greater than 10 percent from the original design.

4.2.4 Replacements.

4.2.4.1 Replacement of ESS shall be considered new ESS installations and comply with the provisions applicable to new ESS.

4.2.4.2 The ESS being replaced shall be decommissioned in accordance with Chapter 8.

4.2.5 Increase in Power Rating or Maximum Stored Energy.

4.2.5.1 A complete new ESS that is added to an existing installation of one or more systems shall be treated as a new system and meet the applicable requirements of this standard.

4.2.5.2 An increase in maximum stored energy or power rating to an existing ESS shall be considered a retrofit and comply with 4.2.3.

4.2.6 Environment. The temperature, humidity, and other environmental conditions in which an ESS is located shall be maintained in accordance with the listing and the manufacturer's specifications.

4.2.7 Charge Controllers.

4.2.7.1 Charge controllers shall be compatible with the battery or ESS manufacturer's electrical ratings and charging specifications.

4.2.7.2 Charge controllers shall be listed and labeled in accordance with UL 1741 or provided as part of a listed ESS.

4.2.7.3 Battery chargers used for the charging of a battery system that is not utility interactive shall be permitted to be listed and labeled in accordance with UL 1564.

4.2.8 Inverters and Converters.

4.2.8.1 Inverters and converters shall be listed and labeled in accordance with UL 1741.

4.2.8.2* Only units listed and labeled for utility interactive system use and identified as interactive shall be allowed to operate in parallel with the electric utility power system.

4.2.9* Energy Storage Management System (ESMS).

4.2.9.1 Where required by the equipment listing in accordance with 4.2.1 or the hazard mitigation analysis in accordance with 4.1.4, an approved ESMS shall be provided for monitoring operating conditions and maintaining voltages, currents, and temperatures within the manufacturer's specifications.

4.2.9.2 The ESMS shall electrically isolate the components of the ESS or place it in a safe condition if potentially hazardous temperatures or other hazardous conditions are detected.

4.2.9.3* When required by the AHJ, visible annunciation shall be provided on the cabinet exterior or in an approved location to indicate potentially hazardous conditions associated with the ESS exist.

4.2.9.4 Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76 are not required to comply with 4.2.9.1 through 4.2.9.3.

4.2.9.5* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to comply with 4.2.9.1 through 4.2.9.3.

4.2.10 Reused and Repurposed Equipment.

4.2.10.1 Storage batteries previously used in other applications, such as electric vehicle propulsion, shall not be permitted unless the equipment is repurposed by a UL 1974 compliant battery repurposing company when reused in ESS applications and the system complies with 4.2.1.

4.2.10.2 Materials, equipment, and devices shall not be reused or reinstalled unless such elements have been reconditioned, tested, and placed in good and proper working condition and approved.

4.3 Installation. ESS shall be installed in accordance with their listing, the manufacturer's installation instructions, and this standard.

4.3.1 Electrical Installation. The electrical installation shall be in accordance with *NFPA 70* or IEEE C2 based on the location of the ESS in relation to and its interaction with the electrical grid.

4.3.2* Working Space. At a minimum, ESS equipment shall be provided with working space in accordance with *NFPA 70* or

IEEE C2, as appropriate, for operation, inspection, troubleshooting, maintenance, or replacement.

4.3.3 Seismic Protection. ESS shall be seismically braced in accordance with the local building code.

4.3.4 Design Loads. The weight of the ESS and all associated equipment, components, and enclosure elements and their impact on the dead and live loads of the building or system foundation shall be in accordance with the local building code.

4.3.5* Signage.

4.3.5.1 Approved signage shall be provided in the following locations:

(1) On the front of doors to rooms or areas containing ESS or in approved locations near entrances to ESS rooms
(2) On the front of doors to outdoor occupiable ESS containers
(3) In approved locations on outdoor ESS that are not enclosed in occupiable containers or otherwise enclosed

4.3.5.2* The signage required in 4.3.5.1 shall be in compliance with ANSI Z535 and include the following information as shown in Figure 4.3.5.2:

(1) "Energy Storage Systems" with symbol of lightning bolt in a triangle
(2) Type of technology associated with the ESS
(3) Special hazards associated as identified in Chapters 9 through 15.
(4) Type of suppression system installed in the area of the ESS
(5) Emergency contact information

4.3.5.3 A permanent plaque or directory denoting the location of all electric power source disconnecting means on or in the premises shall be installed at each service equipment location and at the location(s) of the system disconnect(s) for all energy sources capable of being interconnected.

4.3.5.3.1 Energy storage located on property that is under the exclusive control of utilities, secured from public access, and in accordance with 90.2 B(5) of *NFPA 70* shall not be required to comply with 4.3.5.3.

4.3.5.3.2 Energy storage located in a dedicated-use building that is under the exclusive control of telecommunication utilities and secured from public access shall not be required to comply with 4.3.5.3.

4.3.5.4 Existing ESS shall be permitted to retain the signage required at installation except as modified by 4.3.5.5.

4.3.5.5 Existing ESS signage shall be updated to comply with the requirements for new ESS installations when the system is retrofitted or existing signs need to be replaced.

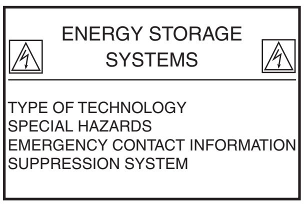

FIGURE 4.3.5.2 Example of ESS Signage.

4.3.5.6 Battery and ESS cabinets in occupied work centers covered by Section 4.7 shall be provided with exterior signs that identify the manufacturer and model number of the system and electrical rating (voltage and current) of the contained system, and any relevant electrical, chemical, and fire hazard.

4.3.6 Separation. Rooms or spaces containing ESS shall be separated from other areas of the building by fire barriers with a minimum 2-hour fire resistance rating and horizontal assemblies with a minimum 2-hour fire resistance rating, constructed in accordance with the local building code.

4.3.7 Impact Protection.

4.3.7.1 ESS shall be located or protected to prevent physical damage from impact where such risks are identified.

4.3.7.2 Vehicle impact protection consisting of guard posts or other approved means shall be provided where ESS are subject to impact by motor vehicles.

4.3.7.3* When guard posts are installed, they shall be designed as follows:

(1) Posts shall be constructed of steel not less than 4 in. (100 mm) in diameter.
(2) Posts shall be filled with concrete.
(3) Posts shall be spaced not more than 4 ft (1.2 m) on center.
(4) Posts shall be set not less than 3 ft (0.9 m) deep in a concrete footing of not less than 15 in. (380 mm) diameter.
(5) The top of the posts shall be set not less than 3 ft (0.9 m) above ground.
(6) Posts shall be located not less than 3 ft (0.9 m) from the ESS.

4.3.7.4* For residential garages, ESS shall not be installed in a location where subject to damage from impact by a motor vehicle.

4.3.8 Security of Installations.

4.3.8.1 ESS shall be secured against unauthorized entry and safeguarded in an approved manner.

4.3.8.2 Security barriers, fences, landscaping, and other enclosures shall not inhibit the required air flow to or exhaust from the ESS and its components.

4.3.9 Elevation. ESS shall be located only on floors that can be accessed by external fire department laddering capabilities unless a higher location is approved by the AHJ.

4.3.9.1 Belowgrade Installations.

4.3.9.1.1 ESS installations where the floor level is below the finished floor of the lowest level of exit discharge shall not be permitted unless the location is approved by the AHJ.

4.3.9.1.2 The ESS shall not be located inside an electrical room.

4.3.9.1.3 The ESS shall be accessible to emergency responders without traversing through an electrical room.

4.3.9.1.4 When approved by the AHJ, ESS installations in underground vaults constructed in accordance with Part III of Article 450 of *NFPA 70* shall be permitted.

4.3.9.2 When approved by the AHJ, ESS installations on rooftops of buildings that do not obstruct fire department rooftop operations shall be permitted.

4.3.9.3 The requirements in 4.3.9 shall not apply to the following:

(1) Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities and located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76

(2)* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations

(3) Lead-acid battery systems in uninterruptable power supplies listed and labeled in accordance with UL 1778, utilized for standby power applications, which is limited to not more than 10 percent of the floor area on the floor on which the ESS is located

4.3.10 Means of Egress.

4.3.10.1 All areas containing ESS shall provide egress from the area in which they are located in accordance with the local building code.

4.3.10.2 Required egress doors shall be provided with emergency lighting as required by the local building code.

4.3.11 Open Rack Installations. Where installed in a room accessible only to authorized personnel, ESS shall be permitted to be installed on an open rack.

4.3.12 Fire Command Centers. In buildings containing ESS and equipped with a fire command center, the command center shall include signage or readily available documentation that describes the location and type of ESS, operating voltages, and location of electrical disconnects as required by *NFPA 70.*

4.4 Location.

4.4.1 ESS installed indoors, outdoors, on rooftops, and in open parking garages shall comply with this section.

4.4.2 Indoor Installations. Indoor ESS installations shall comply with this section and as detailed in Table 4.4.2.

4.4.2.1 Dedicated-Use Buildings. Dedicated-use ESS buildings shall be constructed in accordance with local building codes and comply with all the following:

(1) The building shall only be used for energy storage, energy generation, and other electrical grid-related operations.

(2) Occupants in the rooms and areas containing ESS shall be limited to personnel that operate, maintain, service, test, and repair the ESS and other energy systems.

(3) No other occupancy types shall be permitted in the building.

(4) Administrative and support personnel shall be permitted in incidental-use areas within the buildings that do not contain ESS, provided the following:

(a) The areas do not occupy more than 10 percent of the building area of the story in which they are located.

(b) The areas are separated from the ESS and other rooms and areas containing ESS by 2-hour fire barriers and 2-hour fire resistance-rated horizontal assemblies constructed in accordance with the local building code, as appropriate.

(c) A means of egress is provided from the incidental-use areas to a public way that does not require occupants to traverse through areas containing ESS or other energy systems.

Table 4.4.2 Indoor ESS Installations

Compliance Required	Dedicated-Use Buildings[a]	Non-Dedicated-Use Buildings[b]	Reference
Administrative	Yes	Yes	Chapters 1–3
General	Yes	Yes	Sections 4.1–4.3
Size and separation	Yes[c]	Yes	Section 4.6
Maximum stored energy	No	Yes	Section 4.8
Elevation	Yes	Yes	4.3.9
Separation	NA	Yes	4.3.6
Smoke and fire detection	Yes[d]	Yes	Section 4.10
Fire control and suppression	Yes[c]	Yes	Section 4.11
Water supply	Yes[c]	Yes	Section 4.13
Signage	Yes	Yes	4.3.5
Occupied work centers	Not allowed	Yes	Section 4.7
Technology-specific protection	Yes	Yes	Chapters 9–13

NA: Not applicable.
[a]See 4.4.2.1.
[b]See 4.4.2.2.
[c]Where approved by the AHJ, the fire control and suppression systems, the size and separation requirements, and the water supply are permitted to be omitted in dedicated-use buildings located more than 100 ft (30.5 m) from buildings, lot lines that can be built upon, public ways, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure.
[d]When approved, alarm signals are not required to be transmitted to an approved location when local fire alarm annunciation is provided and trained personnel are always present.

4.4.2.2 Non-Dedicated-Use Buildings. Non-dedicated-use buildings shall include all buildings that contain ESS and do not comply with dedicated-use building requirements in 4.4.2.1.

4.4.2.3 Dwelling Units and Sleeping Units.

4.4.2.3.1 Stationary ESS shall not be installed in sleeping rooms or in living areas of dwelling units unless specifically allowed in Chapters 9 through 13.

4.4.2.3.2 Portable ESS shall be permitted to be used in sleeping rooms and in habitable spaces of dwelling units provided they are listed and are used in accordance with the terms of their listing.

4.4.3 Outdoor Installations. Outdoor ESS installations shall comply with this section and as detailed in Table 4.4.3.

4.4.3.1 Classification. Outdoor ESS installations shall be classified as follows:

(1) *Remote locations.* Remote outdoor locations include ESS located more than 100 ft (30.5 m) from buildings, lot lines that can be built upon, public ways, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure.
(2) *Locations near exposures.* Locations near exposures include all outdoor ESS locations that do not comply with remote outdoor location requirements.

4.4.3.2 Maximum Size.

4.4.3.2.1 Outdoor walk-in containers or enclosures housing ESS shall not exceed 53 ft × 8.5 ft × 9.5 ft (16.2 m × 2.6 m × 2.9 m), not including HVAC and other equipment.

Table 4.4.3 Outdoor Stationary ESS Installations

Compliance Required	Remote Locations[a]	Locations Near Exposures[b]	Reference
Administrative	Yes	Yes	Chapters 1–3
General	Yes	Yes	Sections 4.1–4.3
Maximum size	Yes	Yes	4.4.3.2
Clearance to exposures	NA	Yes	4.4.3.3
Means of egress separation	NA	Yes	4.4.3.4
Walk-in units	Yes	Yes	4.4.3.5
Vegetation control	Yes	Yes	4.4.3.6
Enclosures	Yes	Yes	4.4.3.7
Size and separation	No	Yes[c]	Section 4.6
Maximum stored energy	No	Yes	Section 4.8
Smoke and fire detection	Yes	Yes	Section 4.10
Fire control and suppression	Yes[d]	Yes	Section 4.11
Water supply	Yes[d]	Yes	Section 4.13
Signage	Yes	Yes	4.3.5
Occupied work centers	Not allowed	Not allowed	Section 4.7
Technology-specific protection	Yes	Yes	Chapters 9–13

NA: Not applicable.
[a]See 4.4.3.1(1).
[b]See 4.4.3.1(2).
[c]In outdoor walk-in units, spacing is not required between ESS and the enclosure walls.
[d]When agreeable with the ESS owner and approved by the AHJ, fire suppression systems and water supply are permitted to be omitted.

4.4.3.2.2 Units that exceed the dimensions in 4.4.3.2.1 shall be treated as indoor installations and comply with the requirements in 4.4.2.

4.4.3.3 Clearance to Exposures. ESS located outdoors shall be separated by a minimum 10 ft (3048 mm) from the following exposures:

(1) Lot lines
(2) Public ways
(3) Buildings
(4) Stored combustible materials
(5) Hazardous materials
(6) High-piled stock
(7) Other exposure hazards not associated with electrical grid infrastructure

4.4.3.3.1 The required separation distances shall be permitted to be reduced to 3 ft (914 mm) when a 1-hour freestanding fire barrier, suitable for exterior use, and extending 5 ft (1.5 m) above and 5 ft (1.5 m) beyond the physical boundary of the ESS installation is provided to protect the exposure.

4.4.3.3.2 Clearances to buildings shall be permitted to be reduced to 3 ft (914 mm) where noncombustible exterior walls with no openings or combustible overhangs are provided on the wall adjacent to the ESS and the fire resistance rating of the exterior wall complies with the fire resistance requirements in 4.3.6.

4.4.3.3.3 Clearances to buildings shall be permitted to be reduced to 3 ft (914 mm) based on large-scale fire testing complying with 4.1.5.

4.4.3.3.4 Where approved, clearances to exposures other than buildings shall be permitted to be reduced to 3 ft (914 mm) where large-scale fire testing of the ESS in accordance with 4.1.5 demonstrates that a fire within the ESS enclosure will not generate radiant heat flux sufficient to ignite stored materials or otherwise threaten the exposure.

4.4.3.3.5 Clearances to buildings and exposures shall be permitted to be reduced to 3 ft (914 mm) where the enclosure of the ESS has a 2-hour fire resistance rating established in accordance with ASTM E119 or UL 263.

4.4.3.3.6 Exhaust outlets from an ESS that exhaust other than ventilation air shall be located at least 15 ft (4.572 m) from heating, ventilating, and air conditioning (HVAC) air intakes, windows, doors, loading docks, ignition sources, and other openings into buildings and facilities.

4.4.3.3.7 Exhaust outlet(s) from an ESS shall not be directed onto means of egress, walkways, or pedestrian or vehicular travel paths.

4.4.3.4 Means of Egress Separation.

4.4.3.4.1 ESS located outdoors shall be separated from any means of egress as required by the AHJ to ensure safe egress under fire conditions but in no case less than 10 ft (3048 mm).

4.4.3.4.2 Where approved by the AHJ, clearances to means of egress shall be permitted to be reduced to 3 ft (914 mm) where large-scale fire testing in accordance with 4.1.5 demonstrates that a fire within the ESS will not adversely impact the means of egress.

4.4.3.5 Walk-in Units.

4.4.3.5.1 Where an ESS includes an outer enclosure, the unit shall only be entered for inspection, maintenance, and repair of energy storage units and ancillary equipment and not be occupied for other purposes.

4.4.3.5.2* Walk-in units shall comply with this standard and local building code requirements.

4.4.3.6 Vegetation Control.

4.4.3.6.1 Areas within 10 ft (3 m) on each side of outdoor ESS shall be cleared of combustible vegetation and other combustible growth.

4.4.3.6.2 Single specimens of trees, shrubbery, or cultivated ground cover such as green grass, ivy, succulents, or similar plants used as ground covers shall be permitted to be exempt provided that they do not form a means of readily transmitting fire.

4.4.3.7 Enclosures.

4.4.3.7.1 ESS electrical circuitry shall be within weatherproof enclosures marked with the environmental rating suitable for the type of exposure required by *NFPA 70.*

4.4.3.7.2 Enclosures shall be of noncombustible construction.

4.4.3.8 Access Roads. Fire department access roads shall be provided to outdoor ESS installations in accordance with the local fire code.

4.4.3.9* Hazardous Atmospheres. The ESS shall not be located in a classified area as defined in *NFPA 70* or IEEE C2 unless listed and approved for the specific installation.

4.4.3.10 Exterior Wall Installations.

4.4.3.10.1 ESS shall be permitted to be installed outdoors on exterior walls of buildings when all of the following conditions are met:

(1) The maximum stored energy of individual ESS units shall not exceed 20 kWh (72 MJ).
(2) The ESS shall comply with applicable requirements in Chapter 4.
(3) The ESS shall be installed in accordance with the manufacturer's instructions and their listing.
(4) Individual ESS units shall be separated from each other by at least 3 ft (914 mm).
(5) The ESS shall be separated from doors, windows, operable openings into buildings, or HVAC inlets by at least 5 ft (1524 mm).

4.4.3.10.2 Where approved by the AHJ, smaller separation distances in items (4) and (5) shall be permitted based on large scale fire testing in accordance with 4.1.5.

4.4.4 Rooftop and Open Parking Garage Installations. Rooftop and open parking garage ESS installations shall comply with this section and as detailed in Table 4.4.4.

4.4.4.1 ESS installations shall be classified as follows:

(1) *Rooftop installations.* Rooftop ESS installations are those located on the roofs of buildings.
(2) *Open parking garage installations.* Open parking garage ESS installations are those located in a structure or portion of a structure as defined in 3.3.18.

Table 4.4.4 Rooftop and Open Parking Garage ESS Installations

Compliance Required	Rooftops*	Open Parking Garages†	Reference
Administrative	Yes	Yes	Chapters 1–3
General	Yes	Yes	Sections 4.1–4.3
Maximum size	Yes	Yes	4.4.3.2
Means of egress separation	Yes	Yes	4.4.3.4
Walk-in units	Yes	Yes	4.4.3.5
Enclosures	Yes	Yes	4.4.3.7
Clearance to exposures	Yes	Yes	4.4.4.2
Fire suppression and control	Yes	Yes	Section 4.11
Rooftop installations	Yes	No	4.4.4.4
Open parking garages	No	Yes	4.4.4.5
Size and separation	Yes	Yes	Section 4.6
Maximum stored energy	Yes	Yes	Section 4.8
Elevation	Yes	Yes	4.3.9
Smoke and fire detection	Yes	Yes	Section 4.10
Signage	Yes	Yes	4.3.5
Occupied work centers	Not allowed	Not allowed	Section 4.7
Open rack installations	Not allowed	Not allowed	4.3.11
Technology-specific protection	Yes	Yes	Chapters 9–13

NA: Not applicable.
*See 4.4.4.1(1).
†See 4.4.4.1(2).

4.4.4.2 Clearance to Exposures.

4.4.4.2.1 ESS located on rooftops and in open parking garages shall be separated by a minimum 10 ft (3048 mm) from the following exposures:

(1) Buildings, except the portion of the building on which rooftop ESS is mounted
(2) Lot lines
(3) Public ways
(4) Stored combustible materials
(5) Locations where motor vehicles can be parked
(6) Hazardous materials
(7) Other exposure hazards

4.4.4.2.2 Clearances shall be permitted to be reduced to 3 ft (914 mm) under the following conditions:

(1) Where a 1-hour freestanding fire barrier, suitable for exterior use, and extending 5 ft (1.5 m) above and extending 5 ft (1.5 m) beyond the physical boundary of the ESS installation is provided to protect the exposure
(2) Where the weatherproof ESS enclosure is constructed of noncombustible materials and it has been demonstrated

that a fire within the enclosure will not ignite combustible materials outside the enclosure based on large-scale fire testing complying with 4.1.5

4.4.4.3 Fire Suppression and Control.

4.4.4.3.1 ESS located in walk-in enclosures on rooftops or in open parking garages shall be provided with automatic fire control and suppression systems within the ESS enclosure in accordance with Section 4.11.

4.4.4.3.2 Areas containing ESS other than walk-in units in open parking structures not open above to the sky shall be provided with an automatic fire suppression system complying with Section 4.11.

4.4.4.3.3 When approved by the AHJ, ESS shall be permitted to be installed in open parking garages without the protection of an automatic fire control and suppression system where large-scale fire testing conducted in accordance with 4.1.5 indicates that an ESS fire does not present an exposure hazard to parked vehicles or compromise the means of egress.

4.4.4.4 Rooftop Installations.

4.4.4.4.1 Installations shall be permitted on rooftops of buildings that do not obstruct fire department rooftop operations when approved.

4.4.4.4.2 ESS and associated equipment that are located on rooftops and not enclosed by building construction shall comply with the following:

(1) Stairway access to the roof for emergency response and fire department personnel shall be provided either through a bulkhead from the interior of the building or a stairway on the exterior of the building.
(2) Service walkways at least 5 ft (1524 mm) in width shall be provided for service and emergency personnel from the point of access to the roof to the system.
(3) ESS and associated equipment shall be located from the edge of the roof a distance equal to at least the height of the system, equipment, or component but not less than 5 ft (1.5 m).
(4) The roofing materials under and within 5 ft (1524 mm) horizontally from an ESS or associated equipment shall be noncombustible or shall have a Class A rating when tested in accordance with ASTM E108 or UL 790.
(5) A Class I standpipe outlet shall be installed at an approved location on the roof level of the building or in the stairway bulkhead at the top level.
(6) Installations on rooftops over 75 ft (23 m) in height above grade shall be permitted when approved by the AHJ.
(7) Access, service space, guards, and handrails shall be provided where required by the local building and mechanical codes.
(8) A radiant energy-sensing fire detection system complying with Section 4.10 shall be provided to protect the ESS.
(9) The ESS shall be a minimum of 10 ft (3.48 m) from the fire service access point on the rooftop.

4.4.4.5 Open Parking Garages. ESS and associated equipment that are located in open parking garages shall comply with all of the following:

(1) ESS shall not be located within 50 ft (15.3 m) of air inlets for building HVAC systems. When approved, this distance is permitted to be reduced to 25 ft (7.6 m) if the automatic fire alarm system monitoring the radiant energy-sensing detectors de-energizes the ventilation system connected to the air intakes upon detection of fire.
(2) ESS shall not be located within 25 ft (7.6 m) of exits leading from the attached building when located on a covered level of the parking structure not directly open to the sky above. When approved, the separation distance is permitted to be reduced to 10 ft (3 m) based on large-scale fire and fault condition testing conducted in accordance with 4.1.5.
(3) Means of egress separation shall comply with 4.4.3.4.
(4) A radiant energy-sensing fire detection system complying with Section 4.10 shall be provided to protect the ESS.
(5) An approved fence with a locked gate or other approved barrier shall be provided to keep the general public at least 5 ft (1.5 m) from the outer enclosure of the ESS.

4.5 Mobile ESS Equipment and Operations.

4.5.1 Charging and Storage. For the purpose of Section 4.5, charging and storage shall cover the operation where mobile ESS are charged and stored so they are ready for deployment to another site and where they are charged and stored after a deployment.

4.5.1.1 Mobile ESS used to temporarily provide power to lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to comply with 4.5.1.

4.5.2 Deployment. For the purpose of Section 4.5, deployment shall cover operations where mobile ESS are located at a site other than the charging and storage site and are being used to provide power.

4.5.2.1 Mobile ESS used to temporarily provide power to lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to comply with 4.5.2.

4.5.3 Construction Documents. Construction documents complying with 4.1.2 shall be provided to the AHJ with any locally required construction permit applications for mobile ESS charging and storage locations.

4.5.4 Deployment Documents. The following information shall be provided to the AHJ with any locally required operational permit applications for mobile ESS deployments:

(1) Relevant information for the mobile ESS equipment and protection measures in the construction documents required by 4.1.2
(2) Location and layout diagram of the area in which the mobile ESS is to be deployed, including a scale diagram of all nearby exposures
(3) Location and content of signage
(4) Description of fencing to be provided around the ESS, including locking methods
(5) Details on fire suppression, smoke and automatic fire detection, system monitoring, thermal management, exhaust ventilation, and explosion control, if provided

(6) For deployment, the intended duration of operation, including anticipated connection and disconnection times and dates
(7) Description of the temporary wiring, including connection methods, conductor type and size, and circuit overcurrent protection to be provided
(8) Description of how fire suppression system connections to water supplies or extinguishing agents are to be provided
(9) Contact information for personnel who are responsible for maintaining and servicing the equipment and responding to emergencies

4.5.5 Approved Locations. Locations where mobile ESS are charged, stored, and deployed shall be restricted to the locations approved by the AHJ.

4.5.6 Charging and Storage. Installations where mobile ESS are charged and stored shall be treated as permanent ESS installations and shall comply with the following sections, as applicable:

(1) Indoor charging and storage shall comply with 4.4.2.
(2) Outdoor charging and storage shall comply with 4.4.3.
(3) Charging and storage on rooftops and in open parking garages shall comply with 4.4.4.

4.5.6.1 Electrical connections shall be permitted to be made using temporary wiring complying with the manufacturer's instructions, the UL 9540 listing, and *NFPA 70*.

4.5.6.2 Fire suppression system connections to the water supply shall be acceptable to the AHJ.

4.5.7 Deployed Mobile ESS Requirements. Deployed mobile ESS equipment and operations shall comply with this section and Table 4.5.7.

Table 4.5.7 Mobile Energy Storage Systems (ESS)

Compliance Required	Deployment[a]	Reference
Administrative	Yes	Chapters 1–3
General	Yes	Sections 4.1–4.3
Size and separation	Yes[b]	Section 4.6
Maximum stored energy	Yes	Section 4.8
Fire and smoke detection	Yes[c]	Section 4.10
Fire control and suppression	Yes[d,e]	Section 4.11
Maximum size	Yes	4.4.3.2
Vegetation control	Yes	4.4.3.6
Means of egress separation	Yes	4.4.3.4
Technology-specific protection	Yes	Chapters 9–13

[a]See 4.5.2.
[b]In walk-in units, spacing is not required between ESS units and the walls of the enclosure.
[c]Alarm signals are not required to be transmitted to an approved location for mobile ESS deployed 30 days or less.
[d]See 4.5.7.2.
[e]Only required for walk-in units.

4.5.7.1 Mobile operations on wheeled vehicles or trailers shall not be required to comply with 4.3.3 seismic protection requirements.

4.5.7.2 Fire suppression system connections to the water supply shall be permitted to use approved temporary connections.

4.5.7.3 Duration.

4.5.7.3.1 Mobile ESS deployments that provide power for durations longer than 30 days shall comply with 4.5.6.

4.5.7.3.2 Mobile ESS deployments in excess of 30 days, for emergencies, shall not be required to comply with 4.5.6, with AHJ approval.

4.5.7.4 Restricted Locations. Deployed mobile ESS operations shall not be located indoors, in covered parking garages, on rooftops, below grade, or under building overhangs.

4.5.7.5 Clearance to Exposures.

4.5.7.5.1 Deployed mobile ESS shall be separated by a minimum 10 ft (3 m) from the following exposures:

(1) Public ways
(2) Buildings
(3) Stored combustible materials
(4) Hazardous materials
(5) High-piled stock
(6) Other exposure hazards not associated with electrical grid infrastructure

4.5.7.5.1.1 Required separation distances shall be permitted to be reduced in accordance with 4.4.3.3.1 through 4.4.3.3.4.

4.5.7.5.2 Deployed mobile ESS shall be separated by a minimum 50 ft (15.3 m) from public seating areas and from tents, canopies, and membrane structures with an occupant load of 30 or more.

4.5.7.6 Electrical Connections. Electrical connections shall be made in accordance with the manufacturer's instructions.

4.5.7.6.1 Temporary wiring for electrical power connections shall comply with *NFPA 70* or equivalent code.

4.5.7.6.2 Fixed electrical wiring shall not be permitted.

4.5.7.7 Local Staging. Mobile ESS in transit from the charging and storage location to the deployment location and back shall not be parked within 100 ft (30.5 m) of an occupied building for more than 1 hour during transit, unless specifically approved in advance by the AHJ.

4.5.7.8 Fencing.

4.5.7.8.1 An approved fence with a locked gate or other approved barrier shall be provided to keep the general public at least 5 ft (1024 mm) from the outer enclosure of a deployed mobile ESS.

4.5.7.8.2 A mobile ESS that is locked to prevent access by unauthorized persons shall be accepted as meeting 4.5.7.8.

4.6* Size and Separation.

4.6.1 ESS in the following locations shall comply with 4.6.2 and 4.6.3 unless otherwise permitted by 4.6.4 or 4.6.5.

(1) Indoor ESS installations in non-dedicated-use buildings in accordance with 4.4.2

(2) Outdoor ESS installations in locations near exposures as described in 4.4.3.1(2)

4.6.2 ESS shall be comprised of groups with a maximum stored energy of 50 kWh each.

4.6.3 Each group shall be spaced a minimum 3 ft (914 mm) from other groups and from walls in the storage room or area.

4.6.4 The AHJ shall be permitted to approve groups with larger energy capacities or smaller group spacing based on large-scale fire testing complying with 4.1.5.

4.6.5 Subsections 4.6.2 and 4.6.3 shall not apply to lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc in telecommunications facilities in compliance with NFPA 76.

4.6.6* Subsections 4.6.2 and 4.6.3 shall not apply to lead-acid and nickel-cadmium battery systems designed in accordance with IEEE C2 and used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility.

4.6.7 Subsections 4.6.2 and 4.6.3 shall not apply to lead-acid battery systems in uninterruptable power supplies listed and labeled in accordance with UL 1778, utilized for standby power applications, which is limited to not more than 10 percent of the floor area on the floor on which the ESS is located.

4.7* Occupied Work Centers. ESS in occupied work centers shall comply with this section.

4.7.1 ESS shall be permitted in the same room as the equipment that they support.

4.7.2 ESS shall be housed in a noncombustible, locked cabinet or other enclosure to prevent access by unauthorized personnel unless located in a separate equipment room accessible only to authorized personnel.

4.8 Maximum Stored Energy. ESS in the following locations shall comply with Section 4.8 as follows:

(1) Fire areas within non-dedicated-use buildings containing ESS as described in 4.4.2.2 shall not exceed the maximum stored energy values in Table 4.8 except as permitted by 4.8.1.
(2) Outdoor ESS installations in locations near exposures as described in 4.4.3.1(2) shall not exceed the maximum stored energy values in Table 4.8 except as permitted by 4.8.3.
(3) ESS installations in open parking garages and on rooftops of buildings as described in 4.4.4.1 shall not exceed the maximum stored energy values in Table 4.8 except as permitted by 4.8.3.
(4) Mobile ESS equipment as covered by Section 4.5 shall not exceed the maximum stored energy values in Table 4.8 except as permitted by 4.8.3.

4.8.1 Where approved by the AHJ, fire areas in non-dedicated-use buildings containing ESS that exceed the amounts in Table 4.8 shall be permitted based on a hazardous mitigation analysis in accordance with 4.1.4 and large-scale fire testing complying with 4.1.5.

4.8.2 Where approved by the AHJ, outdoor ESS installations, ESS installations in open parking garages and on rooftops of buildings, and mobile ESS equipment that exceed the amounts in Table 4.8 shall be permitted based on a hazardous mitigation analysis in accordance with 4.1.4 and large-scale fire testing in accordance with 4.1.5.

Table 4.8 Maximum Stored Energy

ESS Type	Maximum Stored Energy[a] (kWh)
Lead-acid batteries, all types	Unlimited
Nickel batteries[b]	Unlimited
Lithium-ion batteries, all types	600
Sodium nickel chloride batteries	600
Flow batteries[c]	600
Other battery technologies	200
Storage capacitors	20

[a]For ratings in amp-hrs, kWh should equal maximum rated voltage multiplied by amp-hr rating divided by 1000.
[b]Nickel battery technologies include nickel cadmium (Ni-Cad), nickel metal hydride (Ni-MH), and nickel zinc (Ni-Zn).
[c]Includes vanadium, zinc-bromine, polysulfide, bromide, and other flowing electrolyte-type technologies.

4.8.3 Where more than one ESS technology is present within a fire area, the fire protection systems shall be designed to protect the greatest hazard.

4.8.4 Where a single fire area within a building or walk-in unit contains a combination of energy systems covered in Table 4.8, the maximum stored energy per fire area shall be determined based on the sum of percentages of each type divided by the maximum stored energy of each type.

4.8.5 The sum of the percentages calculated in 4.8.4 shall not exceed 100 percent except as permitted in 4.8.1 or 4.8.3.

4.9* Exhaust Ventilation.

4.9.1 General. Where required by Table 9.2 or elsewhere in this standard, exhaust ventilation shall be provided for rooms, enclosures, walk-in units, and cabinets in accordance with 4.9.2 or 4.9.3.

4.9.2* Exhaust Ventilation by Design. The ventilation system shall be designed to limit the maximum concentration of flammable gas to 25 percent of the lower flammable limit (LFL) of the total volume of the room, walk-in unit, enclosure, container, or cabinet during the worst-case event of simultaneous "boost" charging of all the batteries, in accordance with nationally recognized standards.

4.9.3 Mechanical Exhaust Ventilation.

4.9.3.1 Mechanical exhaust ventilation shall be provided at a rate of not less than 1 $ft^3/min/ft^2$ (5.1 $L/sec/m^2$) of floor area of the room, walk-in unit, enclosure, container, or cabinet.

4.9.3.1.1 The mechanical exhaust ventilation shall be either continuous or activated by a gas detection system in accordance with 4.9.3.2.

4.9.3.1.2 Required mechanical exhaust ventilation systems shall be installed in accordance with the manufacturer's installation instructions and local building, mechanical, and fire codes.

4.9.3.1.3 Required mechanical exhaust ventilation systems shall be supervised by an approved central station, proprietary, or remote station service in accordance with *NFPA 72* or shall initiate an audible and visual signal at an approved, constantly attended location.

4.9.3.2 Where required by 4.9.3.1.1, rooms, walk-in units, enclosures, walk-in containers, and cabinets containing ESS shall be protected by an approved continuous gas detection system that complies with the following:

(1) The gas detection system shall be designed to activate the mechanical exhaust ventilation system when the level of flammable gas detected in the room, walk-in unit, enclosure, container, and cabinet exceeds 25 percent of the LFL.
(2) The mechanical exhaust ventilation system shall remain on until the flammable gas detected is less than 25 percent of the LFL.
(3) The gas detection system shall be provided with a minimum of 2 hours of standby power.
(4) Failure of the gas detection system shall annunciate a trouble signal at an approved central station, proprietary, or remote station service in accordance with *NFPA 72* or at an approved, constantly attended location.

4.10 Smoke and Fire Detection.

4.10.1 All fire areas containing ESS systems located within buildings or structures shall be provided with a smoke detection system in accordance with *NFPA 72*.

4.10.2* Normally unoccupied, remote stand-alone telecommunications structures with a gross floor area of less than 1500 ft^2 (139 m^2) utilizing lead-acid or nickel-cadmium battery technology shall not be required to have the detection required in 4.10.1.

4.10.3* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall be allowed to use the process control system to monitor the smoke detectors required in 4.10.1.

4.10.4 The smoke detection system shall be permitted to be replaced with a radiant energy–sensing detection system installed in accordance with *NFPA 72* in open parking garages and similar occupancies where conditions negatively impact the use of smoke detection technologies.

4.10.5 Telecommunications facilities with lead-acid and nickel-cadmium battery storage less than 50 V ac, 60 V dc shall have fire detection installed in accordance with NFPA 76.

4.11 Fire Control and Suppression.

4.11.1* Where required elsewhere in this standard, fire control and suppression for rooms or areas within buildings and outdoor walk-in units containing ESS shall be provided in accordance with this section.

4.11.2 Sprinkler System. Sprinkler systems shall be installed in accordance with NFPA 13 or equivalent.

4.11.2.1 Sprinkler systems for ESS units (groups) with a maximum stored energy of 50 kWh, as described in 4.6.2, shall be designed using a minimum density of 0.3 gpm/ft^2 (12.2 mm/min) based over the area of the room or 2500 ft^2 (230 m^2) design area, whichever is smaller, unless a lower density is approved based upon large-scale fire testing in accordance with 4.1.5.

4.11.2.2* Sprinkler systems for ESS units (groups) exceeding 50 kWh shall use a density based on large-scale fire testing in accordance with 4.1.5.

4.11.3 Alternate Automatic Fire Control and Suppression Systems.

4.11.3.1* Other automatic fire control and suppression systems shall be permitted based on reports issued as a result of large-scale fire testing in accordance with 4.1.5.

4.11.3.2* The automatic fire control and suppression systems shall comply with the following standards, or their equivalent, as appropriate:

(1) NFPA 12
(2) NFPA 15
(3) NFPA 750
(4) NFPA 2001
(5) NFPA 2010

4.11.4 Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc that are in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities and located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76 shall not be required to have a fire suppression system installed.

4.11.5 Lead-acid battery systems in uninterruptable power supplies listed and labeled in accordance with UL 1778, utilized for standby power applications, which is limited to not more than 10 percent of the floor area on the floor on which the ESS is located, shall not be required to have a fire suppression system installed.

4.11.6* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to have a fire suppression system installed.

4.11.7 When approved by the AHJ, ESS shall be permitted to be installed in open parking garages without the protection of an automatic fire suppression system where full-scale fire and fault condition testing documents the system does not present an exposure hazard to parked vehicles when installed in accordance with manufacturer's instructions and this standard.

4.11.8 When approved by the AHJ, ESS shall be permitted to be installed in dedicated-use buildings without the protection of an automatic fire control and suppression system where large-scale fire testing conducted in accordance with 4.1.5 documents that an ESS fire does not compromise the means of egress and does not present an exposure hazard to buildings, lot lines, public ways, stored combustible materials, hazardous materials, high-piled stock, and other exposure hazards not associated with electrical grid infrastructure.

4.11.9 When approved by the AHJ, ESS shall be permitted to be installed in outdoor walk-in enclosures without the protection of an automatic fire control and suppression system where large-scale fire testing conducted in accordance with 4.1.5 documents that an ESS fire does not compromise the means of egress and does not present an exposure hazard in accordance with 4.4.3.3 and 4.4.3.4.

4.12* Explosion Control. Where required elsewhere in this standard, explosion prevention or deflagration venting shall be provided in accordance with this section.

4.12.1* ESS installed within a room, building, or walk-in unit shall be provided with one of the following:

(1) Explosion prevention systems designed, installed, operated, maintained, and tested in accordance with NFPA 69
(2) Deflagration venting installed and maintained in accordance with NFPA 68

4.12.2 Explosion prevention and deflagration venting shall not be required where approved by the AHJ based on large-scale fire testing in accordance with 4.1.5 that demonstrates that flammable gas concentrations in the room, building, or walk-in unit cannot exceed 25 percent of the LFL in locations where the gas is likely to accumulate.

4.13 Water Supply.

4.13.1* Where required elsewhere in this standard, sites where nonmechanical ESS are installed shall be provided with a permanent source of water for fire protection.

4.13.2 Where no permanent adequate and reliable water supply exists for fire-fighting purposes, the requirements of NFPA 1142 shall apply.

4.13.3 Accessible fire hydrants shall be provided for site ESS installations where a public or private water supply is available.

4.13.4 Fire hydrants installed on private fire service mains shall be installed in accordance with NFPA 24.

4.13.5 Normally unoccupied, remote stand-alone telecommunications structures with a gross floor area of less than 1500 ft^2 (139 m^2) with lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc that are in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities and located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76 shall not be required to have a fire water supply.

4.13.6* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to have a fire water supply.

4.14 Spill Control.

4.14.1 Rooms, buildings, or areas containing ESS with free-flowing liquid electrolyte in individual vessels having a capacity of more than 55 gal (208 L) or multiple vessels having an aggregate capacity exceeding 1000 gal (3785 L) shall be provided with spill control to prevent the flow of liquids to adjoining areas.

4.14.2* An approved method and materials for the control of a spill of electrolyte or other hazardous liquid shall be provided that will be capable of controlling a spill from the single largest vessel.

4.14.3 In rooms, buildings, or areas protected by water-based fire protection systems, the capacity of the spill containment system shall accommodate the capacity of the expected fire protection system discharge for a period of 10 minutes.

4.14.4 The capacity increase in 4.14.3 shall not apply to integral spill containment systems that are shielded from the fire protection system discharge.

4.14.5 Sealed valve-regulated lead-acid (VRLA) batteries and other ESS equipment with immobilized electrolyte and immobilized hazardous liquids shall not require spill control.

4.14.6 Rooms, buildings, or areas containing other hazardous materials shall include spill control as required in NFPA 1.

4.15 Neutralization.

4.15.1* An approved method to neutralize spills from ESS with free-flowing electrolyte shall be provided.

4.15.2 Neutralization shall not be required for ESS with immobilized electrolyte.

4.15.3 The method shall be capable of neutralizing a spill from the largest battery or vessel to a pH between 5.0 and 9.0.

4.16 Remediation Measures.

4.16.1 Authorized Service Personnel. In the event a fire or other event has damaged the ESS and ignition or reignition of the ESS is possible, the owner, agent, or lessee shall immediately dispatch authorized service personnel to mitigate the hazard or remove damaged equipment from the premises to a safe location.

4.16.2 Fire Mitigation Personnel.

4.16.2.1 When, in the opinion of the AHJ, it is essential for public safety that trained personnel be on site to respond to possible ignition or reignition of damaged the ESS, the owner, agent, or lessee shall provide one or more fire mitigation personnel, as required and approved, at their expense.

4.16.2.2 These personnel shall remain on duty continuously after the fire department leaves the premises until the damaged ESS is removed from the premises or the AHJ indicates they can leave.

4.16.2.3 On-duty fire mitigation personnel shall have the following responsibilities:

(1) Keep diligent watch for fires, obstructions to means of egress, and other hazards
(2) Immediately contact the fire department if their assistance is needed to mitigate any hazards
(3) Take prompt measures for remediation of hazards and extinguishment of fires that occur
(4) Take prompt measures to assist in the evacuation of the public from the structures

Chapter 5 System Interconnections

5.1* General. All electrical connections and wiring to and from an ESS or the components of an ESS shall be in accordance with *NFPA 70* or IEEE C2 based on the location of the ESS in relation to and its interaction with the electrical grid.

5.1.1 Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc that are in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities and located outdoors or in building spaces used exclusively for such installations that are in compliance with NFPA 76 shall not be required to comply with Sections 5.1 and 5.2.

5.1.2 Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations shall not be required to comply with Sections 5.1 and 5.2.

5.2* Disconnecting Means. A readily accessible disconnecting means for the ESS shall be provided within sight of the ESS in accordance with *NFPA 70*.

5.3 Nonelectrical Systems.

5.3.1 Natural Gas. Piping, valves, and fittings from the outlet of the supplier's piping to the outlet of the ESS system's shutoff valve shall be in accordance with NFPA 54.

5.3.2 Compressed Natural Gas (CNG). The design, location, and installation of piping, valves, and fittings from the outlet of the point of delivery from the supplier to the inlets of the equipment shutoff valves shall be in accordance with NFPA 52.

5.3.3 Liquefied Petroleum Gas (LP-Gas) Systems and Storage. The design, location, and installation of liquefied petroleum gas (LP-Gas) storage and piping systems shall comply with NFPA 58.

5.3.4 Hydrogen Fuel Systems and Storage. The design, location, and installation of hydrogen gas and liquid hydrogen storage and piping systems shall comply with NFPA 2.

5.3.5 Biogas. Storage tanks and their associated equipment, piping, valves, and regulators shall be designed and installed in accordance with NFPA 54.

5.3.6 Liquid Fuels. The design of liquid fuel piping systems and the location and storage of liquid fuels shall be in accordance with NFPA 30.

5.3.7 Water. Where the ESS requires water to operate, it shall be provided through a connection to an on-site water supply in accordance with ICC IPC (*International Plumbing Code*), IAPMO UPC (*Uniform Plumbing Code*), or local regulations, or through a self-contained water source.

5.4 Communication Systems. ESS shall have communication interconnections between the ESS components and site-located systems necessary for safe operation of the system and in accordance with the product listing, manufacturer's installation instructions, and this document.

5.5 Support Systems. All connections to and from an ESS or the components of an ESS to required plumbing, fire alarm, detection, or control circuits or to ventilation systems shall be in accordance with nationally recognized standards applicable to those systems, manufacturer's instructions, listings, and the applicable provisions of Chapters 4 and 5.

Chapter 6 Commissioning

6.1 System Commissioning.

6.1.1 ESS shall be evaluated and confirmed for proper operation by the system owner or their designated agent in accordance with a commissioning plan prepared in accordance with 6.1.2 and 6.1.3.

6.1.1.1 Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc that are in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities and located outdoors or in building spaces or walk-in units used exclusively for such installations that are in compliance with NFPA 76 shall be permitted to have a commissioning plan in compliance with recognized industry practices in lieu of complying with 6.1.2 and 6.1.3.

6.1.1.2* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utilities, and located in building spaces or walk-in units used exclusively for such installations shall be permitted to have a commissioning plan in compliance with applicable governmental laws and regulations in lieu of developing a commissioning plan in accordance with 6.1.2 and 6.1.3.

6.1.2 System commissioning shall be conducted in accordance with 6.1.2.1 and 6.1.2.2 after the installation is complete but prior to final inspection and approval.

6.1.2.1 ESS shall be evaluated for their proper operation by the system installer or commissioning agent in accordance with the commissioning plan developed under 6.1.1 and a commissioning report documenting the commissioning process in accordance with 6.1.6.

6.1.2.2 The commissioning results in accordance with 6.1.3 shall be provided by the system installer or commissioning agent to the system(s) owner and the AHJ prior to final inspection and approval.

6.1.3 A commissioning report documenting the commissioning process and the results shall be provided in accordance with 6.1.3.1, 6.1.3.2, and 6.1.3.3.

6.1.3.1 A commissioning report shall be prepared by the system installer or commissioning agent and shall summarize the commissioning process and the operation of the system and associated operational controls and safety systems.

6.1.3.2 The report shall include the final commissioning plan, the results of the commissioning process, as well as a copy of the plans and specifications associated with the as-built system design and installation.

6.1.3.3 The report shall include any issues identified during commissioning and the measures taken to resolve them.

6.1.3.4 A corrective action plan acceptable to the AHJ shall be developed for any open or continuing issues that are allowed to be continued after commissioning.

6.1.4 The system installer or commissioning agent shall prepare a written commissioning plan that provides a description of the means and methods necessary to document and verify that the system and its associated controls and safety systems, as required by this standard, are in proper working condition.

6.1.5 The commissioning plan shall include, but not be limited to, the following information:

(1) An overview of the commissioning process developed specifically for the ESS to be installed and narrative description of the activities to be conducted
(2) Roles and responsibilities for all those involved in the design, commissioning construction, installation, or operation of the system(s)
(3) Means and methods whereby the commissioning plan will be made available during the implementation of the ESS project(s)
(4) Plans and specifications necessary to understand the installation and operation of the ESS and all associated operational controls and safety systems
(5) A detailed description of each activity to be conducted during the commissioning process, who will perform each activity, and at what point in time the activity is to be conducted
(6) Procedures to be used in documenting the proper operation of the ESS and all associated operational controls and safety systems
(7) Testing for any required fire detection or suppression and thermal management, ventilation, or exhaust systems associated with the installation and verification of proper operation of the safety controls
(8) Guidelines and format for a commissioning checklist and relevant operational testing forms and necessary commissioning logs and progress reports
(9) Means and methods whereby facility operating and maintenance staff will be trained on the system
(10) Identification of personnel who are qualified to service and maintain the system and respond to incidents involving each system
(11) A decommissioning plan meeting the provisions of Section 8.1 that covers the removal of the system from service and from the facility in which it is located and information on disposal of materials associated with each ESS

6.1.6 System Testing.

6.1.6.1 ESS shall be evaluated for their proper operation by the system installer in accordance with the manufacturer's instructions, the commissioning plan, and the requirements of this section after the installation is complete but prior to final approval.

6.1.6.2 A report documenting the commissioning process and the results shall be prepared by the entity commissioning the system and a copy provided to the AHJ prior to final inspection and approval and included in the manual required by 4.1.2.3.

6.1.6.3 System testing shall be conducted as a component of the commissioning process and include functional performance testing of the ESS that demonstrates that the installation and operation of the system and associated components, controls, and safety-related systems are in accordance with approved plans and specifications and that the operation, function, and maintenance serviceability for each of the commissioned ESS is confirmed.

6.2 Issues and Resolutions Documentation. (Reserved)

6.3 Operations and Maintenance Documentation.

6.3.1 Operations and maintenance documentation shall be provided to the ESS owner.

6.3.2 The documentation shall include design, construction, installation, testing, and commissioning information associated with the ESS as initially approved after being commissioned.

6.3.3 A copy of the documentation shall be placed in an approved location to be accessible to facility personnel, fire code officials, and emergency responders.

6.4* Recommissioning of Existing Systems.

6.4.1 Recommissioning shall meet the provisions of Section 6.1 and include the entire system with issuance of a new commissioning report, identification of any new issues and resolutions documentation, and identification of any revisions to the operations and maintenance documentation.

6.4.2* When alterations, additions, repositioning, or renovations to the system or any of its components are warranted, they shall be permitted in accordance with Chapter 4 and be performed by qualified entities and the system recommissioned in accordance with Section 6.1.

6.4.3 Repairs or renewals to systems utilizing identical components shall not require recommissioning.

6.4.4* Listed ESS that has been modified in the field beyond the field-installed options that are part of the listing shall be investigated and found suitable by the organization that listed the equipment.

Chapter 7 Operation and Maintenance

7.1 System Operation. All ESS shall be operated in accordance with the manufacturer's instructions and the operation and maintenance documentation.

7.1.1 Electric Utilities Under NERC Jurisdiction.

7.1.1.1 Electric utilities under NERC jurisdiction shall comply with NERC PRC-005 requirements.

7.1.1.2 Electric utilities under NERC jurisdiction shall not be required to follow manufacturer's instructions for lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility, and located outdoors or in building spaces used exclusively for such installations.

7.1.2 The operation and maintenance documentation shall include the following:

(1) Procedures for the safe startup of the ESS system and associated equipment
(2) Procedures for inspection and testing of associated alarms, interlocks, and controls
(3) Procedures for maintenance and operation of the following, when applicable:
    (a) Energy storage management systems (ESMS)

(b) Fire protection equipment and systems
(c) Spill control and neutralization systems
(d) Exhaust and ventilation equipment and systems
(e) Gas detection systems
(f) Other required safety equipment and systems

(4) Response considerations similar to a safety data sheet (SDS) that will address response safety concerns and extinguishment when an SDS is not required
(5) An indication of which changes would necessitate re-permitting
(6)* An instruction that equipment or system changes to the installation are required to be recorded by updating any engineering documentation

7.1.3 SDS for Hazardous Materials.

7.1.3.1 SDS for hazardous materials contained in the ESS shall be posted within sight of the disconnecting means of any ESS or at a location approved by the AHJ.

7.1.3.2 For ESS located outdoors, a means shall be provided to protect the SDS from the weather.

7.1.4 Where the operations and maintenance documentation calls for detailed procedures to be used for specific scheduled operational checks or assessments, an operations record that includes data associated with configurable system settings, system start-up, system shutdown (including emergency shutdown), and long-term shutdown (storage mode) shall be maintained by the system owner or their designated agent and be made available to the AHJ upon request.

7.1.5 The operations record shall indicate the maintenance action taken, the date of the action, who implemented the action, and the results associated with the action.

7.1.6 The operations record shall be kept in a readily accessible location, or a sign indicating where the record is located shall be posted adjacent to the system.

7.1.6.1 For normally occupied facilities, the operations record shall be on site.

7.1.6.2 The operations record shall be permitted to be made available electronically.

7.2 System Maintenance. The ESS shall be maintained in accordance with the system manufacturer's instructions.

7.2.1 The maintenance documentation shall include a detailed maintenance schedule covering all affected equipment and the activities to be performed.

7.2.2 Maintenance shall be performed by qualified individuals.

7.2.3 Maintenance documentation indicating the maintenance action taken, the date of the action, who implemented the action, and the results associated with the action shall be maintained as required by Section 6.3.

7.2.4 Maintenance documentation shall record information on any repair, renewal, or renovation made to the ESS.

7.2.5 Training. Training shall be provided to all those responsible for system operation and maintenance.

7.2.5.1 Training on system operation and maintenance shall be provided by the system owner or their designated agent.

7.2.5.2 After recommissioning the system, training on any changes to the operation and maintenance documentation shall be provided.

7.2.5.3 Training records of site operations and maintenance personnel shall be retained and accessible to the AHJ, indicating the training taken, the name(s) of those taking the training, and the training date.

7.3 System Testing.

7.3.1 System testing shall be performed when required by the operating instructions or maintenance documentation in accordance with testing procedures provided by the ESS manufacturer.

7.3.2 A record of all testing shall be maintained in accordance with the requirements in Section 6.3.

Chapter 8 Decommissioning

8.1 Decommissioning Plan. Prior to decommissioning, the owner of an ESS or their designated agent(s) shall prepare a written decommissioning plan complying with 8.1.3 that provides the organization, documentation requirements, and methods and tools necessary to indicate how the safety systems as required by this standard and the ESS and its components will be decommissioned and the ESS removed from the site.

8.1.1 Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc that are in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities and located outdoors or in building spaces or walk-in units used exclusively for such installations that are in compliance with NFPA 76 shall be permitted to have a decommissioning plan in compliance with recognized industry practices in lieu of complying with 8.1.3.

8.1.2* Lead-acid and nickel-cadmium battery systems that are designed in accordance with IEEE C2, used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utilities, and located in building spaces or walk-in units used exclusively for such installations shall be permitted to have a decommissioning plan in compliance with applicable governmental laws and regulations in lieu of complying with 8.1.3.

8.1.3* The decommissioning plan shall include the following information:

(1) An overview of the decommissioning process developed specifically for the ESS that are to be decommissioned
(2) Roles and responsibilities for all those involved in the decommissioning of the ESS and their removal from the site
(3) Means and methods whereby the decommissioning plan will be made available at a point in time corresponding to the decision to decommission the ESS
(4) Plans and specifications necessary to understand the ESS and all associated operational controls and safety systems, as built, operated, and maintained
(5) A detailed description of each activity to be conducted during the decommissioning process and who will perform that activity and at what point in time
(6) Procedures to be used in documenting the ESS and all associated operational controls and safety systems that have been decommissioned

(7) Guidelines and format for a decommissioning checklist and relevant operational testing forms and necessary decommissioning logs and progress reports
(8) A description of how any changes to the surrounding areas and other systems adjacent to the ESS, such as but not limited to structural elements, building penetrations, means of egress, and required fire detection and suppression systems, will be protected during decommissioning and confirmed as being acceptable after the system is removed

8.2 Decommissioning Process.

8.2.1 The AHJ shall be notified prior to decommissioning an ESS.

8.2.2 The ESS shall be decommissioned by the owner of the ESS or their designated agent(s) in accordance with the decommissioning plan.

8.3 Decommissioning Report. A decommissioning report shall be prepared by the ESS owner or their designated agent and summarize the decommissioning process of the system and associated operational controls and safety systems.

8.3.1 The report shall include the final decommissioning plan and the results of the decommissioning process.

8.3.2 The report shall include any issues identified during decommissioning and the measures taken to resolve them.

Chapter 9 Electrochemical Energy Storage Systems

9.1 Application.

9.1.1* The requirements of this chapter shall apply to installations of electrochemical ESS.

9.1.2 Unless modified by this chapter, the requirements of Chapters 4 through 8 shall also apply.

9.2 General. Electrochemical ESS shall comply with the applicable sections of Chapters 4 and 9 as specified in Table 9.2.

9.3 Thermal Runaway Protection. Where required by Table 9.2, a listed device or other approved method shall be provided to preclude, detect, and minimize the impact of thermal runaway.

9.4 Safety Caps. Where required by Table 9.2, vented batteries used in ESS shall be provided with flame-arresting safety caps.

Table 9.2 Electrochemical ESS Technology-Specific Requirements

Compliance Required	Battery Technology					Other Electrochemical ESS and Battery Technologies[b]	Reference
	Lead-Acid	Nickel[a]	Lithium-Ion	Flow	Sodium Nickel Chloride		
Exhaust ventilation	Yes	Yes[c]	No	Yes	No	Yes	Section 4.9
Spill control	Yes[d]	Yes[d]	No	Yes	No	Yes	Section 4.14
Neutralization	Yes[d]	Yes[d]	No	Yes	No	Yes	Section 4.15
Safety caps	Yes	Yes	No	No	No	Yes	Section 9.4
Thermal runaway	Yes[e]	Yes	Yes[f]	No	Yes[f]	Yes[f]	Section 9.3
Explosion control	Yes[g]	Yes[g]	Yes	No	Yes	Yes	Section 4.12
Size and separation	Yes	Yes	Yes	Yes	Yes	Yes	Section 4.6

[a]Nickel battery technologies covered in this column include nickel cadmium (Ni-Cad), nickel metal hydride (Ni-MH), and nickel zinc (Ni-Zn).
[b]The protection in this column is not required if documentation acceptable to the AHJ, including a hazard mitigation analysis complying with 4.1.4, provides justification that the protection is not necessary based on the technology used.
[c]Exhaust ventilation is not required for nickel metal hydride batteries.
[d]Applicable only to vented- (i.e., flooded-) type nickel and lead-acid batteries.
[e]Thermal runaway protection is not required for vented (e.g., flooded) lead-acid batteries.
[f]The thermal runaway protection is permitted to be part of a battery management system that has been evaluated with the battery as part of the evaluation to UL 1973 or UL 9540.
[g]Explosion control is not required for the following:
(1) Lead-acid and nickel-cadmium battery systems less than 50 V ac, 60 V dc in telecommunications facilities for installations of communications equipment under the exclusive control of communications utilities located in building spaces or walk-in units used exclusively for such installations that are in compliance with NFPA 76
(2) Lead-acid and nickel-cadmium battery systems designed in accordance with IEEE C2 and used for dc power for control of substations and control or safe shutdown of generating stations under the exclusive control of the electric utility located in building spaces or walk-in units used exclusively for such installations
(3) Lead-acid battery systems in uninterruptable power supplies listed and labeled in accordance with UL 1778, utilized for standby power applications, and housed in a single cabinet in a single fire area in buildings or walk-in units

Chapter 10 Capacitor Energy Storage Systems

10.1 Application.

10.1.1 The requirements of this chapter shall apply to installations of capacitor ESS.

10.1.2 Unless modified by this chapter, the requirements of Chapters 4 through 8 shall also apply.

10.1.3 This chapter shall not apply to surge capacitors installed in accordance with Article 460 of *NFPA 70*.

10.1.4* This chapter shall not apply to capacitors and capacitor equipment for electric utilities and industrial facilities used in applications such as flexible ac transmission (FACTS) devices, filter capacitor banks, power factor correction, and standalone capacitor banks for voltage correction and stabilization.

10.2 Protection Features. Capacitor ESS installations shall comply with the applicable sections of Chapters 4 and 10specified in Table 10.2.

Table 10.2 Electrochemical Double Layer Capacitor (EDLC) ESS Technology-Specific Requirements

Compliance Required	EDLC Energy Storage*	Reference
Exhaust ventilation	Yes	Section 4.9
Spill control	Yes	Section 4.14
Neutralization	Yes	4.15
Thermal runaway†	Yes	Section 10.3
Safety caps	Yes	Section 10.4
Explosion control	Yes	Section 4.12

*Not required if documentation acceptable to the AHJ, including a hazard mitigation analysis complying with Section 4.15, provides justification that the protection is not necessary based on the capacitor technology used.

†The thermal runaway protection is permitted to be part of an ESS management system that has been evaluated with the capacitor as part of the evaluation to UL 1973 or UL 9540.

10.3 Thermal Runaway Protection. Where required by Table 10.2, a listed device or other approved method shall be provided to preclude, detect, and minimize the impact of thermal runaway.

10.4 Safety Caps. Where required by Table 10.2, vented capacitors used in ESS shall be provided with flame-arresting safety caps.

Chapter 11 Fuel Cell Energy Storage Systems

11.1 Installation and Maintenance.

11.1.1 Stationary fuel cell ESS shall comply with the following requirements of Chapter 4:

(1) Charge controllers *(see 4.2.7)*
(2) Inverters and converters *(see 4.2.8)*
(3) Energy storage management system (ESMS) *(see 4.2.9)*
(4) Impact protection *(see 4.3.7)*
(5) Smoke and fire detection *(see Section 4.10)*
(6) Fire control and suppression *(see Section 4.11)*
(7) Water supply *(see Section 4.13)*
(8) Signage *(see 4.3.5)*
(9) Combustible storage *(see 4.1.6)*
(10) Hazard mitigation analysis *(see 4.1.4)*
(11) Emergency planning and training *(see 4.1.3)*
(12) Construction documents *(see 4.1.2)*

11.1.2 Non-hydrogen-fueled stationary fuel cell ESS shall be installed and maintained in accordance with *NFPA 70*, NFPA 853, the manufacturer's instructions, and the equipment listing.

11.1.3 Hydrogen-fueled stationary fuel cell ESS shall be installed and maintained in accordance with NFPA 2, *NFPA 70*, NFPA 853, the manufacturer's instructions, and the equipment listing.

11.2 Fuel-Cell-Powered Vehicle Use.

11.2.1 The temporary use of the dwelling unit owner's or occupant's fuel-cell-powered vehicle to power the dwelling in a one- and two-family dwelling or townhouse unit while parked in an attached or detached garage or outside shall only be required to comply with the vehicle manufacturer's instructions and *NFPA 70*.

11.2.2 The temporary use of the dwelling unit owner's or occupant's fuel-cell-powered vehicle to power the dwelling in a one- and two-family dwelling or townhouse unit while parked in an attached or detached garage or outside shall not be for more than 30 days.

Chapter 12 Superconducting Magnet Energy Storage (Reserved)

Chapter 13 Flywheel (Reserved)

Chapter 14 Storage of Used or Off-Specification Batteries

14.1 Used Batteries or Cells. Areas associated with the collection or storage of used or off-specification batteries or cells shall comply with this chapter.

14.1.1 The following areas shall be exempt from the requirements of this chapter:

(1) Areas within a facility that are operated in accordance with procedures that provide for the state of charge of the lithium-ion batteries and cells to be 30 percent or less
(2) Areas where fire and fault condition testing conducted or witnessed and reported by an approved testing laboratory is provided showing that a fire involving the batteries in storage will be limited to the design area of an automatic sprinkler system installed in accordance with NFPA 13 and will not adversely impact occupant egress from the building or adversely impact adjacent stored materials or the building structure

14.1.2 The procedures and test report specified in 14.1.1 shall be provided to the AHJ for review and approval.

14.2 Collection Locations. All areas located indoors in any occupancy where used batteries are collected from employees or the public shall be provided with open-top noncombustible containers or containers approved for battery collection activities.

14.2.1 Containers shall not exceed 1 ft^3 (0.03 m^3) in size.

14.2.2 Containers shall have a minimum of 3 ft (0.9 m) of open space from other battery collection containers and combustible materials and shall be located a minimum of 5 ft (1.5 m) from exits from the room, space, or building.

14.2.3 Where combustible materials are located within the space between collection containers, the containers shall be spaced a minimum 10 ft (3 m) apart.

14.3 Mercantile, Vehicle Repair, Aircraft Repair, and Laboratory Occupancy Battery Collection and Storage Locations.

14.3.1 General.

14.3.1.1 Batteries collected and stored at mercantile, vehicle repair, aircraft repair, or laboratory occupancies other than those in collection containers complying with 14.2.1 shall be stored in accordance with one or more of the following methods provided for in 14.3.2.1 through 14.3.2.5.

14.3.1.2 Battery terminals shall be protected either through battery design methods or a protective packaging method to prevent short circuit of the battery.

14.3.2 Storage Methods.

14.3.2.1 Rooms or Spaces Not Exceeding 200 ft^2 (18.58 m^2). Batteries shall be permitted to be stored in rooms or spaces not exceeding 200 ft^2 (18.58 m^2) in gross floor area.

14.3.2.1.1 The rooms or spaces shall be separated from the remainder of the building areas by fire barriers with a 2-hour fire resistance rating and with horizontal assemblies with a 2-hour fire resistance rating constructed in accordance with the local building code.

14.3.2.1.2 The room or space shall be protected by a radiant-energy detection system installed in accordance with *NFPA 72* and shall be protected by an automatic sprinkler system designed and installed in accordance with NFPA 13.

14.3.2.2 Prefabricated Portable Buildings or Containers Not Exceeding 200 ft^2 (18.58 m^2). Batteries shall be permitted to be stored in approved prefabricated portable buildings or containers not exceeding 200 ft^2 (18.58 m^2) in gross floor area that are constructed with 2-hour fire resistance ratings and provided with radiant-energy detection system installed in accordance with *NFPA 72* and an approved automatic fire suppression system installed in accordance with NFPA 13.

14.3.2.3 Metal Drums. Batteries shall be permitted to be stored in metal drums with batteries separated from each other by vermiculite or other approved material or in containers approved for battery collection and storage activities.

14.3.2.3.1 Each area containing such metal drums or approved containers shall not exceed 200 ft^2 (18.58 m^2) in area and shall be separated from other battery storage areas by a minimum of 10 ft (3 m).

14.3.2.3.2 The collection and storage area shall be protected by a radiant-energy detection system installed in accordance with *NFPA 72*.

14.3.2.4 Containers Approved for Transportation. Batteries shall be permitted to be stored in containers approved for use in transportation that will prevent an event from propagating beyond the container.

14.3.2.4.1 Each area containing the approved transportation containers shall not exceed 200 ft^2 (18.58 m^2) in area and shall be separated from other battery storage areas by a minimum of 10 ft (3 m).

14.3.2.4.2 The storage area shall be protected by a radiant-energy detection system installed in accordance with *NFPA 72*.

14.3.2.5 Indoor Storage Areas. Batteries shall be permitted to be stored in indoor storage areas meeting the provisions of Section 14.4.

14.4 Indoor Storage.

14.4.1 General.

14.4.1.1 Indoor storage involving used or off-specification lithium-ion or lithium metal batteries or cells not meeting the limitations of Sections 14.2 or 14.3 shall be classified as an industrial high-hazard occupancy and shall comply with Section 14.4.

14.4.1.2 The battery or cell storage shall be in rooms or spaces separated from other areas by fire barriers with a 3-hour fire resistance rating and horizontal assemblies with a 3-hour fire resistance rating constructed in accordance with the local building code.

14.4.1.3 Batteries and cells shall not be located within 10 ft (3 m) of exits from the room or space in which they are stored.

14.4.2 Prevention and Mitigation. A plan that provides for the prevention of fire incidents and includes early detection mitigation measures shall be provided to the AHJ for review and approval.

14.4.3 Fire Detection. The room or space shall be protected by a radiant-energy detection system installed in accordance with *NFPA 72*.

14.4.4 Fire Suppression.

14.4.4.1 The building the battery storage is located in shall be provided with an automatic fire suppression system installed in accordance with NFPA 13.

14.4.4.2 The battery or cell storage room or space shall be protected by a water spray automatic suppression system installed in accordance with NFPA 15.

14.4.5 Explosion Protection. Explosion protection shall be installed in accordance with NFPA 68 or NFPA 69.

14.5 Outdoor Storage Location.

14.5.1 Outdoor storage locations shall comply with the following:

(1) Individual pile sizes shall be limited to 200 ft^2 (18.58 m^2) in area separated from other piles by 10 ft (3 m).
(2) Piles located outdoors shall be separated by a minimum 20 ft (6.1 m) from the following exposures:
    (a) Lot lines
    (b) Public ways
    (c) Buildings
    (d) Other storage
    (e) Hazardous materials
    (f) Other exposure hazards

14.5.2 Clearances shall be permitted to be reduced to 3 ft (0.9 m) when a 3-hour freestanding fire barrier, suitable for exterior use, and extending 15 ft (1.5 m) above and extending 15 ft (1.5 m) beyond the physical boundary of the pile is provided to protect the exposure.

Chapter 15 One- and Two-Family Dwellings and Townhouse Units

15.1* General. ESS installations associated with one- or two-family dwellings or townhouse units shall comply with the requirements of this chapter.

15.2 Equipment Listings.

15.2.1 ESS 1 kWh or greater in maximum stored energy shall be listed and labeled in accordance with UL 9540.

15.2.2 ESS listed and labeled solely for utility or commercial use shall not be used for residential applications.

15.3 Installation. ESS shall be installed in accordance with the manufacturer's instructions and their listing.

15.4 Commissioning.

15.4.1 ESS installed in one- and two-family dwellings and townhouse units shall be commissioned as follows:

(1) Verify that the system is installed in accordance with the approved plans and manufacturer's instructions and is operating properly
(2) Provide a copy of the manufacturer's installation, operation, and maintenance instructions provided with the listed system
(3) Provide training on the proper operation and maintenance of the system to the system owner
(4) Provide a label on the installed system containing the contact information for the qualified maintenance and service providers

15.4.2 Where the system is installed in a one- or two-family dwelling or townhouse unit that is owned by the builder and has yet to be sold, commissioning shall be conducted as outlined in Section 15.4, and the builder shall then transfer the required information in Section 15.4 to the home owner when the property is sold.

15.5 ESS Spacing. Individual ESS units shall be separated from each other by a minimum of 3 ft (914 mm) unless smaller separation distances are documented to be adequate as approved by the AHJ, based on large-scale fire testing complying with 4.1.5.

15.6 Location.

15.6.1 ESS shall only be installed in the following locations:

(1) In attached garages separated from the dwelling unit living area and sleeping units in accordance with the local building code
(2) In detached garages and detached accessory structures
(3) Outdoors on exterior walls or on the ground located a minimum of 3 ft (914 mm) from doors and windows
(4) In enclosed utility closets and storage or utility spaces

15.6.1.1 If the room or space where the ESS is to be installed is not finished, the walls and ceiling of the room or space shall be protected with not less than ⅝ in. Type X gypsum board.

15.6.2 ESS shall not be installed in living area of dwelling units or in sleeping units other than within utility closets and storage or utility spaces.

15.7 Energy Ratings. Individual ESS units shall have a maximum stored energy of 20 kWh.

15.7.1 The aggregate rating amount within a dwelling, garage, or accessory structure shall not exceed the following:

(1) 40 kWh within utility closets and storage or utility spaces
(2) 80 kWh in attached or detached garages and detached accessory structures
(3) 80 kWh on exterior walls
(4) 80 kWh in outdoor installations

15.7.2 ESS installations with an aggregate energy rating exceeding that allowed by 15.7.1 shall comply with Chapters 4 through 9.

15.7.3* The use of an electric-powered vehicle to power the dwelling while parked shall comply with Section 15.13.

15.8 Electrical Installation. ESS shall be installed in accordance with *NFPA 70*.

15.8.1 Inverters shall be listed and labeled in accordance with UL 1741 or provided as part of the UL 9540 listing.

15.8.2 Systems connected to the utility grid shall use inverters listed for utility interaction.

15.9 Fire Detection.

15.9.1 Interconnected smoke alarms shall be installed throughout the dwelling, including in rooms, attached garages, and areas in which ESS are installed in compliance with local building code.

15.9.2 Where ESS are installed in an attached garage or an area in which smoke alarms cannot be installed in accordance with their listing, an interconnected listed heat alarm shall be installed and be connected to the smoke alarm system required by the local building code.

15.10 Protection from Impact. Stationary storage battery systems installed in a location subject to vehicle damage shall be protected by approved barriers.

15.11 Exhaust Ventilation. Indoor installations of ESS that include batteries that produce hydrogen or other flammable gases during charging shall meet the exhaust ventilation requirements in accordance with Section 4.9.

15.12 Toxic and Highly Toxic Gas. ESS that have the potential to release toxic or highly toxic gas during charging, discharging, and normal use conditions shall be installed outdoors.

15.13 Electric Vehicle Use.

15.13.1 The temporary use of the dwelling unit owner's or occupant's electric-powered vehicle to power the dwelling while parked in an attached or detached garage or outside shall comply with the vehicle manufacturer's instructions and *NFPA 70*.

15.13.2 The temporary use of the dwelling unit owner's or occupant's electric-powered vehicle to power the dwelling while parked in an attached or detached garage or outside shall not exceed 30 days.

Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.3 These portable devices are typically consumer devices that can be listed to UL 2743 or other equivalent standards. The aggregate capacity in Table 1.3 should be the aggregate capacity per fire area.

A.1.4.2 In order to help determine if an existing ESS installation presents an unacceptable risk and that retroactivity should apply, the AHJ can request a hazard mitigation analysis be submitted by the owner in accordance with 4.1.4.

Based on the hazardous mitigation analysis, the AHJ can apply retroactively any portions of this standard deemed appropriate to mitigate any hazards that could be identified in the risk assessment as unacceptable.

A.1.5 Data and analysis that documents equivalency with the intent of this standard should be prepared and submitted to the AHJ.

A.3.2.1 Approved. The National Fire Protection Association does not approve, inspect, or certify any installations, procedures, equipment, or materials; nor does it approve or evaluate testing laboratories. In determining the acceptability of installations, procedures, equipment, or materials, the authority having jurisdiction may base acceptance on compliance with NFPA or other appropriate standards. In the absence of such standards, said authority may require evidence of proper installation, procedure, or use. The authority having jurisdiction may also refer to the listings or labeling practices of an organization that is concerned with product evaluations and is thus in a position to determine compliance with appropriate standards for the current production of listed items.

A.3.2.2 Authority Having Jurisdiction (AHJ). The phrase “authority having jurisdiction,” or its acronym AHJ, is used in NFPA documents in a broad manner, since jurisdictions and approval agencies vary, as do their responsibilities. Where public safety is primary, the authority having jurisdiction may be a federal, state, local, or other regional department or individual such as a fire chief; fire marshal; chief of a fire prevention bureau, labor department, or health department; building official; electrical inspector; or others having statutory authority. For insurance purposes, an insurance inspection department, rating bureau, or other insurance company representative may be the authority having jurisdiction. In many circumstances, the property owner or his or her designated agent assumes the role of the authority having jurisdiction; at government installations, the commanding officer or departmental official may be the authority having jurisdiction.

A.3.2.4 Listed. The means for identifying listed equipment may vary for each organization concerned with product evaluation; some organizations do not recognize equipment as listed unless it is also labeled. The authority having jurisdiction should utilize the system employed by the listing organization to identify a listed product.

A.3.3.1 Apartment Building. NFPA *101* specifies that, wherever there are three or more living units in a building, the building is considered an apartment building and is required to comply with either the provision of Chapter 30 or Chapter 31 of NFPA *101*, as appropriate. Townhouse units are considered to be apartment buildings if there are three or more units in the building. The type of wall required between units in order to consider them to be separate buildings is normally established by the authority having jurisdiction. If the units are separated by a wall of sufficient fire resistance and structural integrity to be considered as separate buildings, then the provisions of Chapter 24 of NFPA *101* apply to each townhouse. Condominium status is a form of ownership, not occupancy; for example, there are condominium warehouses, condominium apartments, and condominium offices. [***101***, 2018]

A.3.3.2.1 Flow Battery. Typically, a flow battery includes storage tanks and pumps.

A.3.3.5.1 One- and Two-Family Dwelling Unit. The application statement of 24.1.1.1 of NFPA *101* limits each dwelling unit to being “occupied by members of a single family with not more than three outsiders.” NFPA *101* does not define the term *family*. The definition of family is subject to federal, state, and local regulations and might not be restricted to a person or a couple (two people) and their children. The following examples aid in differentiating between a single-family dwelling and a lodging or rooming house:

(1) An individual or a couple (two people) who rent a house from a landlord and then sublease space for up to three individuals should be considered a family renting to a maximum of three outsiders, and the house should be regulated as a single-family dwelling in accordance with Chapter 24 of NFPA *101*.
(2) A house rented from a landlord by an individual or a couple (two people) in which space is subleased to 4 or more individuals, but not more than 16, should be considered and regulated as a lodging or rooming house in accordance with Chapter 26 of NFPA *101*.
(3) A residential building that is occupied by 4 or more individuals, but not more than 16, each renting from a landlord, without separate cooking facilities, should be considered and regulated as a lodging or rooming house in accordance with Chapter 26 of NFPA *101*.

[***101***, 2018]

A.3.3.7 Electrochemical Double Layer Capacitor (EDLC). These capacitors can also be referred to as ultra-capacitors, super capacitors, double layer capacitors, electrochemical capacitors, and so forth.

A.3.3.8 Energy Storage Management System (ESMS). This system can control one or more individual management systems such as battery management systems (BMS).

A.3.3.9 Energy Storage Systems (ESS). ESS include but are not limited to the following categories:

(1) Chemical: hydrogen storage
(2) Thermal: thermal energy storage
(3) Electrochemical:
    (a) Batteries
    (b) Flow batteries
(4) Mechanical:
    (a) Flywheel
    (b) Pumped hydro
    (c) Compressed air energy storage (CAES)

(5) Electrical:
   (a) Capacitors
   (b) Superconducting magnetic energy storage (SMES)

These systems can have ac or dc output for utilization and can include inverters and converters to change stored energy into electrical energy. It is not the intention for ESS to include energy generation systems.

A.3.3.9.1.1 Electrochemical Energy Storage System. The electrochemical energy is related to fuel cells, photoelectrochemical cells, and systems such as batteries.

A.3.3.9.1.2 Mechanical Energy Storage System. The mechanical energy is related to fly wheels, pump storage, compressed air systems, and systems such as reservoirs, pressure vessels, or magnets.

A.4.1 Chapter 4 requirements are intended to be applicable to all ESS technologies. However, it is recognized that hazards and mitigation requirements differ among the various ESS technologies covered by Chapters 9 through 15. This section allows requirements in those chapters to supplement or supersede the general requirements of Chapter 4.

A.4.1.1 The installation of a mechanical exhaust system as part of the system to pick up and exhaust the contaminants released is an acceptable method to meet the requirements of this section. It is not the intent of this section to address the presence of toxic and highly toxic gases that are produced during abnormal conditions, such as a fire in the building.

A.4.1.2.3(3) The term personnel can refer to a call center, an individual, or department that has responsibility for the operation and maintenance of the ESS.

A.4.1.3.1 NFPA 1620 provides criteria for developing pre-incident plans for use by personnel responding to emergencies. It can be a useful resource to help in the development of pre-incident plans to assist personnel in effectively managing incidents and events for the protection of occupants, responding personnel, property, and the environment.

A.4.1.3.2.1.4(3) The energy storage management system (ESMS) monitors and responds to a variety of normal and off-normal conditions associated with the ESS. Many of these conditions are associated with nonemergency conditions, such as the energy efficiency and minor voltage fluctuations. Off-normal conditions can also signal the need for maintenance and service, or in some cases shut down of the ESS until the condition can be evaluated by trained personnel. There can be certain ESMS notifications that the fire department wishes to be notified of, and these need to be included in the facility emergency operations plan. The degree of hazard associated with the notification will let the fire department know what level of response, if any, is required for the off-normal condition.

A.4.1.3.2.1.4(4) Procedures can include sounding the alarm, notifying the fire department, evacuating personnel, de-energizing equipment, and controlling and extinguishing the fire.

A.4.1.4.1 One form of hazard mitigation analysis (HMA) is a failure mode and effects analysis (FMEA), which is a systematic technique for failure analysis. An FMEA is often the first step of a system reliability study and involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes and their causes and effects. For each component, the failure modes and their resulting effects on the rest of the system are recorded. Other formal methodologies for conducting the analysis can also be used depending on the complexity and type of the system being assessed. Guidance for analysis can be found in the following standards:

(1) IEC 60812, *Analysis techniques for system reliability — Procedure for failure mode and effects analysis (FMEA)*
(2) IEC 61025, *Fault tree analysis (FTA)*
(3) MIL-STD-1629A, *Procedures for Performing a Failure Mode, Effects and Criticality Analysis*

A.4.1.4.5 In order for the ESS to comply with the hazard mitigation analysis acceptance criteria, the building owner could be requested to provide construction, equipment, and protection systems in addition to those identified in this standard. This section clarifies that these protection measures must be installed, tested, and maintained in accordance with nationally recognized standards.

A.4.1.5.1 A UL 9540A test, or equivalent, methodology should evaluate the fire characteristics of an ESS that undergoes thermal runaway, such as might occur due to a fault, physical damage, or exposure hazard. The data generated by the large-scale fire testing is intended to be used by manufacturers, system designers, and AHJs to determine the fire and explosion protection required for an ESS installation.

A.4.1.5.4 The test report will provide nonproprietary information that, among other things, describes the size and energy capacity rating of the unit being tested, model numbers of the modules and ESS units, orientation of ESS in the test facility, and proximity of the ESS unit under test to adjacent ESS, walls, and monitoring sensors. The test report also includes a complete set of test results and measurements.

A.4.2.1 It is envisioned that equipment provided will be listed in accordance with UL 9540. ESS that are not listed in accordance with UL 9540 should be documented and verified as meeting the provisions of this standard using the equivalency requirements in Section 1.5, where technical documentation provided shows the ESS that is proposed results in a system that is no less safe than a system meeting the construction and performance requirements of UL 9540. If nonlisted equipment is to be evaluated for compliance with UL 9540, the evaluation and documentation should be provided as part of a field evaluation conducted by an approved third-party certification organization.

In specific instances, this standard will not require equipment such as lead-acid batteries to be listed.

A.4.2.1.2 This subsection is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.2.3.3 This subsection is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.2.8.2 A utility-interactive inverter forms a protective barrier between the dc power source side of the inverter and the ac utility interface. In the event of an out-of-tolerance utility connection, the inverter shuts down the ac output. Inverters investigated and listed for this application in accordance with UL 1741 include a "utility-interactive inverter" marking.

A.4.2.9 The most common form of energy storage management system is a battery management system that plays a critical role in verifying that the system parameters identified are maintained within safe values for the ESS technology involved. In addition to shutting down the system, the ESMS can also transmit system status conditions to on-site and off-site personnel to notify them of the off-normal condition.

A.4.2.9.3 Local visible annunciation, when required by the AHJ, is intended to provide on-scene emergency responders with information about potentially hazardous conditions with the ESS so appropriate deployment tactics can be taken. It is not the intent of this section to require the ESMS to transmit alarm signals to an off-site locale. The ESS manufacturer is most qualified to identify conditions with its equipment that constitutes a hazardous, not just abnormal, condition. These conditions typically include high temperature but might also include other conditions such as overcharge, short circuit, etc. The AHJ should consult with individuals responsible for the system to verify that the conditions used to identify a hazardous condition are understood and acceptable, and the location of the unit in trouble is adequately identified.

Visible annunciation can consist of a colored light on an ESS unit, an annunciation panel, or other approved means.

A.4.2.9.5 This is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.3.2 Adequate working space is vital for electrical safety-related work practices. Articles 110 and 706 of *NFPA 70* provide working space requirements for electrical equipment. NECA 416 is another installation standard that provides guidelines for working space requirements.

A.4.3.5 Signage provides important information for fire fighters and emergency responders who respond to a fire or other incident in a building or facility in which ESS is contained. Being able to quickly understand the following is critical to maintain their safety:

(1) The presence and location of multiple disconnects that can be used to de-energize and isolate portions of the electrical system
(2) The location of ESS rooms and areas and the types of ESS within the room or area
(3) Significant hazards associated with the ESS technology present

The intent of this standard is to allow flexibility in the exact wording used on required signage so conflicts are not created with other codes and standards.

Some jurisdictions can choose to supplement these required markings with NFPA 704 hazard identification system markings or the fire fighter safety building marking system described in Annex E of NFPA 1. However, some ESS technologies have hazards not clearly categorized in the hazard ranking system or present no hazards.

A.4.3.5.2 This sign can be broken into multiple segments. An example of this would be if the manufacturer provides their own separate signage about the fire suppression system.

A.4.3.7.3 Guard post spacing can be required with greater spacing requirements based on location.

A.4.3.7.4 ESS installed in residential garages should not be installed in a location where a motor vehicle being parked in the garage could come in contact with the ESS. Protection can be provided by approved barriers, by locating the ESS upon a 6 in. (152.4 mm) high platform located to the side of the garage, by locating the ESS components at a level above the potential impact height, or by recessing the ESS to one side of the space where the garage door is not the full width of the garage.

A.4.3.9.3(2) This is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.4.3.5.2 Walk-in ESS are units where personnel can enter the enclosure or container housing the system or system components for any reason. This includes ESS enclosed within an outer enclosure similar to an ISO shipping container. It does not include ESS cabinets where personnel can partially enter into the outer enclosure to perform service or maintenance.

A.4.4.3.9 Classified areas might contain hazardous and flammable atmospheres that could damage an ESS installation. ESS installations might also provide an ignition source for these atmospheres unless properly listed. See *NFPA 70*, IEEE C2, NFPA 497, or NFPA 499 for more information.

A.4.6 This section includes requirements designed to keep fires originating in a single energy storage unit from easily spreading to adjacent energy storage units or out of the fire area in which the ESS is installed. This is done by limiting potential fire size within an individual energy storage unit by limiting the total energy capacity of individual units. It also reduces the potential of fire originating in one unit from igniting an adjacent unit, or breaching a fire resistance rated wall through radiant heat transfer by requiring spacing between individual energy storage units, and between units and walls. An option is provided for increasing individual unit energy capacity or reducing spacing by successfully passing large-scale fire testing in accordance with 4.1.5.

A.4.6.6 This is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.7 An occupied work center is typically an area in which stationary battery systems are provided in an electronic equipment or computer room with occupiable space. Personnel in these locations are not responsible for maintaining or servicing the battery systems. The requirements in this section are provided to help ensure their safety and the safety of emergency responders dispatched to the work area.

A.4.9 This section addresses hazards associated with the release of flammable gases from ESS during normal charging, discharging, and use conditions. Similar requirements have been in fire codes for many years primarily to address off-gassing of hydrogen from stationary vented lead-acid battery systems but not limited to that technology.

This section is not intended to provide protection against the release of flammable gases during abnormal charging or thermal runaway conditions. Those conditions are addressed in Section 4.12. In addition, this section does not regulate ventilation of toxic and highly toxic gases, which are regulated by 4.1.1.

A.4.9.2 See IEEE 1635/ASHRAE 21 which covers the ventilation of stationary battery systems utilizing vented (flooded) lead-acid, valve-regulated lead-acid (VRLA), and nickel-cadmium (Ni-Cad) batteries.

A.4.10.2 This requirement is intended to address small, normally unoccupied structures in remote locations, such as repeater stations, which are not adjacent to other important buildings or structures. It is not intended to apply to structures in an urban or suburban setting. The AHJ determines which structures are considered to be remote. The hardship of installing and maintaining smoke detection in these small, remote structures, along with heating and cooling to maintain the smoke detectors within listing specifications, is a reason for this exclusion.

A.4.10.3 This is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.11.1 Fire control and suppression is only required to protect ESS when so specified elsewhere in the standard, such as Table 4.4.2, Table 4.4.3, and Table 4.4.4.

The fire control and suppression systems requirements in this section are intended to provide protection in ESS rooms and outdoor walk-in units containing ESS. The protection serves the following two purposes:

(1) Protect the building and nearby exposures from a fire initiating in the ESS
(2) Provide protection for ESS from an external exposure fire that impinges on the ESS

A phased approach to suppression can help mitigate failure points and limit fire impacts that can potentially lead to thermal runaway or other more severe fire conditions.

Thermal Runaway. While non-water-based fire suppression has been shown to be effective at suppressing Class B and Class C fires in ESS enclosures, current suppression agents, both water based and non-water based, are probably not going to be able to stop thermal runaway. No published case studies, test reports, or data generated to date indicate otherwise. The current protection concepts in this standard, including size and separation, maximum rated energy, and elevation, are designed to try and keep a thermal runaway event from propagating from one ESS unit to another, contain a fire within a room or outdoor walk-in unit, and not allow it to compromise exposures.

A.4.11.2.2 UL 9540A Installation Level Test, Method 1, provides the data needed to determine if automatic sprinkler design densities can be changed. A sprinkler density in excess of 0.3 gpm/ft^2 (12.2 mm/min) can be necessary to provide an adequate level of protection, especially for some lithium-ion battery ESS designs. However, test results for some ESS designs and technologies indicate sprinkler densities less than 0.3 gpm/ft^2 (12.2 mm/min) could be acceptable. Equivalent test standards, as permitted in 4.1.5, might provide comparable data.

A.4.11.3.1 UL 9540A Installation Level Test, Method 2, provides the data needed to determine if other fixed fire control and suppression systems are suitable for the application. Equivalent test standards, as permitted in 4.1.5, can provide comparable data.

A.4.11.3.2 *Gaseous Agents.* Gaseous agent fire suppression systems can be used to protect ESS fires in either of the following two ways:

(1) Total flooding systems are used where there is a permanent enclosure around the fire hazard that is adequate to enable the design concentration to be built up and maintained for the period of time required to ensure the complete and permanent extinguishment of a fire for the specific combustible materials involved. For total flooding systems, potential leakage sources should be included in the gaseous agent design quantities, which should include leakage through ventilation dampers. Usually ventilation dampers are either gravity actuated (i.e., close when the ventilation fans automatically shut down upon gaseous agent discharge) or pressure actuated (i.e., close by means of counterweight and a pressure-operated latch that is activated by the gaseous agent). Leakage from the interface between the enclosure walls and the foundation should also be taken into consideration. For ESS enclosures where the normal temperature of the enclosure exceeds 200°F (93°C) or is below 0°F (−18°C), gaseous agent levels should be adjusted as required by the appropriate NFPA standard or the manufacturer's instruction manual.
(2) Local application systems are used for the extinguishment of surface fires of combustible gases, liquids, or solids, where the fire hazard is not enclosed or where the enclosure does not conform to the requirements for a total flooding system. For local application systems, it is imperative that the entire fire hazard be protected. The hazard area should include all areas that are subject to spillage, leakage, splashing, condensation, and so forth, and are of combustible materials that might extend a fire outside the protected area or lead a fire into the protected area. This type of hazard could necessitate dikes, drains, or trenches to contain any combustible material leakage. When multiple ESS equipment fire hazards are in an area such that they are interposing, provisions should be made to ensure that the hazards can be protected simultaneously, which could involve subdividing the hazards into sections and providing independent protection to each section.

Total flooding and local application gaseous agent systems should be designed based on factors including but not limited to the following:

(1) Agent concentrations required for the specific combustible materials involved including building systems and battery electrolytes, whichever are higher
(2) Design concentration for the electrolyte determined by a cup burner test of the appropriate battery electrolyte
(3) Specific configuration of the equipment and enclosure
(4) Design maintains the design concentration within the enclosure for a time to ensure that the fire is extinguished and that the enclosure temperatures of the ESS have has cooled to below the autoignition temperature of combustible material present and below the enclosure temperature that can cause thermal runaway as defined in the emergency operations plan
(5) Suppression systems' inability to cool the internal battery temperature once thermal runaway has started

To reduce potential downtime, gaseous agent fire suppression systems should generally be designed to have the capacity to supply two full discharges to avoid having to keep the ESS shut down until the gaseous agent reservoir can be replenished, particularly after a minor fire or accidental discharge. Two full discharges should use 90 percent of the total gaseous agent reservoir capacity as an optimum design; however, up to 95 percent is acceptable. For applications where ambient temperatures are above the normal operating conditions of the gaseous agent reservoir, a shelter with ventilation openings or an equivalent alternative should be used. Where ambient temperatures are below the normal operating conditions of the gaseous agent reservoir, reservoir heaters (such as immersion heaters) and instrument line heaters should be used or, where applicable, the reservoir can be superpressurized with nitrogen to maintain the required flows and pressures in a low-temperature environment. Warning signs and safety instructions are required on some types of gaseous agent systems. The user should refer to the appropriate NFPA standards for those systems for detailed requirements.

Where total flooding gaseous systems are used, the ESS enclosure should be arranged for minimum leakage by automatic shutdown of fans and automatic closing of doors, ventilation dampers, and other openings. During operation of an ESS, there could be a need for substantial amounts of cooling and ventilation air. This air flow will not stop immediately upon ESS shutdown and should be considered in the extinguishing system design. Also, continuous mixing per 5.3.6 of NFPA 2001 can be considered as it can help cooling, improve mixing, and improve dispersion of agent in to the battery rack.

If gas levels should continue to increase during a fire event an operating device should be available in an approved location such that fire services can begin exhaust prior to hold time expiration if deemed necessary.

Suppression systems can extinguish a fire but will not stop thermal runaway or off gassing if the cells are damaged, creating a potential explosive environment. Similar to a natural gas fire, if gas is allowed to accumulate, a more hazardous condition can develop. There might be times that venting is more critical than suppression. If the gas detection system continues to see increasing levels of combustible gas or toxic gases during suppression, venting might be required through either a direct tie to the gas detection system or a manual operation to begin venting. The suppression systems might not have reached their hold times yet and agent might be vented. Even if the fire has been extinguished and hold times have been met, the gas detection system should still be monitored in case of any subsequent events. Venting might be required a later point as well.

Water Mist. Water mist fire suppression systems need to be designed specifically for use with the size and configuration of the specific ESS installation or enclosure being protected. Currently there is no generic design method recognized for water mist systems. System features such as nozzle spacing, flow rate, drop size distribution, cone angle, and other characteristics need to be determined for each manufacturer's system through large-scale fire testing in accordance with 4.1.5 to obtain a listing for each specific application and must be designed, installed, and tested in accordance with NFPA 750.

Discharge Duration. Fire suppression system discharge durations should be held as long as the hazards of temperatures above the autoignition temperature and the temperature at which thermal runaway can occur. The manufacturer should be consulted for applicable ESS cooldown times. Information on fire tests that demonstrate the extinguishment time for an ESS should also be considered in determining the minimum discharge time. It is recommended that the minimum discharge time be no less than twice the time demonstrated to achieve fire extinguishment for the suppressant used. An extended discharge time is necessary to prevent potential fire reignition due to smoldering and heat soak. Where design concentrations cannot be maintained effectively, an alternative system should be provided.

A.4.11.6 This is in line with the scope of 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.12 During failure conditions such as thermal runaway, fire, and abnormal faults, some ESS, in particular electrochemical batteries and capacitors, begin off-gassing flammable and toxic gases, which can include mixtures of CO, H_2, ethylene, methane, benzene, HF, HCl, and HCN. Among other things, these gases present an explosion hazard that needs to be mitigated. Explosion control is provided to mitigate this hazard.

Both the exhaust ventilation requirements of Section 4.9 and the explosion control requirements of Section 4.12 are designed to mitigate hazards associated with the release of flammable gases in battery rooms and walk-in units. The difference is that exhaust ventilation is intended to provide protection for flammable gases released during normal charging and discharging of battery systems since some electrochemical ESS technologies such as vented lead-acid batteries release hydrogen when charging.

In comparison, the Section 4.12 provisions are designed to provide protection for electrochemical ESS during an abnormal condition, such as thermal runaway, which can be instigated by overcharging, short circuiting, and overheating technologies such as lithium-ion batteries, which incidentally do not release detectable amounts of flammable gas during normal charging and discharging, but which can release significant quantities of flammable gas during a thermal event.

A.4.12.1 This requirement targets rooms, buildings, and walk-in units, not ESS in cabinets installed indoors or outdoors or in open parking garages.

NFPA 68 applies to the design, location, installation, maintenance, and use of devices and systems that vent the combustion gases and pressures resulting from a deflagration within an enclosure so that structural and mechanical damage is minimized, and provides criteria for design, installation, and maintenance of deflagration vents and associated components.

NFPA 69 applies to the design, installation, operation, maintenance, and testing of systems for the prevention of explosions in enclosures that contain flammable concentrations of flammable gases, vapors, mists, dusts, or hybrid mixtures by means of the following methods:

(1) Control of oxidant concentration
(2) Control of combustible concentration
(3) Pre-deflagration detection and control of ignition sources
(4) Explosion suppression
(5) Active isolation
(6) Passive isolation
(7) Deflagration pressure containment
(8) Passive explosion suppression

Data on flammable gas composition and release rates, such as that included in UL 9540A large-scale fire testing, provide the information needed to design effective explosion control systems.

A.4.13.1 Water supplies could be one or any combination of the following:

(1) A connection to an approved public or private waterworks system

(2) A connection including a fire pump
(3) A connection to a water storage tank at grade or below grade installed in accordance with NFPA 22 and filled from an approved source
(4) A connection to a pressure tank and filled from an approved source
(5) A connection to a gravity tank and filled from an approved source
(6) A penstock, flume, river, lake, pond, or reservoir
(7) A cistern
(8) A source of recycled or reclaimed water where the building owner (or their agent) has analyzed the water source and the treatment process (if any) that the water undergoes before being made available and determined that any materials, chemicals, or contaminants in the water will not be detrimental to the components with which it is in contact

A.4.13.6 This is in line with the scope of the 90.2(B)(5) of *NFPA 70* and applies to lead-acid or nickel-cadmium batteries.

A.4.14.2 Methods of achieving this protection can include, but are not limited to, the following:

(1) Liquidtight sloped or recessed floors in indoor locations or similar areas in outdoor locations
(2) Liquidtight floors in indoor locations or similar areas in outdoor locations provided with liquidtight raised or recessed sills or dikes
(3) Sumps and collection systems

A.4.15.1 One method to determine compliance with the neutralization requirements of this subsection is found in UL Subject 2436. UL Subject 2436 investigates the liquid tightness, level of electrolyte absorption, pH neutralization capability, and flame spread resistance of spill containment systems.

A.5.1 Installations of communications equipment under the exclusive control of utilities located outdoors or in buildings used exclusively for such installations are outside the scope of *NFPA 70* and are not addressed in this section.

A.5.2 Installations of communications equipment under the exclusive control of utilities located outdoors or in buildings used exclusively for such installations are outside the scope of *NFPA 70*.

A.6.1.1.2 The North American Electric Reliability Corporation (NERC) and Federal Energy Regulatory Commission (FERC) are two examples of entities that have, or are developing, commissioning requirements for electric utilities ESS installations that form the basis for governmental laws and regulations.

A.6.4 After an ESS is commissioned and put into operation, it becomes an existing system. There could come a time when that existing system or impacted portion of a system is altered, repositioned, added to, renovated, or in some way modified beyond simple service or replacement of in-kind parts and components. When any of those activities are conducted on the system, there is no documentation or verification that the system will properly operate (e.g., the original commissioning plan and commissioning report would not necessarily support the system since it was modified in some way by one or more of these activities). That necessitates the resultant system be commissioned again. While the term recommissioning might be used in this case, that term can also be used to describe the conduct (again) of an initial commissioning activity on a new system where that initial commissioning process failed and was redone. With respect to an existing system or impacted portion of a system that has been modified in some way, the intent of the standard is simply to recommission the system in accordance with the recommissioning requirements in Section 6.4.

A.6.4.2 Listed software changes should be considered system renewals because it is a listed change.

A.6.4.4 When listed ESS is modified in the field, it can change its ability to comply with the requirements in the standard used to list the product. It is difficult or impossible for AHJs and service personnel to verify that the modified product complies with those requirements. Certification organizations have the expertise to evaluate modifications and have field evaluation programs to investigate the modified product and provide a field evaluation label on the product. It is not anticipated that a field evaluation is needed to evaluate modifications that are identified in the instruction manual provided with the listed equipment, such as swapping out or adding listed modules. It is also not anticipated that a field evaluation is needed for like-for-like repairs that do not impair the overall safety of the product.

A.7.1.2(6) Examples of engineering documentation include one-line diagrams, lock-out/tag-out procedures, and shock and arc flash labeling.

A.8.1.2 The North American Electric Reliability Corporation (NERC) and Federal Energy Regulatory Commission (FERC) are two examples of entities that have, or might be developing, decommissioning requirements of ESS installations for electric utilities that form the basis for governmental laws and regulations.

A.8.1.3 Considerations that should be included in the decommissioning plan would include but not be limited to the following:

(1) An identification of all energy sources (batteries, connected batteries in other enclosures or structures), inverters [also known as *power conversion systems* (PCS)], dc bus precharge power supplies, UPS, support equipment with batteries, and ac or dc auxiliary power equipment and distribution systems
(2) Information about PPE and requirements for use as needed (site dependent), noting that each electrical equipment cabinet should already have shock and arc flash warning labels applied as per *NFPA 70E*
(3) A notification that the ESS should be discharged to its safe state of charge (SOC) for transport
(4) Assurance that during the decommissioning process, critical support equipment such as, but not limited to, fire detection and suppression equipment, emergency lighting, electrical circuits to facilitate decommissioning, and so forth, remain operational to the extent possible
(5) A warning not to disconnect any ESS grounding until all energy sources are isolated and locked out
(6) A notification to disconnect and shut down all batteries and support or auxiliary equipment associated with the system or its component parts
(7) Isolation of all energy sources, starting with those with highest fault energy, by isolating the ac point of interconnection, then isolating strings, then isolating the individual battery modules
(8) The need to mechanically uninstall battery trays and place them into original or equivalent packing materials or protect terminals

(9) Assurance that the materials are properly classified and packaged based on regulations governing the classification before removing material from the site (e.g., requirement that shipments on public roads comply with DOT regulations, including UN/DOT 38.3-tested packing for Li-ion batteries and UN2800 for VRLA nonspillable batteries)
(10) The need to remove batteries from other equipment associated with the system as part of decommissioning and prior to removal

A.9.1.1 Annex B includes information on general hazards associated with ESS. Section B.5 provides a description of commercially available battery technologies and the hazards associated with them.

A.10.1.4 Capacitors used for utility applications that are not included in this chapter for capacitor ESS are typically technologies that have metallized film electrodes with a polymer film (polypropylene) and aromatic hydrocarbon fluid dielectric and are referred to as metallized film capacitors or all film capacitors.

A.15.1 Dwelling. Any detached building, or any part of a townhouse structure that is separated from the remainder of the townhouse structure with fire resistance rated assemblies in accordance with local building code, that contains no more than two dwelling units intended to be used, rented, leased, let, or hired out to be occupied or that are occupied for habitation purposes. [**13D:**3.3.3]

A.15.7.3 The batteries on electric vehicles should not be included in the aggregate energy capacity limitations in 15.6.1.

Annex B Battery Energy Storage System Hazards

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

B.1 General Introduction. Battery energy storage systems (ESS) that are designed with sufficient safety protections and are installed, operated, and maintained in a manner that maintains the system safety can be operated without incident as evidenced by the systems currently operating safely in the field. The safety controls and hazard mitigation approach needs to consider the inherent hazards associated with these systems, which can vary depending on the battery technology.

B.2 Hazards Concerns.

B.2.1 The hazards that need to be addressed for ESS are fire and explosion hazards, chemical hazards, electrical hazards, stranded or stored energy hazards, and physical hazards. These hazards can vary by technology but can also vary under normal operating conditions compared with emergency and abnormal conditions.

B.2.2 The potential for fire hazards can be evaluated through control of the elements of the fire triangle. These elements are the fuel for the fire, the oxidant, and the ignition source heat. There is no potential for fire unless there is an appropriate concentration of fuel, oxidant, and a heat source sufficient to ignite the concentration.

B.2.3 Chemical hazards are categorized in accordance with OSHA/NIOSH hazardous materials limits for normal operation of the ESS and NFPA 704 for ESS involved in a fire or other emergency incident.

B.2.4 Electrical hazards for persons working with ESS where they might come in contact with energized parts greater than 50 V and exposed to arcing of electric energy with an incident energy level of 1.2 cal/cm^2 (5 J/cm^2) (potential to cause second-degree burns on skin), are electrical shock and arc flash as identified in *NFPA 70E*. Electrical hazards to emergency responders from ESS that have been exposed to fire or other emergency incidents need to be addressed, including the potential for arc faults and shock hazards due to shorting from damaged parts and water. Since first responders are not trained electrical workers and might not have appropriate PPE for direct contact with live parts or arc flash incidents, acceptable levels of voltage and incident energy need to be reduced from that allowed for trained workers with suitable PPE.

B.2.5 The term *stranded or stored* energy refers to unquantified hazardous levels of electrical energy that can be contained in all or part of an ESS, including one that has been damaged and/or thought to be discharged and that represents a hazard to persons in contact with the system, who are unaware of the hazardous energy. Since this hazard represents a potential unquantified electrical hazard, the allowed levels will be different depending on whether it pertains to normal conditions for repair and replacement by trained workers or for emergency responders dealing with damaged ESS that can still contain hazardous energy.

B.2.6 Physical hazards are hazards to persons that can occur from contact with parts having sufficient kinetic energy, parts that have hazardous thermal characteristics that can cause burns, or parts that contain fluids at hazardous pressure levels with either insufficient structural integrity to safely contain the fluids or the ability to safely relieve the pressure. For electrochemical ESS, the potential exists for burn hazards to workers in contact with some technologies during normal operation and repair, if not properly thermally insulated.

B.2.7 There are no known high-pressure hazards with these systems under normal operations, but under abnormal conditions, there can be overpressurization due to overheating of contents, which can result in a physical hazard. This could present a hazard to first responders dealing with damaged ESS. There are also no kinetic energy hazards associated with commercially available battery ESS, except for moving parts in the balance of plant components of the system that might not be properly guarded, such as cooling or ventilation fan blades.

B.3 Hazard Considerations Under Normal Operating Conditions.

B.3.1 Fire and Explosive Hazards. Fire and explosive hazards under normal operating conditions can be due to heat sources such as live parts, and so forth, that can be in contact with combustible materials during service or maintenance or to ignition of combustible concentrations or flammable fluids and solids that can occur as part of the normal operation of ESS, such as hydrogen off-gassing from batteries with aqueous electrolytes that are open to the atmosphere.

B.3.2 Chemical Hazards. Under normal operating conditions, the potential exists for exposure to hazardous materials by workers in contact with the system for maintenance, repair, and replacement of systems. OSHA and NIOSH have guidelines on exposures to hazardous materials, including limits for workers that have the potential for exposure during normal operation maintenance, and so forth.

Examples of chemical hazards are as follows:

(1) Liquid hazards:

(a) Corrosive electrolytes: Batteries with electrolytes in the range of pH ≤2 or ≥11.5 are considered corrosive (acid or caustic). This is an issue with systems with these electrolytes, where there can be a situation of leaks or spills during maintenance or normal operation. There should be measures for spill control, and workers should have appropriate safe work procedures and protective clothing to work around systems with these corrosive liquids.

(b) Toxic liquids: The potential exists for exposure to toxic liquids during normal operating, servicing, and maintenance of some systems. Guidance for worker exposure to toxic liquids can be found in OSHA hazardous materials guidelines. Workers in contact with these systems need to be aware of potential hazards and have appropriate procedures and equipment/PPE to avoid these hazards.

(2) Oxidizers: The potential exists for oxidizers to be present within the ESS. An oxidizer will increase the flammability potential of other materials. Annex G in NFPA 400 provides information on tests to classify an oxidizer material and identifies known oxidizing materials under their classifications. Annex G in NFPA 400 also provides guidance on safety measures to use when there are significant exposed quantities of known oxidizers, which can occur during normal maintenance conditions of certain ESS technologies that contain them.

(3) Gases — Toxic gases: The potential exists for exposure to toxic gases under normal conditions of maintenance and service of some ESS systems. OSHA and NIOSH provide guidance for exposures, including permissible exposure limits (PEL), recommended exposure limits (REL) for exposure during an 8- or 10-hour workday, ceiling limits, which are the upper limit of a safe exposure, and IDLH, which represents concentrations that are immediately dangerous to life and health.

(4) Solids: Water-reactive and toxic metals that might be contained in some battery technologies typically are not exposed during routine maintenance and servicing of these systems but can present issues under abnormal conditions. Batteries containing these hazardous materials should be marked with the NFPA 704 diamond hazard symbols.

B.3.3 Electrical Hazards. Under normal operating conditions some battery systems might have electrical hazards that need to be addressed as part of operation and maintenance. Electrical hazards that can occur during normal operating conditions follow:

(1) Electrical shock: ESS with voltages above 50 V (per *NFPA 70E* limits for electrical shock) can pose hazards to trained workers who might come in contact with live parts during operation and servicing of the systems. It is necessary that appropriate labeling and procedures and protective equipment are utilized by workers when servicing these systems.

(2) Arc flash: ESS that have an incident energy level greater than 1.2 cal/cm^2 (5 J/cm^2) should have the arc flash boundaries calculated, identified through markings, and proper procedures and equipment in place to prevent worker injury from arc flash during normal operation and servicing.

(3) Stranded or stored energy hazards: Energy that can be accumulated and reserved for future use, generally in the form of electricity, is stranded or stored energy. An example of a stranded or stored energy hazard is worker exposure to ESS that are not discharged sufficiently or ESS that are damaged and where the potential exists for electric shock and arc flash issues. For normal operating conditions, sites housing commercial and industrial battery ESS should maintain onsite instructions for isolation of hazardous voltage and energy for maintenance and for discharging batteries for safe replacement and disposal. Residential and smaller commercial systems should have information provided and access to trained technicians to perform these duties to ensure that stranded and stored energy do not represent a hazard under normal operating conditions.

B.3.4 Physical Hazards. Physical hazards can include the following:

(1) Burn hazards: Potential contact with hot surfaces during maintenance that could result in burns if not wearing PPE.

(2) Parts containing pressurized fluids, including compressed gasses.

(3) Parts with kinetic energy: Parts of the ESS balance of plant components that might contain moving parts that could cause injury if not guarded properly. This might also be an issue for a hybrid system of batteries and flywheels.

B.4 Hazard Considerations Under Emergency/Abnormal Conditions.

B.4.1 Fire Hazards. Fire hazards can include the following:

(1) Combustible/flammable concentrations due to overheating and venting of flammable gases near sources of ignition can occur during emergency/abnormal conditions. If concentrations of vented gases such as hydrogen are sufficient to create combustible/flammable concentrations in the presence of hot parts, there will be ignition resulting in either a fire or an explosion. All batteries, with the exception of hermetically sealed types such as sodium beta, have means to relieve internal pressure when overheated to prevent explosions of the battery cell from overpressurization.

(2) There can be fires due to overheating of electrical parts under abnormal conditions such as short circuits.

B.4.2 Chemical Hazards. Examples of chemical hazards are as follows:

(1) Liquid hazards such as the following:

(a) Corrosive spills: A liquid with a pH ≤2 or ≥11.5 is considered corrosive and hazard level 3 and can cause serious or permanent eye injury for someone who comes in direct contact with it per Table B.1, Health Hazard Rating Chart, in NFPA 704. With some systems that contain corrosive liquids, there can be the possibility of leaks or spills from the system under emergency/abnormal conditions. Batteries containing corrosive liquids are to be marked health hazard level 3 in the NFPA 704 hazard diamond.

(b) Toxic liquid vapor exposure: There are different levels of toxicity from liquid vapors that can occur under emergency conditions such as fires and hazardous leaks and spills. There are a range of hazard levels outlined in NFPA 704 as follows:

i. Level 4: Is lethal under emergency conditions. Any liquid whose saturated vapor concentration at 68°F (20°C) is equal to or greater than 10 times its LC_{50} for acute inhalation toxicity, if its LC_{50} is less than or equal to 1000 ppm
ii. Level 3: Can cause serious or permanent injury. Any liquid whose saturated vapor concentration at 68°F (20°C) is equal to or greater than its LC_{50} for acute inhalation toxicity, if its LC_{50} is less than or equal to 3000 ppm, and that does not meet the criteria for degree of hazard 4
iii. Level 2: Can cause temporary incapacitation or residual injury under emergency conditions. Any liquid whose saturated vapor concentration at 20°C (68°F) is equal to or greater than one-fifth its LC_{50} for acute inhalation toxicity, if its LC_{50} is less than or equal to 5000 ppm, and that does not meet the criteria for either degree of hazard 3 or degree of hazard 4
iv. Level 1: Can cause significant irritation under emergency conditions. Mists whose LC_{50} for acute inhalation toxicity is greater than 10 mg/L but less than or equal to 200 mg/L

(2) Oxidizers: The potential exists for oxidizers to be present within the ESS. An oxidizer will increase the intensity of a fire of other materials. Annex G in NFPA 400 provides information on tests to classify an oxidizer material and identifies known oxidizing materials under their classifications. Annex G in NFPA 400 also provides guidance on safety measures to use when there are significant exposed quantities of known oxidizers, which can occur during abnormal conditions of certain ESS technologies that contain them. Batteries containing oxidizers are to be marked in the special hazard section of the NFPA 704 hazard diamond.
(3) Solids: Some battery technologies contain water-reactive material that can react violently when in contact with moisture, including moisture in the air. Although not exposed under normal operating conditions, these materials could be exposed under abnormal conditions. Batteries containing water-reactive substances should be marked as such in the NFPA 704 hazard diamond.
(4) Gases — Toxic gases: Similar to toxic vapors emanating from liquids, there are different levels of hazards associated with toxic gases from level 4 to level 1:

(a) Level 4: Gases that can be lethal under emergency conditions; gases whose LC_{50} for acute inhalation toxicity is less than or equal to 1000 parts per million (ppm)
(b) Level 3: Gases that can cause serious or permanent injury under emergency conditions; gases whose LC_{50} for acute inhalation toxicity is greater than 1000 ppm but less than or equal to 3000 ppm
(c) Level 2: Gases that can cause temporary incapacitation or residual injury under emergency conditions; gases whose LC_{50} for acute inhalation toxicity is greater than 3000 ppm but less than or equal to 5000 ppm
(d) Level 1: Gases that can cause significant irritation under emergency conditions; gases and vapors whose LC_{50} for acute inhalation toxicity is greater than 5000 ppm but less than or equal to 10,000 ppm

Note: As outlined in NFPA 704, LC_{50} for acute toxicity on inhalation is that concentration of vapor, mist, or dust, which, when administered by continuous inhalation to both male and female young adult albino rats for 1 hour, is most likely to cause death within 14 days in one half of the animals tested. The criteria for inhalation toxicity of vapors are based on LC_{50} data relating to 1-hour exposures.

B.4.3 Electrical Hazards. Examples of electrical hazards are as follows:

(1) Electrical shock: Circuits with voltages above 50 V have the potential for electrical shock hazards, because first responders under emergency conditions would not have the training and protective equipment that trained electrical workers would have under normal servicing and maintenance conditions. Information needs to be available for maintenance staff and first responders on how to address electrical hazards. In addition, under emergency conditions the potential exists for emergency responder exposure to live parts in contact with conductive fluids such as water and live parts exposed as a result of abnormal conditions. Manufacturers/installers of battery energy systems should define standoff distance and type and angle of water spray for first responders. Emergency response guidelines as outlined in 4.1.3.2.1.3 should address the issue of isolation of hazardous voltages.
(2) Shock, arc flash, and arc blast hazards: First responders are generally not provided with training and proper protection from arc flash, arc blast, and shock hazards, including clothing, gloves, and so forth, so the potential for sufficient energy that will result in a hazardous electrical event occurring during an emergency response exists. Manufacturers should provide emergency response guidance on how to reduce arc flash and blast hazards. See the emergency response guidance in 4.1.3.2.1.3.
(3) Stranded or stored energy hazards: ESS damaged during an emergency incident can present potential shock, arc flash, arc blast, and reignition hazards. Sites should have access to on-call trained staff to assist in emergency situations to isolate potential hazard energy and, if necessary, to drain energy to prevent potential reignition of some technologies at a later time. For commercial and industrial installations, there needs to be trained personnel available for emergency response on site. For residential and smaller scale commercial systems, on-call trained personnel need to be made available to assist first responders and address discharging of stored energy in batteries for disposal.

Note: UL research into the issue of potential shock to fire fighters from water spray on PV fires indicated that the electric shock hazard due to application of water is dependent on voltage, water conductivity, distance, and spray pattern. For example:

(1) A slight adjustment from a solid stream toward a fog pattern (a 10-degree cone angle) reduced measured current below perception level.
(2) Salt water should not be used on live electrical equipment.
(3) A distance of 20 ft (6.1 m) had been determined to reduce potential shock hazard from a 1000 V dc source to a level below 2 mA considered as safe.

B.4.4 Physical Hazards. Examples of physical hazards are as follows:

(1) Hazardous pressures can develop due to overheating of equipment and devices that do not have pressure relief means (for some chemistries such as flow batteries, etc.)
(2) Potential hot parts
(3) Exposed parts with hazardous kinetic energy sufficient to cause bodily harm for persons coming in contact with them, such as exposed fan blades, and so forth, under abnormal conditions

B.5 Commercially Available Battery Technologies.

B.5.1 Flow Batteries — General Description. A flow battery is an energy storage component similar to a fuel cell that stores its active materials in the form of electrolytes external to the reactor interface. When in use, the electrolytes are transferred between reactor and storage tanks. Two commercially available flow battery technologies are zinc bromine and vanadium redox. Zinc bromine flow batteries have zinc at the negative electrode and bromide at the positive electrode with an aqueous solution containing zinc bromide and other compounds contained in reservoirs. During charging, energy is stored as zinc metal within the cell and polybromide in the cathode reservoir. During discharge, the zinc is oxidized to zinc oxide and the bromine is reduced to bromide. Vanadium redox flow batteries contain vanadium salts in various stages of oxidation in a sulfuric acid electrolyte. Charging and discharging the battery changes the oxidation state of the vanadium in the electrolyte solutions.

B.5.1.1 Vanadium Redox Flow Batteries. Hazard considerations for vanadium redox flow batteries under normal operating conditions are as follows:

(1) Fire hazards: Not applicable.
(2) Chemical hazards: They contain corrosive liquid that might present a safety concern under normal conditions if there is a need to handle/replenish the electrolyte as part of maintenance.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they have hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: Not applicable.
(5) Physical hazards: Not applicable.

Hazard considerations for vanadium redox flow batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: Corrosive liquids can boil off to create gases that are flammable (e.g., hydrogen). There can also be the problems with the balance of plant components overheating and creating the potential for fire hazards under abnormal conditions.
(2) Chemical hazards: There are large amounts of corrosives.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: Not applicable.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating, if there is insufficient pressure relief when the system is overheating and gas is generated, or if there is exposure to moving hazardous parts such as fans or exposed pump parts where guards might be missing.

B.5.1.2 Zinc Bromine (ZnBr) Flow Batteries. Hazard considerations for ZnBr flow batteries under normal operating conditions are as follows:

(1) Fire hazards: Not applicable.
(2) Chemical hazards: These batteries contain zinc bromide electrolyte, which is corrosive (acid) and toxic with a hazardous classification level of 3 per NFPA 704. The electrolyte should be reliably sealed in the system, so this should only be an issue for normal operating conditions if there is a need to add electrolyte as part of maintenance or installation.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: Not applicable.
(5) Physical hazards: Not applicable.

Hazard considerations for ZnBr flow batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: If there is overheating of the system due to abnormal conditions, there can be off-gassing of flammable gasses that can present a fire hazard if they are near an ignition source. There can also be problems with the balance of plant components overheating and creating potential for fire hazards under abnormal conditions.
(2) Chemical hazards: These batteries contain zinc bromide electrolyte, which is corrosive (acid) and toxic with a hazardous classification level of 3 per NFPA 704. Under abnormal conditions, care should be taken where there might be spills of the electrolyte.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: Not applicable.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating, if there is insufficient pressure relief when the system is overheating and gas is generated, or if there is exposure to moving hazards parts such as fans or exposed pump parts where guards may be missing.

B.5.2 Lead-Acid Batteries — General Description. Lead-acid batteries have lead dioxide as the active material of their positive electrode and metallic lead as the negative electrode with a dilute sulfuric acid solution electrolyte. During discharge, both positive and negative electrodes are converted to lead sulfate. The two basic categories of lead-acid batteries are as follows:

(1) Vented lead-acid batteries, also called *wet cell* or *flooded* lead-acid batteries
(2) Valve-regulated lead-acid (VRLA) batteries, sometimes referred to as *starved electrolyte* or *maintenance-free* batteries

Vented lead-acid batteries typically require periodic water additions, and the contents of the battery are open to the atmosphere through a vent/flame arrester assembly. VRLA batteries are generally sealed to the atmosphere and contain a valve that can open when pressure builds up in the battery and then closes again. The electrolyte in VRLA batteries is immobilized either through use of a gel electrolyte or through absorption of the electrolyte in a porous AGM separator.

B.5.2.1 Vented Lead-Acid Batteries. Hazard considerations for vented lead-acid batteries under normal operating conditions are as follows:

(1) Fire hazards: There is the potential for concentrations of hydrogen from vented lead-acid batteries if the area where the batteries are located is not properly ventilated. However, this should be taken care of if the installation complies with the codes.
(2) Chemical hazards: There is the potential for contact with the sulfuric acid electrolyte but this is only a risk when workers are handling electrolyte. Workers handling electrolyte need to use proper PPE. These systems should be provided with spill control and neutralization per codes.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards during maintenance.
(5) Physical hazards: There are lifting hazards that are only an issue during installation, replacement, or removal.

Hazard considerations for vented lead-acid batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: There is the potential for concentrations of hydrogen from vented lead-acid batteries due to overheating from abnormal conditions if the area where the batteries are located is not properly ventilated. Another area that can create problems during abnormal conditions is the potential for shorting of high current circuits.
(2) Chemical hazards: There is the potential for contact with the corrosive sulfuric acid electrolyte during abnormal conditions should acids leak. First responders, in emergency situations, need to be aware of potential acid spills that can occur and use appropriate caution around these batteries.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stored or stranded energy hazards if batteries are subject to abnormal conditions.
(5) Physical hazards: The potential exists for overheating.

B.5.2.2 Valve-Regulated Lead-Acid Batteries (VRLA). Hazard considerations for VRLA batteries under normal operating conditions are as follows:

(1) Fire hazards: There should be no combustible gas generation under normal operating conditions if batteries are operated as intended to prevent overheating and thermal runaway conditions.
(2) Chemical hazards: These batteries are starved electrolyte types, so there should be no issue with exposure to corrosive electrolyte under normal operating conditions.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards during maintenance.
(5) Physical hazards: There are lifting hazards due to the weight of the battery that are only an issue during installation, replacement, or removal.

Hazard considerations for VRLA batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: There is the potential for off-gassing of hydrogen under abnormal conditions when batteries overheat. This can present a potential fire hazard due to combustible concentrations. There can be the potential for thermal runaway if the batteries are not maintained at appropriate operating parameters. Also, there can be fire hazards due to short-circuiting abnormal conditions.
(2) Chemical hazards: Although these batteries contain corrosive electrolyte, they do not have as much free electrolyte that could result in spill hazards similar to vented types. There might be some bubbling of electrolyte or potential for some leakage under abnormal conditions if battery cases crack or leak.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards if the batteries are subject to abnormal conditions.
(5) Physical hazards: The potential exists for overheating.

B.5.3 Lithium Ion (Li-ion) Batteries — General Description. The term *lithium-ion battery* refers to a battery where the negative electrode (anode) and positive electrode (cathode) materials serve as a host for the lithium ion (Li+). Lithium ions move from the anode to the cathode during discharge and are intercalated into (inserted into voids in the crystallographic structure of) the cathode. The ions reverse direction during charging. Since lithium ions are intercalated into host materials during charge or discharge, there is no free lithium metal within a lithium-ion cell and thus, even if a cell does ignite due to external flame impingement or an internal fault, metal fire suppression techniques are not appropriate for controlling the lithium-ion fire.

Hazard considerations for Li-ion batteries under normal operating conditions are as follows:

(1) Fire hazards: There can be the potential for fire hazards if there are latent defects within the cells or design issues with the controls that prevent thermal runaway of the cells. Systems need to be evaluated for their ability to prevent propagation due to these defects.
(2) Chemical hazards: Not applicable.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance or replacement.
(5) Physical hazards: Not applicable.

Hazard considerations for Li-ion batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: There can be the potential for thermal runaway if the batteries are not maintained at appropriate operating parameters as a result of abnormal conditions. Also, there might be fire hazards due to short-circuiting abnormal conditions.

(2) Chemical hazards: There can be the potential for off-gassing of hazardous vapors under abnormal conditions depending on the size of the cells and the level of failure.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded energy hazards if the batteries are exposed to abnormal conditions. Damaged batteries might contain stored energy that can be a hazard during disposal if care is not taken.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating or if there is exposure to moving hazardous parts such as fans where guards might be missing.

B.5.4 Lithium Metal, Solid State Batteries — General Description. Lithium metal batteries employing liquid electrolytes have been developed for commercial use but have had safety and performance problems in the field. These batteries have not been developed at this time for stationary battery energy storage. Commercially available lithium metal batteries utilized for ESS do not employ liquid electrolytes. The current lithium metal technologies use solid polymer electrolytes, a lithium metal negative electrode and a metal oxide cathode such as vanadium oxide combined with lithium salt and polymer to form a plastic composite. The SPE-type lithium metal batteries must be heated to about 140°F to 176°F (60°C to 80°C) in order to be activated.

Hazard considerations for lithium metal batteries under normal operating conditions are as follows:

(1) Fire hazards: There can be the potential for fire hazards if there are defects within the cells or design issues with the controls that prevent thermal runaway of the cells. Systems need to be evaluated for their ability to prevent propagation due to these defects.
(2) Chemical hazards: Not applicable.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance or replacement.
(5) Physical hazards: Not applicable.

Hazard considerations for lithium metal batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: There can be the potential for thermal runaway if the batteries are not maintained at appropriate operating parameters as a result of abnormal conditions and if not evaluated for ability to prevent propagation due to latent defects. Also there might be fire hazards due to short-circuiting abnormal conditions.
(2) Chemical hazards: The potential exists for exposure of water-reactive lithium metal.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards if the batteries are exposed to abnormal conditions where they might still contain hazardous levels of energy. Damaged batteries might contain stored energy that can be a hazard during disposal if care is not taken.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating or if there is exposure to moving hazardous parts such as fans where guards might be missing.

B.5.5 Nickel Batteries — General Description. Nickel batteries for stationary applications are divided into two main technologies: nickel-cadmium (Ni-Cad) and nickel-metal hydride (Ni-MH). There is also a third category that has become commercialized, nickel-zinc (Ni-Zn), which is very similar to Ni-Cad batteries. Nickel-cadmium batteries have nickel hydroxide active material for the positive electrode and cadmium for the negative electrode with potassium hydroxide solution for the electrolyte. The nickel-cadmium batteries for stationary applications can be vented pocket plate or vented sintered-plate batteries that are designed of multiple cells in a monobloc battery similar to a vented lead-acid battery. They also have vents for maintenance of the electrolyte. Nickel-cadmium batteries can also be sealed types, such as a fiber nickel-cadmium battery that is sealed and provided with a pressure relief valve similar to a VRLA battery. Nickel-zinc batteries are similar to Nickel-cadmium batteries except the negative electrode is zinc. Nickel-metal hydride batteries have nickel hydroxide active material for the positive electrode, a metal hydride alloy for the negative electrode, and a solution of potassium hydroxide as the electrolyte. Nickel-metal hydride batteries are sealed either a single cell design or a monobloc design with multiple internal cells and are provided with an enclosable valve for relieving pressure similar to a VRLA battery.

B.5.5.1 Nickel-Cadmium (Ni-Cad) and Nickel-Zinc (Ni-Zn) Batteries. Hazard considerations for Ni-Cad and Ni-Zn batteries under normal operating conditions are as follows:

(1) Fire hazards: There is the potential for concentrations of hydrogen from vented Ni-Cad and Ni-Zn batteries if the area where the batteries are located is not properly ventilated. However, this should be taken care of if the installation complies with the codes.
(2) Chemical hazards: There is the potential for contact with the corrosive/caustic potassium hydroxide electrolyte but this is only a risk when workers are handling electrolyte. Workers handling electrolyte need to use proper PPE. These systems should be provided with spill control and neutralization per codes.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance or replacement.
(5) Physical hazards: There are lifting hazards due to the weight of the battery that are only an issue during installation replacement or removal.

Hazard considerations for Ni-Cad and Ni-Zn batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: There is the potential for concentrations of hydrogen from vented Ni-Cad and Ni-Zn batteries due to overheating from abnormal conditions if the area where the batteries are located is not properly ventilated. Another area that might create problems during abnor-

mal conditions would be the potential for shorting of high-current circuits.
(2) Chemical hazards: There is the potential for contact with the corrosive/caustic potassium hydroxide electrolyte during abnormal conditions should electrolyte leak. First responders, in an emergency situation, need to be aware of potential caustic spills that can occur and take appropriate caution around these batteries. Ni-Cad batteries contain cadmium, which is toxic and a hazardous waste. Although not exposed under normal conditions, there might be potential for cadmium in vapors of burning batteries during abnormal conditions.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards if the batteries are exposed to abnormal conditions where they could still contain hazardous levels of energy. Damaged batteries might contain stored energy that can be a hazard during disposal if care is not taken.
(5) Physical hazards: The potential exists for overheating.

B.5.5.2 Nickel-Metal Hydride (Ni-MH) Batteries. Hazard considerations for Ni-MH batteries under normal operating conditions are as follows:

(1) Fire hazards: There should be no combustible gas generation under normal operating conditions, if batteries are operated as intended to prevent overheating and thermal runaway conditions.
(2) Chemical hazards: These batteries are starved electrolyte types, so there should be no issue with exposure to corrosive electrolyte under normal operating conditions.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance or replacement.
(5) Physical hazards: Not applicable.

Hazard considerations for Ni-MH batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: There is the potential for off-gassing of hydrogen under abnormal conditions when batteries overheat. This can present a potential fire hazard due to combustible concentrations. There can be the potential for thermal runaway if the batteries are not maintained at appropriate operating parameters. Also, there could be fire hazards due to short-circuiting abnormal conditions.
(2) Chemical hazards: Although these batteries contain corrosive electrolyte, they do not have as much free electrolyte that could result in spill hazards similar to vented types. There might be some bubbling of electrolyte or potential for some leakage under abnormal conditions if battery cases crack or leak. Burning Ni-MH batteries can release toxic vapors, including cobalt oxide fumes, nickel oxide fumes, and so forth.
(3) Electrical hazards: Electrical hazards can be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: There can be the potential for stranded or stored energy hazards if the batteries are exposed to abnormal conditions where they might still contain hazardous levels of energy. Damaged batteries might contain stored energy that can be a hazard during disposal if care is not taken.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating or if there is exposure to moving hazardous parts such as fans where guards might be missing.

B.5.6 Sodium Batteries, Aqueous — General Description. Aqueous sodium batteries, which are also referred to as *sodium ion batteries* or *saltwater batteries*, consist of a manganese oxide positive electrode, a carbon titanium phosphate composite anode, and a saltwater solution electrolyte, and sodium ions intercalate between the positive and negative electrode during the charge and discharge operation. These sodium batteries operate at ambient temperatures with an optimal range of 23°F to 104°F (–5°C to 40°C).

Hazard considerations for aqueous sodium batteries under normal operating conditions are as follows:

(1) Fire hazards: There should be no combustible gas generation under normal operating conditions if batteries are operated as intended to prevent overheating and thermal runaway conditions.
(2) Chemical hazards: Not applicable.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: The potential exists for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance.
(5) Physical hazards: Lifting hazards due to the weight of the battery that are only applicable during installation, replacement, or removal.

Hazard considerations for aqueous sodium batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: These systems have aqueous electrolytes, so the potential exists for off-gassing of hydrogen under abnormal conditions. The potential might also exist for fire hazards for high-energy systems that are subject to short-circuit or other abnormal conditions.
(2) Chemical hazards: Not applicable.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: The potential exists for stranded or stored energy hazards if the batteries are exposed to abnormal conditions where they might still contain hazardous levels of energy.
(5) Physical hazards: The potential for overheating exists.

B.5.7 Sodium Batteries, High-Temperature — General Description. High-temperature sodium batteries, sometimes referred to as *sodium beta batteries* or *molten salt batteries*, are hermetically sealed batteries with metallic sodium as the negative electrode and a ceramic beta-alumina as the electrolyte. These batteries operate at high temperatures of 500°F to 698°F (260°C to 370°C) so that the active materials are in a molten state and to ensure ionic conductivity. There are two types of commercially available high-temperature sodium batteries: sodium sulfur and sodium nickel chloride. Sodium sulfur batteries consist of a sodium negative electrode, a beta-alumina electrolyte, and a sulfur positive electrode with an operating temperature within a temperature range of 590°F to 698°F (310°C to 370°C). Sodium nickel chloride batteries consist of a sodium negative electrode, a beta-alumina as the electrolyte, and a positive electrode that could consist of nickel, nickel chloride, or sodium chloride with an operating temperature range of 500°F to 662°F (260°C to 350°C).

B.5.7.1 Sodium Sulfur (NaS) Batteries. Hazard considerations for NaS batteries under normal operating conditions are as follows:

(1) Fire hazards: The potential exists for fire hazards if there are latent defects within the cells or design issues with the controls that prevent thermal runaway of the cells. Systems need to be evaluated for their ability to prevent propagation due to these defects.
(2) Chemical hazards: Not applicable. The batteries contain water-reactive sodium, but the systems are hermetically sealed.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: The potential exists for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance.
(5) Physical hazards: There should be no hazards associated with these batteries if the designs have sufficient insulation to prevent exposure to hot surfaces, because these batteries run at very hot temperatures under normal operating conditions.

Hazard considerations for NaS batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: These systems might be subject to thermal runaway due to defects within the cells and protection scheme. Large energy systems can result in fires if there are abnormal conditions such as short-circuiting.
(2) Chemical hazards: The potential exists for exposure to hazardous water-reactive materials if the hermetic seals are broken and sodium is exposed to the atmosphere. PPE is required to address exposure during abnormal conditions.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: The potential exists for stranded or stored energy hazards if the batteries are exposed to abnormal conditions where they might still contain hazardous levels of energy.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating.

B.5.7.2 Sodium Nickel Chloride Batteries. Hazard considerations for sodium nickel chloride batteries under normal operating conditions are as follows:

(1) Fire hazards: The potential exists for fire hazards if there are latent defects within the cells or design issues with the controls that prevent thermal runaway of the cells. Systems need to be evaluated for their ability to prevent propagation due to these defects.
(2) Chemical hazards: Not applicable. Although sodium is water reactive, the systems are hermetically sealed.
(3) Electrical hazards: There are electrical hazards associated with routine maintenance of these batteries if they are at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: The potential exists for stranded or stored energy hazards during maintenance if the batteries cannot be isolated for maintenance.
(5) Physical hazards: There should be no hazards associated with these batteries if the designs have sufficient insulation to prevent exposure to hot surfaces, because these batteries run at high temperatures under normal operating conditions.

Hazard considerations for sodium nickel chloride batteries under emergency/abnormal conditions are as follows:

(1) Fire hazards: These systems might be subject to thermal runaway due to defects within the cells and protection scheme. Large energy systems can result in fires if there are abnormal conditions such as short-circuiting.
(2) Chemical hazards: The potential exists for exposure to hazardous water-reactive materials if the hermetic seals are broken and sodium is exposed to the atmosphere. PPE is required to address exposure during abnormal conditions.
(3) Electrical hazards: Electrical hazards might be present under abnormal conditions if the system is at hazardous voltage and energy levels.
(4) Stranded or stored energy hazards: The potential exists for stranded or stored energy hazards if the batteries are exposed to abnormal conditions where they could still contain hazardous levels of energy.
(5) Physical hazards: Depending on the design of the system, the potential exists for physical hazards under abnormal conditions if accessible parts are overheating.

B.6 Other Technologies. (Reserved)

Annex C Fire-Fighting Considerations (Operations)

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

C.1 Overview. Annex C provides information that fire fighters and emergency responders should know to allow them to effectively respond to events involving energy storage systems (ESS).

C.1.1 Emergency Responder Pre-incident Planning. Emergency planning and training for facility staff and emergency responders is covered in 4.1.3. The fire department should develop a pre-incident plan for responding to fires, explosions, and other emergency conditions associated with the ESS installation, and the pre-incident plan should include the following elements:

(1) Understanding the procedures included in the facility operation and emergency response plan described
(2) Identifying the types of ESS technologies present, the potential hazards associated with the systems, and methods for responding to fires and incidents associated with the particular ESS
(3) Identifying the location of all electrical disconnects in the building and understanding that electrical energy stored in ESS equipment cannot always be removed or isolated
(4) Understanding the procedures for shutting down and de-energizing or isolating equipment to reduce the risk of fire, electric shock, and personal injury hazards
(5) Understanding the procedures for dealing with damaged ESS equipment in a post-fire incident, including the following:

(a) Recognizing that stranded electrical energy in fire-damaged storage batteries and other ESS has the potential for reignition long after initial extinguishment
(b) Contacting personnel qualified to safely remove damaged ESS equipment from the facility (This contact information is included in the facility operation and emergency response plan.)

C.2 General. Battery ESS based on electrochemical technologies represent the majority of ESS being designed and installed. The safe operation of electrochemical ESS is critical especially when installed inside occupied structures. The primary concerns of the fire service with this type of installation would include the implications of overheating via internal or external heat source, thermal runaway, potential deflagration event in enclosed spaces, and the effective operation of fire detection, suppression, and smoke exhaust systems. There are additional concerns to be considered when assessing fire fighter responses to electrochemical ESS.

Handover procedures for potentially damaged systems should be developed for fire departments to ensure the timely response of qualified technical representatives to manage safety issues. These procedures would also cover issues such as the removal or recycling of damaged equipment. Another procedural component is the realization that damaged ESS system components could include significant stored or stranded energy with no known method for safe dissipation. Stored or stranded energy could be defined as energy that remains in a battery after the system has been shut down.

C.3 Suppression Systems. Some ESS design validations have included pre-engineered inert or clean agent fire suppression systems for fire protection. These system installations were often approved without validation based on large-scale fire testing in accordance with 4.1.5 by nationally recognized testing laboratories. Evidence-based data is needed to ensure ESS designers specify appropriate fire protection systems based on the material involved and physical design characteristics. Several early research papers from multiple organizations, including NFPA's Fire Protection Research Foundation, and third-party engineering groups have shown that fires involving lithium-ion cells must be cooled to terminate the thermal runaway process. Water is the agent of choice, yet system cabinet design could pose a significant barrier to the efficient application of water while simultaneously allowing the free movement of fire and combustion gases.

C.4 Emergency Response to ESS Incidents. Responses to ESS incidents should take into consideration the range of possible conditions and associated hazards as specified in Annex B. The response should include commonly accepted practices with any hazmat response, including isolating the area to all personnel, confirming location and type of alarm, performing air monitoring, managing ventilation/exhaust, and suppressing fires.

One of the more challenging types of incidents will be one where no signs of overheating are visible and no information is available via integral displays. This places the responding fire official in the challenging position of determining what is safe or not with very little information. Integrated energy management systems (EMS) are designed to monitor and manage critical safety parameters of the battery such as cell temperature, voltage, and available current. While this data might prove valuable to responders to best understand the current state of the battery, there is no standard for manufacturers to provide a user interface to access the state of these parameters or a method to interface to monitored alarm systems within the building. Responders should attempt to gather any visible information prior to shutting down the system unless there is clear evidence of imminent danger. Additionally, the response of a qualified and trained individual in ESS should be made available in the event of damage to an installed system.

C.4.1 Overheated Batteries. The process of charging/discharging results in heat dissipation from cells. An optimum overall system design should include cascading layers of hardware and software protection, including at the battery cell, module or pod, and rack levels. Should a fault occur and overheating of a cell continues, damage could occur resulting in swelling, off-gassing, fire, or explosion. Proper response to an overheated battery should include the following procedures and steps:

(1) Isolate area of all nonessential personnel
(2) Review status of both building and ESS alarm system with available data
(3) Review status of any fire protection system activation
(4) Perform air monitoring of all connected spaces
(5) Identify location of overheated battery
(6) Isolate affected battery, string, or entire system based on the extent of damage by opening battery disconnect switches, where provided
(7) Contact person or company responsible for operation and maintenance of system
(8) Continue temperature monitoring to ensure mitigation of overheating condition

C.4.2 Fires. Fires in electrochemical ESS are often a result of a process called *thermal runaway*. Thermal runaway can simply be defined as the process in which a battery creates heat but cannot dissipate that heat, resulting in dynamic temperature increase. Initial signs of thermal runaway might include pressure increase at the cell level, temperature increase, and off-gassing. As the process continues, additional signs might include vent gas ignition, exploding cells, projectile release, heat propagation, and flame propagation.

As the failure cascades, responders should also be prepared for toxic and potentially explosive gas release. Though large-scale testing in accordance with Section 4.5 to determine battery burn outcomes, including toxic gas release calculations, remains incomplete, responders should treat them as highly dangerous and use their full suite of PPE and breathing apparatus when responding.

Proper response to electrochemical ESS fires should include the following procedures and steps:

(1) System isolation and shutdown
(2) Hazard confinement and exposure protection
(3) Fire suppression
(4) Ventilation

C.5 Suppressing Agent Choice Considerations. An in-depth understanding of battery failure and suppressing agent properties is essential to the response strategy. There is anecdotal evidence that a number of suppressants could work to suppress burning batteries. However, some perform better than others. Battery chemistry plays a significant role in suppressant choice as some suppressants will perform well on a single chemistry while others might work well on a suite of battery chemistries. Additionally, some suppressants might be inappropriate for certain battery chemistries, and their release could create a more dangerous situation.

When choosing a suppression system, the following should be considered:

(1) Cooling effect
(2) Availability
(3) Portability
(4) Conductivity
(5) Available testing data
(6) Cascading protections

C.5.1 Lithium-Ion (Li-ion) Batteries. Water is considered the preferred agent for suppressing lithium-ion battery fires. Water has superior cooling capacity, is plentiful (in many areas), and is easy to transport to the seat of the fire. While water might be the agent of choice, the module/cabinet configuration could make penetration of water difficult for cooling the area of origin, but might still be effective for containment. Water spray has been deemed safe as an agent for use on high-voltage systems. The possibility of current leakage back to the nozzle, and ultimately the fire fighter, is insignificant based on testing data published in the Fire Protection Research Foundation report *Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results*. Fire-fighting foams are not considered to be effective for these chemistries because they lack the ability to cool sufficiently and can conduct electricity. There is also some evidence that foams might actually encourage thermal runaway progression by insulating the burning materials and exacerbating heat rise.

Fire-fighting dry chemical powders can eliminate visible flame. However, they also lack the ability to cool burning battery components. Quite often, even if visible flame is removed, the thermal runaway inside the battery will continue resulting in reignition. Carbon dioxide and inert gas suppressing agents will also eliminate visible flame but will likely not provide sufficient cooling to interrupt the thermal runaway process. ESS with clean agent suppression systems installed have ventilation systems that are tied in with the fire detection and control panel so that the HVAC shuts down and dampers close to ensure the agents have sufficient hold times at the proper concentration levels to be effective suppressants. In some fire suppression systems, the HVAC recirculates and does not shut down and provides a means of dispersing the clean agents. Responders must ensure adequate hold time has occurred prior to accessing battery room/container. Manufacturer-recommended times should be made clear. These agents might also reduce flammability by suppressing oxygen levels, but data has identified that flammable gases will continue to be produced due to the continued heating and could create an environment ripe for flashover or backdraft when oxygen is reintroduced into the system.

C.5.2 Lead-Acid, Nickel-Cadmium, and Other Aqueous Battery Technologies. Lead-acid, nickel-cadmium, and other aqueous batteries are a very familiar chemistry to fire fighters. However, though the chemistries employed in ESS are similar to those that would be found in battery backup systems, they can be expected to be found in much larger arrays. The size of the battery system is certainly a factor when determining suppression agent requirements, strategy, and tactics.

Overcharging can lead to overheating and production of hydrogen gas, case swelling, and electrolyte leakage. Large fires can be treated as hazardous materials events.

Water, powders, inert gases, and carbon dioxide are all considered acceptable suppression agents for small fires involving these batteries. However, if the fire is large, water will be the preferred agent because of its superior accessibility, portability, and cooling effectiveness.

C.5.3 Flow Batteries. Flow batteries do not pose flammability risks like more solid batteries, and the fire load is comparably smaller as most of the mass of the system is nonflammable liquid. Though the plastics comprising the balance of the system might pose a fire risk, in general, the system is mostly nonflammable and does not contain many ignition risks beyond the power electronics, which are typically housed separately. Under certain extreme conditions, such as exposure to significant heat, the system can generate hydrogen, which is likely to be captured in the large tanks and vented in a controlled manner.

The system does pose toxicity risks, as electrolyte is typically composed of hydrochloric acid, sulfuric acid, or some combination of the two. Electrolyte capacity can be from tens of gallons to thousands of gallons in each containerized system. Spill containment is an inherent part of a flow battery design.

In the case of zinc bromine (ZnBr) flow batteries, the bromine or hydrobromic acid can pose a health risk. Though unlikely, the vanadium oxide in vanadium flow batteries might form trace, salt-like deposits, which can also pose a health risk. When dealing with failures involving either type of system, it is recommended to wear PPE, including SCBA, at all times.

C.5.4 Sodium Sulfur (NaS) Batteries. Sodium sulfur batteries operate at very high temperatures during normal operation. Though these batteries have become safer over time, there are cases where they have caught fire. NaS fires are very energy dense and cannot, per manufacturer recommendations, be extinguished with water, which could ultimately make them far worse. Sulfur dioxide (SO_2), hydrogen sulfide (H_2S), and other sulfur-based gases can be generated during a fire and can damage the human respiratory system. Proper monitoring equipment and tactics should be employed to gauge the level of detectable gases during fire and post-fire events.

When NaS batteries are deployed, it is advised that fire services work with owner/operators or system owners to develop appropriate standard operating procedures for dealing with NaS emergencies.

C.6 Air Monitoring. Air monitoring should be a priority for responders during and after any ESS emergency. Though the ESS might include an air-monitoring system, it is recommended that the responding fire companies use 4-meter or other gas detection equipment to determine toxic gas levels. Many fire departments carry single gas carbon monoxide meters that can be used to offer limited data on the condition of the ESS environment.

When testing the involved areas, responders should be aware that hydrogen can give an erroneous reading on the carbon monoxide meter because there is a cross-sensitivity with hydrogen. Full PPE and SCBA should always be used during a fire and post-fire event.

The battery room or building might employ a fixed inert gas or other oxygen-displacing fire suppression system. When activated, these agents will displace oxygen from the environment in an effort to control flame. This impact on oxygen levels can impact the lower explosive limit (LEL). Begin metering in areas outside the affected BESS room to establish baseline readings. These areas should include floors above and below the BESS, corners, low-lying areas, and areas out of the path of smoke/gas travel, including near ventilation points.

C.7 Fire Detection and Suppression.

C.7.1 Fire Detection. Battery management systems are primarily designed to monitor temperatures and voltages of cells and modules. They can be designed to shut down the affected charging/discharging circuits in the event of out-of-parameter conditions but might not be able to determine whether a fire is actually occurring. Fire detection should be designed into the ESS installation.

C.7.2 Passive Fire Control. Passive fire control features should be designed to meet the unique challenges of managing electrochemical ESS fires. Passive fire control features should be designed to limit the cascading effects of fire spread. This might include cell to cell (built into the module), module to module (built into the rack/or pack), rack to rack (built into the ESS room or container), or even protection from system to system propagation.

C.7.3 Suppression Tactics. As previously mentioned, battery components are often housed in cabinets or other configurations that can serve to protect the components and thus limit the ability of fire stream penetration. Fire fighters should never use piercing nozzles and long penetrating irons. Mechanically damaged cells or puncturing unburned or undamaged cells can result in the immediate ignition of those cells. In addition, internal shorting within the cabinets could create an electrocution risk.

Movement of damaged cells might result in arcing or reignition if active material or cells remain in the modules. Modules should not be moved without consultation from qualified personnel.

Ventilation during suppression is critical. Research has shown that Li-ion batteries might continue to generate flammable gases during and after extinguishing. In addition, testing has shown that during sprinkler suppression, removal of combustion and flammable gases emitted from the battery significantly improves the effectiveness of the suppression.

Testing has shown that electrical current leakage back through hose streams will not be a shock hazard when appropriate streams are used and distances maintained. In cases where systems are thoroughly destroyed and electric potential is shown to be minimal, close range engagement with hoses for the purpose of drowning modules can be performed to provide more direct cooling.

During post-fire operations, SCBA should continue to be worn by all persons near the damaged ESS, especially when systems are in confined or poorly ventilated spaces or have not been sufficiently cooled yet. Gases, and in particular CO, should be monitored during this period, as dangerous buildups have been observed during post-fire testing. If possible, batteries should be monitored for residual heat and temperature, as reignition is a possibility in cells that are not sufficiently cooled.

Care should be taken to secure the area the batteries are located in and ensure that the heat has been removed and that the batteries are not at risk of being electrically shorted or mechanically damaged. This should be done at the guidance of a qualified technician. At this point, the fire scene should be handed over to the owner, operator, or responsible party appointed by the site owner.

Though trace amounts of heavy metals such as nickel and cobalt can be deposited from combustion of the batteries, these elements are not expected to be present in large quantities or in quantities larger than any other similar fire. In most instances, water exposed to the batteries shows very mild acidity, with an approximate pH of 6. Runoff water pH can be monitored during fire-fighting operations but should not pose a greater risk than normal fire-fighting run-off.

In unique cases where a system on fire poses little or no risk to the surrounding uninvolved equipment or the environment, it is can be reasonable to assume a defensive posture and allow the system to burn itself out. Some typical steps for this approach include the following: local municipal fire fighters responding to the scene to make sure that the flames do not spread beyond the property perimeter, having ESS operations personnel arriving at the scene to review the situation and conditions, and then allowing the fire to burn out. This option should only be considered when no risks are posed to the environment and the risk to fire-fighting operations is great or unknown. It is up to the site owner/operator to communicate with fire services in the event of an emergency to relay vital system information to fire services.

C.8 Flooding and Seismic Influences. Flooding can induce electrical damage to ESS that should be taken into consideration after water has receded. Battery systems in earthquake-prone zones should be seismically tested and certified for such abuse. Systems damaged in earthquakes might be prone to fire if cells have been mechanically damaged or power electronics are damaged and operating improperly, leading to electrical overcharge or other abuse conditions that can cause fire. In addition, if there is an extended power outage for several days, balance of system power might be out, and ventilation fans or automatic suppression systems might be inoperable, leading to more hazardous fire conditions.

Annex D Overview of Energy Storage Systems Technologies

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

D.1 Introduction. ESS can be classified according to the form of energy, and the main categories are mechanical, electrochemical, chemical, electrical, and thermal as depicted in Figure D.1. Hydrogen is a secondary energy carrier that can be produced, along with oxygen. In fuel cells, electricity is produced through the oxidation of a fuel, such as hydrogen, and the reduction of oxygen from the air or an alternate oxygen source. The system comprised of an electrolyzer and a fuel cell is a chemical ESS[1].

The purpose of this annex is to provide insight into the types, features, and applications of currently available ESS that have not been included in the standard in detail and their deployment status. The technologies of focus include, but are not limited to, pumped hydro storage (PHS), compressed air energy storage (CAES), flywheel energy storage (FES), superconducting magnet ESS (SMES), and thermal ESS. These technologies can both store and release electrical energy but are not power generation systems that require a fuel source to function. These technologies will also be compared to other technologies, including a variety of batteries and capacitors that have been evaluated in detail and fall within the jurisdiction of the standard. The standard recognizes that there are a large variety of ESS technologies, and some will be excluded for a multitude of reasons, including inapplicability to grid storage, immaturity (commercialization is estimated to require more than 5 years), size, or the requirement that the installation and safety validation needs specialized expertise or conditions that cannot be generalized as effectively as the more common technologies. Grid ESS technologies range from over 100 GW of installed pumped hydro plants to experimental metal-air batteries and flywheels. Each offers unique advantages in terms of energy, power, lifetime, applicability, technical maturity, and cost. The disadvantages can be equally diverse, from geographic limitations (CAES) to cycle life issues (batteries). Also, grid ESS must deal with location-specific competition from alternative solutions such as added transmission and natural gas plants.

Pumped hydro and CAES are mature with well-documented use, so batteries and flywheels are currently the primary focus for enhanced grid-scale safety. For these systems and possibly some others, the associated failure modes for grid-scale power and energy requirements have not been well-characterized, and this results in much larger uncertainty around the risks and consequences of failures. This uncertainty around system safety can lead to barriers to adoption and commercialization success but more importantly, the determination of impacts to health and the environment. To address these risks, it is recommended that efforts be concentrated in the following areas:

(1) Materials science R&D extending into all device components
(2) Engineering controls and system design
(3) Simulation and modeling
(4) System testing and analysis
(5) Commissioning and field system safety protocols

The key modus operandi for using the areas outlined in the preceding list is to develop understanding and confidence by relating results at one scale to expected outputs at a higher scale. It is important to try and predict the interplay between components, as well as protecting against unexpected outcomes when multiple failure modes are present at the same time. Extensive research, modeling, and validation testing are required to address these challenges. This warrants building a reliable safety program by combining hazard analysis approaches with research and commissioning plans. The primary mandate is to identify, respond to, and mitigate any observed safety events that are critical for the validation of safe ESS.

D.2 Technical Comparison and Future Potential for ESS. It is apparent that there are a wide range of different ESS technologies, and it is highly likely that more will emerge in the next 10 to 15 years. Different applications with varying requirements will determine what features are needed, and this makes it difficult to conduct a comprehensive assessment and comparison. Not all ESS are commercially available in the current ranges for rated power (1 kW to 1 GW) and energy capacity (0.1 kWh to 100 GWh). Most of the technologies could be installed or upgraded with even larger power output and energy capacity (at least double), due to the modular design options. Figure D.2(a) shows a very broad and generalized comparison of storage technologies and their applications.

Some exceptions are PHS and systems with underground storage for H_2, SNG, and CAES. The energy-to-power (ETP) ratio adds an additional system characterization factor known as the discharge time [1 sec (short) to several months (long)] as a function of energy density. The higher the power and energy density, the lower the required volume for the system. There are many trade-offs for how each ESS is positioned with respect to performance based on these properties and best fit for key markets (utility, consumer, and renewable) and the applications within them. Figure D.2(b) illustrates which ESS is or could become feasible for what applications, and where further research, development, and scale-up are necessary.

It can be concluded that many different types of ESS will be required to cover all the applications outlined, as no single superior universal storage technology exists[1].

D.3 Mechanical ESS. The most common mechanical ESS are pumped hydroelectric power plants [pumped hydro storage (PHS)], compressed air energy storage (CAES), and flywheel energy storage (FES).

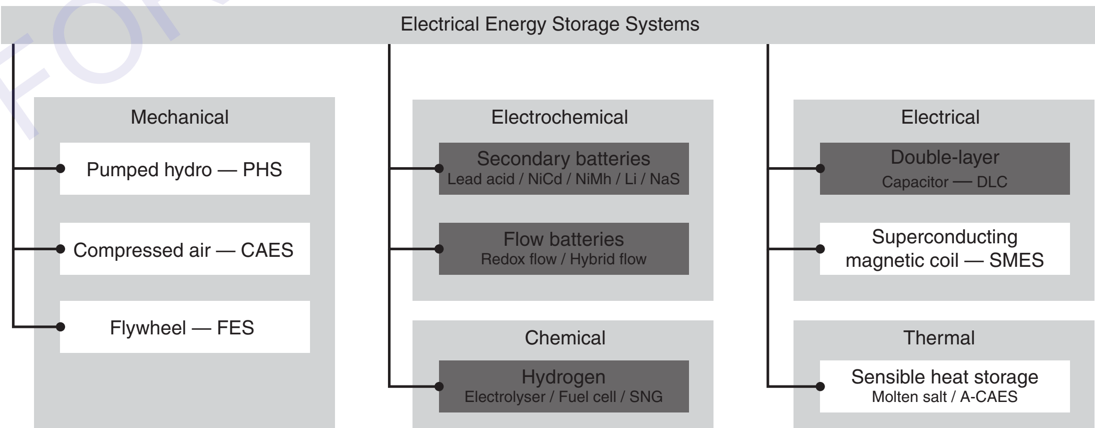

FIGURE D.1 Classification of Electrical ESS. ***(Source: Fraunhofer ISE.)***

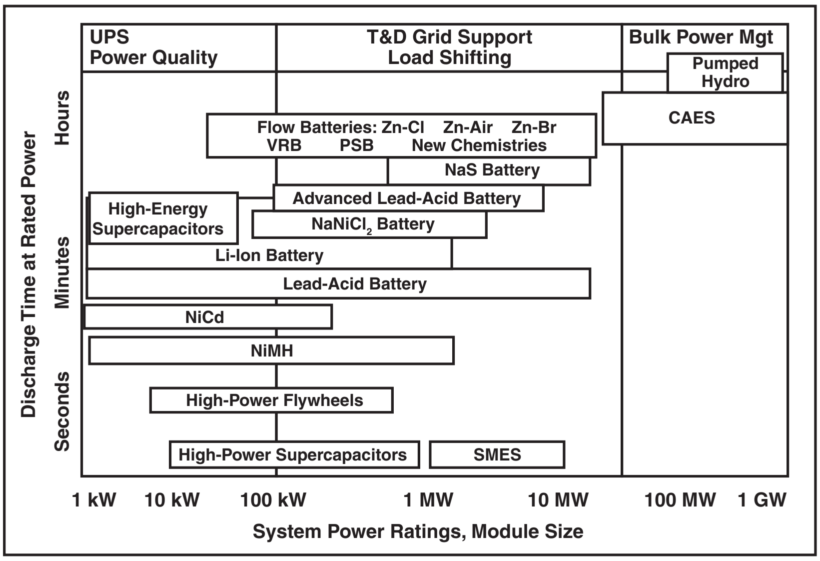

FIGURE D.2(a) Positioning of Energy Storage Technologies. *(Source: U.S. Department of Energy, Energy Storage System Guide for Compliance with Safety Codes and Standards.)*

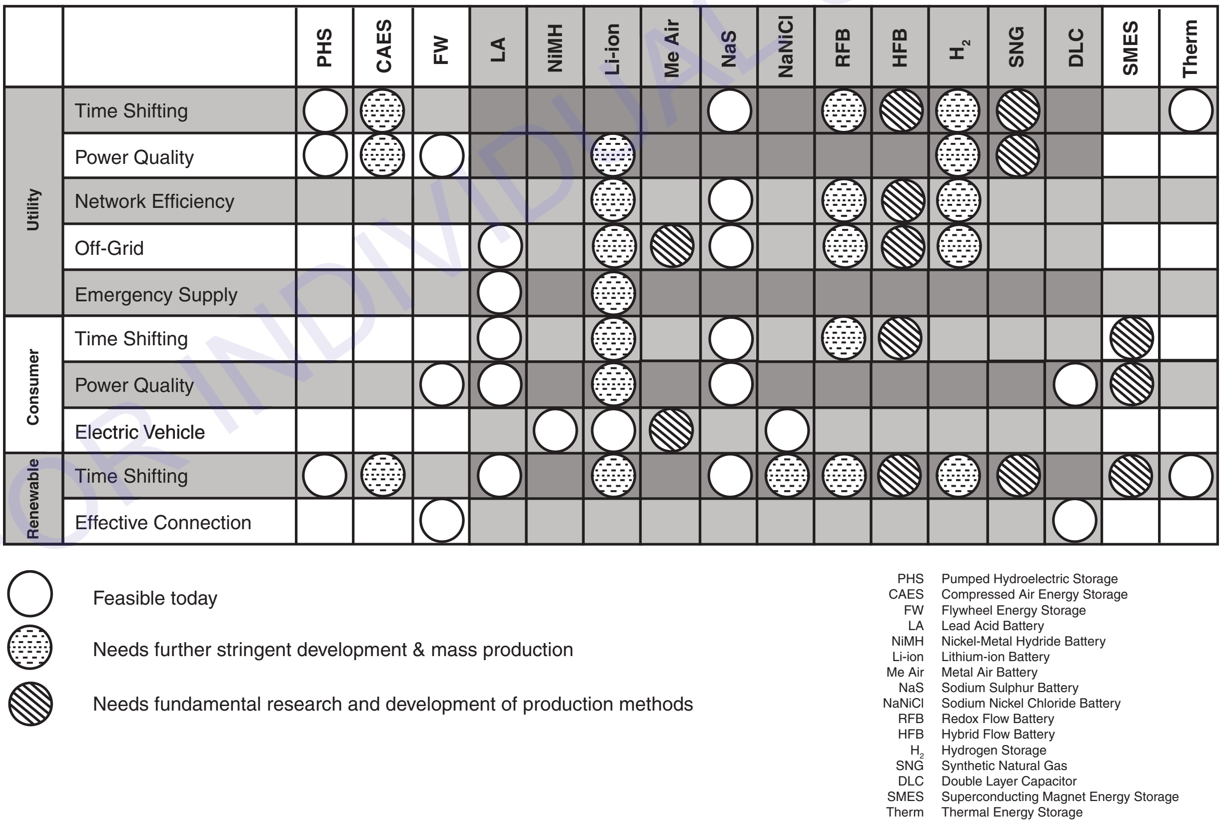

FIGURE D.2(b) ESS Feasibility, Future Potential, and Need for Development by 2030. *(Source: Fraunhofer ISE.)*

D.3.1 Pumped Hydroelectric Storage (PHS). The key elements of a pumped hydroelectric (pumped hydro) system include turbine/generator equipment, a waterway, an upper reservoir, and a lower reservoir. The turbine/generator is similar to equipment used for normal hydroelectric power plants that do not incorporate storage. Pumped hydro systems store energy (charge up) by operating the turbine/generator in reserve to pump water to a higher elevated reservoir or vessel when inexpensive energy is available and during off-peak hours. The water is later released (discharged) to return to the lower reservoir when electricity is needed and more valuable. When the water is released, it goes through the turbine, which rotates the generator to produce electric power. PHS is one of the oldest grid storage technologies (used in Europe since 1890) and likely the most widespread, accounting for almost 99 percent (127 GW) of the worldwide installed electrical storage capacity as of September 2012[2]. This is about 3 percent of the global generation capacity[3].

PHS capabilities will vary from plant to plant. The amount of energy stored in a PHS facility depends on the height difference between the lower and upper reservoirs as well as the volume of the upper reservoir. PHS plants have efficiencies between 60 percent and 85 percent, with larger elevation differences giving better efficiency[4]. Some newer plants have variable speed capabilities, which increases the load following and frequency regulation capabilities. The ability of PHS plants to ramp from 0 percent to 100 percent power output in several minutes, as well as quickly change their power output in response to automatic generation control (AGC) signals, makes them suitable for a wide range of applications, including spinning reserve, load following, frequency regulation, and voltage regulation. Typical discharge times range from several hours to a few days. Other advantages are the very long lifetime and practically unlimited cycle stability of the installation. PHS also has significant drawbacks. Because of its large land use, pumped hydro cannot provide distribution-level or end-user services. Topographically, PHS is usually unsuitable for arid or flat regions, many of which have abundant wind resources. PHS can be used in conjunction with water towers in areas where the topography is unfavorable for PHS. The main applications are for energy management via time shift, namely nonspinning and supply reserve.

D.3.2 Compressed Air Energy Storage (CAES). For compressed air (gas) energy storage systems (CAES), air is used as a storage medium due to its availability. Off-peak electricity is used to compress air and store it in an underground or underwater structure (cavern, aquifer, abandoned mine, or reservoir) or an aboveground system of vessels or pipes. When electricity is needed, the compressed air is heated or mixed with natural gas and burned and then expanded to drive a modified gas turbine that produces electricity. The energy storage capacity of CAES is determined by the volume of the storage reservoir while the power capacity is determined by the turbine used to generate electricity. Since natural gas–fired turbines spend approximately half of their fuel compressing the air intake, using already compressed air requires considerably less fuel than a conventional natural gas–fired power plant. For belowground CAES, the heat-rate can range from 3845 Btu/kWh to 3860 Btu/kWh; for aboveground CAES, the heat rate is around 4000 Btu/kWh. Simple-cycle natural gas turbines have a heat-rate between 9000 and 10,000 Btu/kWh. If the heat released during compression is dissipated by cooling and not stored, the air must be reheated prior to expansion in the turbine. This process is called diabatic CAES and results in low overall efficiencies of less than 50 percent. Diabatic technology is well proven, with plants that have high reliability and are capable of start-up without extraneous power.

CAES is the second largest grid energy storage technology after pumped hydro. It has been used since the 19th century for different industrial applications, including mobile ones. Currently, there are only a few large-scale plants (110 MW to 300 MW) in operation worldwide, and growth in CAES capacity has been minimal in recent years. However, this should change over the next decade due to government support for projects featuring new technologies like adiabatic and isothermal compression and expansion systems that do not require fuel[5]. In an adiabatic CAES process, the released heat is retained in thermal storage and used again during expansion in a turbine. The advantage of CAES is its large capacity. In general, CAES is less efficient and slower responding than PHS, which makes the technology less applicable to short-duration, fast-response services like frequency regulation. In addition to low efficiency, there are geographic limitations in terms of locating a suitable underground reservoir[6].

D.3.3 Flywheel Energy Storage (FES). Flywheels store electricity in the form of rotational kinetic energy. The energy density of a flywheel ESS depends on the rotational speed, the mass distribution, and the size of the spinning rotor. The main components of a flywheel include a rotating body or cylinder comprised of a rim attached to a shaft contained in a compartment. There are also bearings and the transmission device, which is a motor/generator mounted onto a stator. The stator is the static part of the assembly, usually at the top of the tower.

The energy is maintained in the flywheel by keeping the rotating body at a constant speed. An increase in the speed produces a higher amount of energy stored. The transmission device is utilized to accelerate the supply of flywheel electricity. If the flywheel's rotational speed is reduced, electricity can be extracted from the system by the same transmission device. First generation flywheels have been available since 1970, consisting of a large steel rotating body on mechanical bearings. Advanced FES systems have rotors made of high-strength carbon fiber, suspended by magnetic bearings and spinning at speeds from 20,000 rpm to over 50,000 rpm in a vacuum enclosure. Flywheel system level safety issues require special considerations, including mechanical containment testing and modeling, vacuum loss testing, and material fatigue testing under stress.

Notable performance features of flywheel ESS are high-power density, excellent cycle stability/life, low maintenance, and the incorporation of environmentally inert materials. Flywheel operation has a high level of self-discharge due to air resistance and bearing losses and as a result, suffer from low current efficiency. Smaller flywheel systems capable of charging and discharging for several seconds are widely used for uninterruptible power supply (UPS) applications. Larger commercially deployed high-speed flywheel technology (100 kW to 25 kWh) is used in the industrial power field for applications such as frequency regulation. Flywheels are commonly used in hybrid ESS configurations, and efforts are currently being made to optimize designs for long duration storage operation (up to several hours) for use in vehicles and power plants.

D.4 Electrical ESS. The two most common electrical ESS are capacitors and superconducting magnetic energy storage (SMES). Electrochemical double-layer capacitors (DLC) or supercapacitors are a technology that has been known for 60 years. They fill the gap between classical capacitors used in electronics and batteries, due to almost unlimited cycle stability, extremely high-power capability, and high orders of magnitude better energy storage capability relative to traditional capacitors. Therefore, supercapacitors have a large development potential that could lead to much greater capacitance and energy density, thus enabling compact designs in the future.

D.4.1 Superconducting Magnetic Energy Storage (SMES). Superconducting magnetic energy storage (SMES) systems function according to an electrodynamic principle. The energy is stored in the magnetic field created by the flow of direct current in a superconducting coil, which is maintained below its superconducting critical temperature. At the discovery of superconductivity approximately 100 years ago, a temperature of about 4 K was needed. Important research has now produced available superconducting materials with higher critical temperatures and stability at around 100 K. The main component of this storage system is a coil made of superconducting material. Additional system components include power conditioning equipment and a cryogenically cooled refrigeration system.

The main advantage of SMES is the rapid response time that allows the power demand to be available almost instantaneously. The system is also characterized by its high overall round-trip efficiency (85 percent to 90 percent) and the very high power output that can be provided for a short period of time. There are no moving parts in the main portion of SMES, but the overall reliability still depends heavily on the refrigeration system. In principle, the energy can be stored indefinitely if the cooling system is operational, but longer storage times are limited by the energy demand of the refrigeration system.

Large SMES systems with more than 10 MW power are mainly used in particle detectors for high-energy physics experiments and nuclear fusion. Currently, a few small SMES products are commercially available as these are mainly used for power quality control in manufacturing plants such as microchip fabrication facilities[7].

D.5 Thermal Energy Storage. Thermal (energy) storage systems store available heat by different means in insulated containment for later release in different industrial and residential applications, such as space heating or cooling, hot water production, or electricity generation. Thermal storage systems are deployed to overcome the disconnect between demand and supply of thermal energy and as a result become important for the integration of renewable energy sources.

Thermal storage can be subdivided into different technologies, including storage of sensible heat, storage of latent heat, and thermo-chemical (adsorption and absorption) storage[8]. The storage of sensible heat is the most common of the technologies with the domestic hot water tank as an example. The storage medium can be a liquid such as water or thermo-oil or a solid such as concrete or the ground. Thermal energy is stored only by a change of temperature of the storage medium. The capacity of a storage system is defined by the specific heat capacity and the mass of the medium used.

Latent heat storage is achieved by using phase change materials (PCMs) as storage media. There are organic (waxes) and inorganic PCMs (salt hydrates) available for such storage systems. Latent heat is the energy released during a phase change such as the melting of ice. It is also called "hidden" heat, because the energy transfer is isothermal. Most PCMs use the solid-liquid phase change, such as molten salts, as the medium for concentrated solar power (CSP) plants[9]. The advantage of latent heat storage is its capacity to store large amounts of energy in a small volume and with a minimal temperature change for efficient heat transfer.

Adsorption and absorption storage systems work as thermo-chemical heat pumps under vacuum conditions and have a more complex design. Heat from a high-temperature source heats up an adsorbent (e.g., silica gel or zeolite), and vapor from the working fluid (e.g., water) is desorbed from this adsorbent and condensed in a condenser at low temperatures. The heat of condensation is withdrawn from the system. The dried adsorbent and the separated working fluid can be stored as long as desired. During the discharging process the working fluid takes up low-temperature heat in an evaporator. Subsequently, the vapor of the working fluid adsorbs on the adsorbent and the heat of adsorption is released at high temperatures[10]. Depending on the adsorbent/working fluid combination, the temperature level of the released heat can be up to 392°F (200°C)[8], and the energy density is up to three times higher than that of sensible heat storage with water.

It is mainly sensible and latent heat storage systems that are important for thermal ESS. Concentrated solar power (CSP) plants primarily produce heat that can be easily stored before conversion to electricity. State-of-the-art technology is a two-tank system for solar power plants, with one single molten salt as the heat transfer fluid and storage medium[11]. The molten salt is heated by solar radiation and then transported to the hot salt storage tank. To produce electricity, the hot salt passes through a steam generator that powers a steam turbine. Subsequently, the cold salt (still molten) is stored in a second tank before it is pumped to the solar tower again. The main disadvantages are the risk of liquid salt freezing at low temperatures and the risk of salt decomposition at higher temperatures. Typical salt mixtures such as Na-K-NO3 have freezing temperatures >392°F (>200°C).

It is important to know if a pressurized tank is needed for the thermal storage or if a nonpressurized compartment can be used. In liquid systems, a heat exchanger can be used to avoid the need for a large pressurized tank for the liquid. A dual-media approach (salt and oil) must be used to cover the temperature range from 122°F to 1202°F (50°C to 650°C)[12]. Direct contact between the pressurized air and the storage medium in a solid thermal storage system has the advantage of a high surface area for heat transfer.

Annex E Permits, Inspections, Approvals, and Connections

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

E.1 Permits. Permits should conform to E.1.1 through E.1.4.

E.1.1 Application. Permits should be secured from and issued by the authority having jurisdiction for the following:

(1) Installation of new stationary ESS
(2) Additions, alterations, or renovations to existing stationary ESS
(3) Recommissioning or decommissioning of existing ESS
(4) Placement of mobile ESS
(5) Stationary installations of mobile or portable ESS

(6) A change in the occupancy classification of a building or facility in which a stationary ESS is installed

E.1.2 Content. Permits should be issued by and in accordance with the procedures of all authorities having jurisdiction and should bear the name and signature of each authority having jurisdiction or their designated representative(s). In addition, the permit should indicate the following:

(1) Purpose of the ESS for which the permit is issued
(2) Type of ESS, size, weight broken down by subcomponents or subsystems, type, and amount of any hazardous materials, general arrangement of the system, and extent of work to be performed
(3) Address where the ESS is to be installed and operated
(4) Name and address of the permittee
(5) Permit number and date of issuance
(6) Period of validity of the permit
(7) Inspection requirements

E.1.3 Issuance of Permits. The authority having jurisdiction should be authorized to establish and issue permits, certificates, notices, and approvals, or orders pertaining to any ESS as covered in E.1.1. Once permitted, the owner of the ESS, or their designated agent, should be responsible for the maintenance of the system and the abatement of any hazardous conditions that exist that are associated with the system or are external to and could adversely affect the system.

E.1.4 Revocation of Permits. Revocation of permits should conform to the following:

(1) The authority having jurisdiction should be permitted to revoke a permit or approval issued if any violation of this standard is found on inspection or where the ESS is not in accordance with the approved plans and specifications on which the permit or approval was based.
(2) Any attempt to defraud or otherwise deliberately or knowingly violate the requirements prescribed by this standard should constitute a violation of this standard. Such violations should be cause for immediate revocation of permits for the ESS issued by the authority having jurisdiction.
(3) Any person who operates or causes an ESS that has a revoked permit to be operated should be in violation of this standard.

E.2 Inspections and Approvals. The inspection and approval of an ESS should conform to E.2.1 through E.2.5.

E.2.1 Application. On completion of the installation of any new ESS or work on an existing ESS requiring a permit the person, firm, corporation, or system integrator making the installation should notify the authority having jurisdiction, who should inspect or authorize their designated representative(s) to inspect the installation.

E.2.2 Inspection. Where those responsible for inspection of the ESS find the installation to be in conformity with this standard, the authority having jurisdiction should issue to the owner of the system a certificate of approval. A duplicate copy of the certificate of approval should be provided in writing to any supplier of energy to the system authorizing the connection of energy to the system. When the approval has a specific date of expiration, as in the case of a temporary system installation, the certificate of approval should be issued to expire at the time to be stated therein and should be revocable by the authority having jurisdiction for cause.

E.2.3 Concealment. Any portion or component of the system that is to be hidden from view by permanent placement of parts of the system or construction associated with the installation should notify the authority having jurisdiction and should not conceal it until inspected and approved by the authority having jurisdiction or their designated representative(s).

E.2.4 Reinspection. The authority having jurisdiction should be permitted to visit any ESS installation to inspect such system for compliance with the plans and specifications that were submitted with the permit application and, with the inspection of the system, formed the basis for validating compliance with this standard.

E.2.5 Revocation of Permits. The authority having jurisdiction should be permitted to revoke a permit or approval issued if any violation of this standard is found on inspection or in case there have been any false statements or misrepresentations submitted in the application or plans and specifications on which the permit or approval was based.

E.3 Connection to an Energy Supply. Connections of the ESS to any energy source should conform to E.3.1 and E.3.2.

E.3.1 Authorization. It should be unlawful to connect the ESS to a supply of energy to the system or to supply energy from the system for any purpose unless the ESS has been permitted and approved in accordance with the requirements of this standard.

E.3.2 Temporary Consideration. By special permission of the authority having jurisdiction and the applicable entities to supply and/or receive energy from the system, energy should be permitted to be supplied on a temporary basis for specific needs associated with testing, commissioning, or inspecting the ESS.

Annex F Fire and Building Codes — A Short History on Stationary Storage Battery Systems

This annex is not a part of the requirements of this NFPA document but is included for informational purposes only.

F.1 General. The National Fire Protection Association's (NFPA) development of NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems*, is not the first effort to address the safety of energy storage systems. Energy storage technologies have long been addressed by *NFPA 70*, *National Electrical Code* (*NEC*), along with building and fire codes under the topic stationary storage battery systems.

More focused treatment of battery systems began with the 1997 edition of the ICC *Uniform Fire Code* (UFC). Before that various standards and model codes provided safety requirements that addressed batteries both as primary sources of electrical energy and for emergency backup power. Because of the amount of acid electrolyte in lead-acid batteries, when viewed in the aggregate and individually, they were being regulated for the hazardous material properties of the electrolyte, which then triggered more stringent high-hazard occupancy construction and protection requirements. As a result, the telecommunications industry sought a change to the UFC that addressed the operating hazards associated with batteries in their facilities without triggering the more stringent building and fire code requirements.

This treatment of battery systems in building and fire codes based upon the chemistry and amount of electrolytes was uniform across the three legacy model codes produced by the Building Officials and Code Administrators International, International Conference of Building Officials, and Southern Building Code Congress International that existed prior to their merger and the creation of the International Code Council series of model codes completed in 2000.

F.2 Historical Development of Codes.

F.2.1 1997 Uniform Fire Code. Section 6401 of the 1997 edition of the *Uniform Fire Code*, based on approved modifications to the 1994 edition, contained the following requirements for stationary lead-acid battery systems:

SECTION 6401 SCOPE. Stationary lead-acid battery systems having a liquid capacity of more than 100 gallons (378.5 L) used for facility standby power, emergency power or uninterrupted power supplies shall be in accordance with Article 64. Stationary lead-acid battery systems with individual lead-acid batteries exceeding 20 gallons (75.7 L) each shall also comply with Article 80. [**UFC,** 1997]

The requirements addressed were as follows:

(1) Safety venting
(2) Occupancy separation
(3) Spill control
(4) Neutralization
(5) Ventilation
(6) Signs
(7) Seismic protection
(8) Smoke detection

Note that the scope was not open ended. The individual battery limitation was set at 20 gallons and exceeding that amount per battery still triggered the more extensive hazardous material provisions in the UFC.

The topics addressed were based upon normal operation. Overcharging, thermal runaway, or other abnormal operational conditions were not considered, if in fact they were even recognized safety concerns at the time.

F.2.2 2000 International Code Council Codes. The targeted regulation of stationary lead-acid battery systems that began with the 1997 *Uniform Fire Code* was carried forward as the three legacy model code organizations merged as the International Code Council and completed work on the development of, among others, the 2000 *International Fire Code* and 2000 *International Building Code*. The topics covered were as follows:

(1) Safety venting
(2) Room design and construction
(3) Spill control and neutralization
(4) Ventilation
(5) Signs
(6) Seismic protection
(7) Smoke detection

The threshold for application was reduced to 50 gal, and the 20 gal per battery limitation was eliminated compared to the 1997 UFC. In addition, the *International Building Code* classified the battery storage as incidental use areas and added an exemption from the high-hazard use classification.

The purpose of the requirements was to provide for relief for certain battery system applications from being designated a high-hazard occupancy due to the amount of hazardous materials that were contained within the batteries. In practice, if a stationary lead-acid battery system satisfies these requirements then the facility containing those batteries is not regulated as a hazardous material occupancy and would not be designated a high-hazard use. That said, if the hazardous material maximum allowable quantities (MAQ) relative to the amount of electrolyte was exceeded then the battery system would result in a hazardous material classification.

The requirements for stationary lead-acid battery systems were brought into the 2000 *International Fire Code* as Section 608 with the topics listed in F.2.2 addressed. For room design and construction, the user was pointed to the 2000 *International Building Code* where the battery systems were identified as an incidental use area and required to be separated from the remainder of the occupancy by fire resistance rated assemblies.

As with the 1997 UFC, the topics addressed were based upon normal operation. Overcharging, thermal runaway, or other abnormal operating conditions were not considered or recognized at the time.

F.2.3 2003 International Code Council Codes and NFPA 1, *Fire Code*. In Section 608 of the 2003 *International Fire Code*, the scope of lead-acid battery systems was changed to lead-acid battery systems using vented (flooded) lead-acid batteries. A new Section 609 was added to the IFC covering valve-regulated lead-acid battery systems and contained similar language. The requirements in the 2003 *International Building Code* remained the same applying to lead-acid batteries generally.

Section 608 vented (flooded) lead-acid batteries covered the following:

(1) Safety venting
(2) Room design and construction
(3) Spill control and neutralization
(4) Ventilation
(5) Signs
(6) Seismic protection
(7) Smoke detection

Section 609 valve-regulated lead-acid battery systems covered the following:

(1) Safety venting
(2) Thermal runaway
(3) Room design and construction
(4) Spill control and neutralization
(5) Ventilation
(6) Cabinet ventilation
(7) Signs
(8) Seismic protection
(9) Smoke detection

It should be noted that NFPA 1, *Fire Code*, did not have any requirements for stationary storage battery systems in the 2000 edition. The requirements were added to the 2003 edition of NFPA 1 from the same source used for the 2000 edition of the *International Fire Code*, the *Uniform Fire Code*, along with the added coverage of valve-regulated lead-acid batteries. The NFPA 1, *Fire Code*, battery storage provisions then remained unchanged until the 2009 edition.

F.2.4 2006 International Code Council Codes and NFPA 1, *Fire Code*. In the 2006 edition of the *International Fire Code* (IFC), Section 608 was rewritten to cover the following:

(1) Flooded lead-acid batteries
(2) Flooded nickel-cadmium (Ni-Cad) batteries
(3) Valve-regulated lead-acid (VRLA) batteries
(4) Lithium-ion batteries

This edition of the IFC signaled a recognition for and the introduction of new chemistries such as nickel-cadmium and lithium-ion batteries.

The same general topics were covered in the revisions to the 2003 IFC that were implemented as the 2006 IFC, including the need for a separate room or space created in accordance with the building code. That said, beyond the separate room, only the IFC signage, seismic protection, and smoke detection requirements applied to the lithium-ion batteries. Figure F.2.4 provides the overview of the 2006 IFC provisions.

There were no changes made between the 2003 and the 2006 edition of NFPA 1, *Fire Code*. As such, it continued to apply only to the flooded lead-acid and valve-regulated lead-acid batteries.

F.2.5 2009 International Code Council Codes and NFPA 1, *Fire Code*. The 2009 edition of NFPA 1, *Fire Code*, contained new provisions that added lithium-ion and nickel-cadmium technologies, and both NFPA 1 *(see Table F.2.5)* and the IFC *(see Figure F.2.5)* contained new provisions that added lithium metal polymer batteries to the list of regulated battery technologies. The key difference in treatment between lithium-ion batteries and lithium metal polymer batteries was the requirement for thermal runaway protection for lithium metal polymer batteries. It should be noted that although Table 52.1 of the 2009 edition of NFPA 1 indicates no thermal runaway requirement for lithium-ion batteries, the technical language in 52.3.2 indicates thermal runaway was required for lithium-ion as well.

Thermal Runaway. VRLA and lithium-ion and lithium metal polymer battery systems shall be provided with a listed device or other approved method to preclude, detect, and control thermal runaway. [**1:**52.3.2, 2009]

A change to the *International Building Code* (IBC) unrelated to battery storage systems limited all incidental uses, the classification the IBC applies to battery systems, to no more than 10 percent of the area of the floor of the building they are located on.

F.2.6 2012 and 2015 International Code Council Codes and NFPA 1, *Fire Code*. Between the 2009 and 2012 editions of the fire codes, there were insignificant changes made to the requirements associated with battery systems. Between the 2012 and 2015 editions no changes were made. Essentially the 2009 and 2015 editions were the same with respect to battery systems.

TABLE 608.1
BATTERY REQUIREMENTS

REQUIREMENT	NONRECOMBINANT BATTERIES		RECOMBINANT BATTERIES	
	Flooded Lead Acid Batteries	Flooded Nickel-Cadmium (Ni-Cd) Batteries	Valve Regulated Lead Acid (VRLA) Batteries	Lithium-Ion Batteries
Safety caps	Venting caps (608.2.1)	Venting caps (608.2.1)	Self-resealing flame-arresting caps (608.2.2)	No caps
Thermal runaway management	Not required	Not required	Required (608.3)	Not required
Spill control	Required (608.5)	Required (608.5)	Not required	Not required
Neutralization	Required (608.5.1)	Required (608.5.1)	Required (608.5.2)	Not required
Ventilation	Required (608.6.1; 608.6.2)	Required (608.6.1; 608.6.2)	Required (608.6.1; 608.6.2)	Not required
Signage	Required (608.7)	Required (608.7)	Required (608.7)	Required (608.7)
Seismic protection	Required (608.8)	Required (608.8)	Required (608.8)	Required (608.8)
Smoke detection	Required (608.9)	Required (608.9)	Required (608.9)	Required (608.9)

FIGURE F.2.4 2006 International Fire Code Battery Requirements. ***(Source: 2006 International Fire Code.)***

Table F.2.5 Battery Requirements

Requirement	Nonrecombinant Batteries: Flooded Lead-Acid	Nonrecombinant Batteries: Flooded Nickel-Cadmium (Ni-Cd)	Recombinant Batteries: Valve-Regulated Lead–Acid (VRLA)	Recombinant Batteries: Lithium-Ion	Other: Lithium Metal Polymer
Safety caps	Venting caps	Venting caps	Self-resealing flame-arresting caps	No caps	No caps
Thermal runaway management	Not required	Not required	Required	Not required	Required
Spill control	Required	Required	Not required	Not required	Not required
Neutralization	Required	Required	Required	Not required	Not required
Ventilation	Required	Required	Required	Not required	Not required
Signage	Required	Required	Required	Required	Required
Seismic control	Required	Required	Required	Required	Required
Fire detection	Required	Required	Required	Required	Required

[**1:**Table 52.1, 2009]

TABLE 608.1
BATTERY REQUIREMENTS

REQUIREMENT	NONRECOMBINANT BATTERIES: Flooded Lead Acid Batteries	NONRECOMBINANT BATTERIES: Flooded Nickel-Cadmium (Ni-Cd) Batteries	RECOMBINANT BATTERIES: Valve Regulated Lead Acid (VRLA) Batteries	RECOMBINANT BATTERIES: Lithium-Ion Batteries	OTHER: Lithium Metal Polymer
Safety caps	Venting caps (608.2.1)	Venting caps (608.2.1)	Self-resealing flame-arresting caps (608.2.2)	No caps	No caps
Thermal runaway management	Not required	Not required	Required (608.3)	Not required	Required (608.3)
Spill control	Required (608.5)	Required (608.5)	Not required	Not required	Not required
Neutralization	Required (608.5.1)	Required (608.5.1)	Required (608.5.2)	Not required	Not required
Ventilation	Required (608.6.1; 608.6.2)	Required (608.6.1; 608.6.2)	Required (608.6.1; 608.6.2)	Not required	Not required
Signage	Required (608.7)	Required (608.7)	Required (608.7)	Required (608.7)	Required (608.7)
Seismic protection	Required (608.8)	Required (608.8)	Required (608.8)	Required (608.8)	Required (608.8)
Smoke detection	Required (608.9)	Required (608.9)	Required (608.9)	Required (608.9)	Required (608.9)

FIGURE F.2.5 2009 International Fire Code Battery Requirements. ***(Source: 2009 International Fire Code.)***

F.2.7 2018 International Code Council Codes and NFPA 1, *Fire Code*. Recognizing the development of new battery technologies and the evolution of battery storage into a more robust and wider energy storage industry in relation to the requirements in the various fire and building codes, the International Code Council's Fire Code Action Committee created an Energy Storage Systems Work Group (ESS WG). The work of the ESS WG resulted in a new chapter being approved for inclusion in the 2018 *International Fire Code* — Chapter 12, Energy Systems — into which all the key energy-storage-related requirements (including batteries) were moved including the following:

(1) Emergency and stand-by power systems
(2) Solar photovoltaic power systems
(3) Stationary fuel cell power systems
(4) Electrical energy storage systems

As part of this work the requirements of the former stationary storage battery systems chapter took on the broader application of electrical energy storage systems and addressed the following topics:

(1) Battery storage system threshold quantities
(2) Construction documents
(3) Hazard mitigation analysis
(4) Fault condition
(5) Thermal runaway
(6) Seismic and structural design
(7) Vehicle impact protection
(8) Combustible storage
(9) Testing, maintenance, and repair

(10) Location and construction
(11) Stationary battery arrays
(12) Outdoor installations
(13) Maximum allowable quantities
(14) Storage batteries and equipment
(15) Fire-extinguishing and detection systems
(16) Specific battery-type requirements
(17) Capacitor energy storage systems

A major change within this work of the IFC was the introduction of array (unit) spacing as follows:

1206.2.8.3 Stationary battery arrays. Storage batteries, prepackaged stationary storage battery systems and preengineered stationary storage battery systems shall be segregated into stationary battery arrays not exceeding 50 kWh (180 megajoules) each. Each stationary battery array shall be spaced not less than 3 feet (914 mm) from other stationary battery arrays and from walls in the storage room or area. The storage arrangements shall comply with Chapter 10. [**IFC,** 2018]

This is intended to restrict the amount of energy in arrays (units) and requires a larger footprint for an energy storage system installation due to the 3 ft separation requirement. Exceptions were provided that eliminate lead-acid and nickel-cadmium storage batteries from this limitation, allow listed prepackaged units to have a 250 kWh threshold for separation, and elimination of the limits based upon large-scale fire testing as follows:

Exceptions:

(1) *Lead acid and nickel cadmium storage battery arrays.*
(2) *Listed preengineered stationary storage battery systems and prepackaged stationary storage battery systems shall not exceed 250 kWh (900 megajoules) each.*
(3) *The fire code official is authorized to approve listed, preengineered and prepackaged battery arrays with larger capacities or smaller battery array spacing if large-scale fire and fault condition testing conducted or witnessed and reported by an approved testing laboratory is provided showing that a fire involving one array will not propagate to an adjacent array, and be contained within the room for a duration equal to the fire-resistance rating of the room separation specified in Table 509 of the International Building Code.*

[**IFC,** 2018]

The IFC relies upon 1- or 2-hour fire-resistant construction to separate systems from the remainder of the building and an assessment that that level of protection can contain the fire impacts within the room or space where a system is installed. A large-scale fire test is needed to document such containment.

The other significant change between the 2015 and 2018 IFC editions was the specification of a maximum allowable battery quantity *(see Figure F.2.7)*.

This was the first time there was an upper limit applied to the amount of energy allowed to be stored in an energy storage system located in a room or space. As with the spacing limitations, there was an exception that could be applied based upon large-scale fire testing as follows:

Exception: Where approved by the fire code official, areas containing stationary storage batteries that exceed the amounts in Table 1206.2.9 shall be treated as incidental use areas and not Group H occupancies based on a hazardous mitigation analysis in accordance with Section 1206.2.3 and large-scale fire and fault condition testing conducted or witnessed and reported by an approved testing laboratory. [**IFC,** 2018]

Along with the provisions in the 2018 IFC, energy storage language was added to the 2018 *International Residential Code* for the first time. In summary, the new language in the *International Residential Code* required energy storage systems to be listed and precluded them from being installed within the habitable space of a dwelling unit.

The 2018 NFPA 1, *Fire Code,* Chapter 52 contained modifications to the 2015 edition that were very similar to all of the new requirements introduced to the 2018 IFC.

F.2.8 2021 International Code Council Code Development and 2019 NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems.* While the code revision process was being completed for the 2018 editions of the IFC and NFPA 1, NFPA developed the new standard NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems.* The work of the NFPA 855 technical committee closely tracked and utilized the 2018 language added to the fire codes along with the language from NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems,* for the initial NFPA 855 draft document.

TABLE 1206.2.9
MAXIMUM ALLOWABLE BATTERY QUANTITIES

BATTERY TECHNOLOGY	MAXIMUM ALLOWABLE QUANTITIES[a]	GROUP H OCCUPANCY
Flow batteries[b]	600 kWh	Group H-2
Lead acid, all types	Unlimited	Not Applicable
Lithium, all types	600 kWh	Group H-2
Nickel cadmium (Ni-Cd)	Unlimited	Not Applicable
Sodium, all types	600 kWh	Group H-2
Other battery technologies	200 kWh	Group H-2[c]

For SI: 1 kilowatt hour = 3.6 megajoules.
a. For batteries rated in amp-hours, Kilowatt-hours (kWh) shall equal rated battery voltage times the amp-hour rating divided by 1,000.
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 F.2.7 2018 International Fire Code Maximum Allowable Battery Quantities. ***(Source: 2018 International Fire Code.)***

With the adoption and availability of the 2018 editions of the codes, a broader audience was reached that generated additional input to the NFPA 855 committee on the impact of the requirements and questions on how to apply them in differing circumstances such as follows:

(1) Roof installs
(2) Open parking garage installs
(3) Remote installations
(4) Dedicated ESS buildings
(5) Array (unit) spacing threshold
(6) Maximum allowable quantity impact
(7) Incidental use 10 percent of floor area limitation
(8) Appropriate requirements based upon technology
(9) Deflagration prevention/venting
(10) Suppression system selection
(11) Fire detection method and where required

Going into the NFPA 855 First Draft process, language improvements were coordinated with work in progress on the proposals for the 2021 editions of the *International Fire Code*, *International Building Code*, and the *International Residential Code*.

Key areas addressed by the current proposals approved by the ICC Fire Code Action Committee and the Fire Code Committee at the proposal hearings for the 2021 edition code change process were as follows:

(1) Permits, operational as well as installation
(2) Large-scale fire test reliance on new UL 9540A
(3) Fire remediation actions and personnel
(4) Commissioning
(5) Decommissioning
(6) Operation and maintenance
(7) Repairs, retrofits, and replacements
(8) Reused and repurposed equipment
(9) Toxic and highly toxic gases
(10) Security of installations
(11) Occupied work centers
(12) Walk-in units
(13) Size and separation threshold reduction
(14) Maximum allowable quantities as simply a testing trigger
(15) Remote installations
(16) Dedicated-use buildings designated as an F-1 Group use
(17) Non-dedicated-use buildings
(18) Elimination of incidental use 10 percent of floor area restriction and H Group designation
(19) Explosion control
(20) Outdoor installations
(21) Rooftop installations
(22) Open parking garage installations
(23) Mobile ESS equipment and operations

Though some of the new language is more conservative, such as the threshold before large-scale fire testing and the requirement for explosion protection for lithium-ion energy storage systems, other proposed changes provide relief from some requirements such as dedicated-use buildings, remote locations, and rooftop and open parking garage installations.

The most restrictive requirements were maintained to address when an energy storage system is installed within a mixed-use occupancy building and it is important to contain an event for life safety and property protection.

The changes proposed for the 2021 I-Codes, and coordinated with the 2019 NFPA 855 development process, are significantly different from the 2018 provisions because of industry participation. The initial language of the 2018 editions of the fire codes and the draft of NFPA 855 are intended to obtain an acceptable level of safety recognizing how challenging and dynamic events from batteries and energy storage systems can be, whether the system instigates an issue or is a casualty of outside events. Those who verify code compliance and others working on the code language have maintained an open view, and where industry has provided data on different technologies and/or on documented safety practices, or a reduction in exposure hazards, there has been a willingness to modify the requirements in recognition of the new information and data.

F.3 NFPA Fire Protection Research Foundation. There are a few research projects involving the NFPA Fire Protection Research Foundation, Factory Mutual, and Sandia National Laboratories, and the Pacific Northwest National Laboratory on behalf of the DOE Office of Electricity Energy Storage Program, and others that have provided background and understanding for those involved in the code writing process. There are numerous other sources for information, however; the following sources are those best known to many of those involved in the code development process:

(1) NFPA — for fire fighter safety in battery energy storage system fires, see https://www.nfpa.org/News-and-Research/Resources/Fire-Protection-Research-Foundation/Current-projects/Fire-Fighter-Safety-in-Battery-Energy-Storage-System-Fires
(2) NFPA — for lithium-ion batteries hazard and use assessment, see the following:
    (a) "Lithium Ion Batteries Hazard and Use Assessment"
    (b) "Lithium Ion Batteries Hazard and Use Assessment — Phase IIB — Flammability Characterization of Li-ion Batteries for Storage Protection"
    (c) "Lithium Ion Batteries Hazard and Use Assessment — Phase III"
(3) DNV GL — for considerations for energy storage systems fire safety, see https://www.dnvgl.com/publications/considerations-for-energy-storage-systems-fire-safety-89415
(4) Sandia National Laboratory — for energy storage, see http://energy.sandia.gov/energy/ssrei/energy-storage/

When industry joined the code-development process, they successfully used additional data specific to their products and operations to bring validity and functionality to proposed code language. The increased industry participation will be a benefit moving forward.

Annex G Informational References

G.1 Referenced Publications. The documents or portions thereof listed in this annex are referenced within the informational sections of this standard and are not part of the requirements of this document unless also listed in Chapter 2 for other reasons.

G.1.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2018 edition.

NFPA 22, *Standard for Water Tanks for Private Fire Protection*, 2018 edition.

NFPA 68, *Standard on Explosion Protection by Deflagration Venting*, 2018 edition.

NFPA 69, *Standard on Explosion Prevention Systems*, 2019 edition.

NFPA 70®, National Electrical Code®, 2017 edition.

NFPA 70E®, Standard for Electrical Safety in the Workplace®, 2018 edition.

NFPA *101®, Life Safety Code®*, 2018 edition.

NFPA 400, *Hazardous Materials Code*, 2019 edition.

NFPA 497, *Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2017 edition.

NFPA 499, *Recommended Practice for the Classification of Combustible Dusts and of Hazardous (Classified) Locations for Electrical Installations in Chemical Process Areas*, 2017 edition.

NFPA 704, *Standard System for the Identification of the Hazards of Materials for Emergency Response*, 2017 edition.

NFPA 750, *Standard on Water Mist Fire Protection Systems*, 2019 edition.

NFPA 1620, *Standard for Pre-Incident Planning*, 2015 edition.

NFPA 2001, *Standard on Clean Agent Fire Extinguishing Systems*, 2018 edition.

G.1.2 Other Publications.

G.1.2.1 FPRF Publications. Fire Protection Research Foundation, 1 Batterymarch Park, Quincy, MA 02169-7471.

Best Practices for Emergency Response to Incidents Involving Electric Vehicles Battery Hazards: A Report on Full-Scale Testing Results, July 2013.

G.1.2.2 IEC Publications. International Electrotechnical Commission, 3, rue de Varembé, P.O. Box 131, CH-1211 Geneva 20, Switzerland.

IEC 60812, *Analysis techniques for system reliability — Procedure for failure mode and effects analysis (FMEA)*, 2006.

IEC 61025, *Fault tree analysis (FTA)*, 2006.

G.1.2.3 IEEE Publications. IEEE, 3 Park Avenue, 17th Floor, New York, NY 10016-5997.

IEEE 1635/ASHRAE 21, *Guide for the Ventilation and Thermal Management of Batteries for Stationary Applications,* 2018.

IEEE C2, *National Electrical Safety Code*, 2017.

G.1.2.4 Military Specifications. Department of Defense Single Stock Point, Document Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094.

MIL-STD-1629A, *Procedures for Performing a Failure Mode, Effects and Criticality Analysis,* 1980.

G.1.2.5 NECA Publications. National Electrical Contractors Association, 3 Bethesda Metro Center, Suite 1100, Bethesda, MD 20814.

NECA 416, *Recommended Practice for Installing Energy Storage Systems (ESS)*, 2017.

G.1.2.6 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 1741, *Standard for Inverters, Converters, Controllers and Interconnection System Equipment for Use With Distributed Energy Resources*, 2016.

UL 2743, *Standard for Portable Power Packs,* 2016.

UL 9540, *Safety of Energy Storage Systems and Equipment*, 2016.

UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2018.

G.1.2.7 UN Publications. United Nations Headquarters, New York, NY 10017.

UN 38.3, *Recommendations on the Transport of Dangerous Goods: Lithium Metal and Lithium Ion Batteries*, 2015.

G.1.2.8 References for Annex D.

1. International Electrotechnical Commission (IEC), "Electrical Energy Storage," White Paper, Geneva/Switzerland, pp. 17–34, December 2011.

2. Rastler, D., "Electricity Energy Storage Technology Option," Electric Power Research Institute, December 2010.

3. Doetsch, C., "Electrical energy storage from 100 kW – State of the art technologies, fields of use," 2nd International Renewable Energy Storage Conference, Bonn, Germany, November 2007.

4. Xie, S., and L. S. Wang, "Industry Trends — Issue 9," China Energy Storage Alliance, January 2012.

5. The ADELE project in Germany uses adiabatic compression, while the SustainX, General Compression, and LightSail projects in the U.S. use Isothermal compression. See "ADELE — Adiabatic Compressed-Air Energy Storage (CAES) for Electricity Supply," RWE, www.rwe.com, accessed May 17, 2012; "SustainX's ICAES," SustainX, www.sustainx.com, accessed May 17, 2012; "General Compression, Who We Are," General Compression, www.generalcompression.com, accessed May 17, 2012.

6. Nakhamkin, M., "Novel Compressed Air Energy Storage Concepts," developed by Energy Storage and Power Consultants (ESPC) and presented to EESAT, May 2007.

7. Inage, Shin-ichi, "Prospects for Large-Scale Energy Storage in Decarbonised Grids," International Energy Agency, Report, 2009.

8. Schossig, P., "Thermal Energy Storage," 3rd International Renewable Energy Storage Conference, Berlin, Germany, November 2012.

9. Fairley, P., http://spectrum.ieee.org/energy/environment/largest-solar-thermal-storage-plant-to-start-up, Article 2008, Accessed July 2011.

10. Jahnig D. et al., "Thermo-chemical storage for solar space heating in a single-family house," 10th International Conference on Thermal Energy Storage, Ecostock 2006, New Jersey, May/June 2006.

11. Tamme, R., "Development of Storage Systems for SP Plants," DG TREN – DG RTD Consultative Seminar on Concentrating Solar Power, Brussels, Belgium, June 2006.

12. Bullough, C., "Advanced Adiabatic Compressed Air Energy Storage for the Integration of Wind Energy," European Wind Energy Conference and Exhibition, London, GB, November 2004.

G.1.2.9 References for Annex F.

G.1.2.9.1 NFPA Publications. National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02169-7471.

NFPA 1, *Fire Code*, 2000, 2003, 2006, 2009, 2012, 2015, and 2018 editions.

NFPA 853, *Standard for the Installation of Stationary Fuel Cell Power Systems*, 2015 edition.

"Lithium Ion Batteries Hazard and Use Assessment," Fire Protection Research Foundation, July 2011.

"Lithium Ion Batteries Hazard and Use Assessment — Phase IIB — Flammability Characterization of Li-ion Batteries for Storage Protection," Fire Protection Research Foundation, April 2013.

"Lithium Ion Batteries Hazard and Use Assessment — Phase III," Fire Protection Research Foundation, November 2016.

G.1.2.9.2 ICC Publications. International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001.

International Building Code (IBC), 2000, 2003, 2009, 2012, and 2015.

International Fire Code (IFC), 2000, 2003, 2006, 2009, 2012, 2015, and 2018.

International Residential Code, 2018.

Uniform Fire Code (UFC), 1994 and 1997.

G.1.2.9.3 UL Publications. Underwriters Laboratories Inc., 333 Pfingsten Road, Northbrook, IL 60062-2096.

UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems*, 2018.

G.2 Informational References. (Reserved)

G.3 References for Extracts in Informational Sections.

NFPA 1, *Fire Code*, 2009 edition.

NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*, 2019 edition.

NFPA *101*®, *Life Safety Code*®, 2018 edition.

Index

Sequence of Events for the Standards Development Process

Once the current edition is published, a Standard is opened for Public Input.

Step 1 – Input Stage

- Input accepted from the public or other committees for consideration to develop the First Draft
- Technical Committee holds First Draft Meeting to revise Standard (23 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Technical Committee ballots on First Draft (12 weeks); Technical Committee(s) with Correlating Committee (11 weeks)
- Correlating Committee First Draft Meeting (9 weeks)
- Correlating Committee ballots on First Draft (5 weeks)
- First Draft Report posted on the document information page

Step 2 – Comment Stage

- Public Comments accepted on First Draft (10 weeks) following posting of First Draft Report
- If Standard does not receive Public Comments and the Technical Committee chooses not to hold a Second Draft meeting, the Standard becomes a Consent Standard and is sent directly to the Standards Council for issuance (see Step 4) or
- Technical Committee holds Second Draft Meeting (21 weeks); Technical Committee(s) with Correlating Committee (7 weeks)
- Technical Committee ballots on Second Draft (11 weeks); Technical Committee(s) with Correlating Committee (10 weeks)
- Correlating Committee Second Draft Meeting (9 weeks)
- Correlating Committee ballots on Second Draft (8 weeks)
- Second Draft Report posted on the document information page

Step 3 – NFPA Technical Meeting

- Notice of Intent to Make a Motion (NITMAM) accepted (5 weeks) following the posting of Second Draft Report
- NITMAMs are reviewed and valid motions are certified by the Motions Committee for presentation at the NFPA Technical Meeting
- NFPA membership meets each June at the NFPA Technical Meeting to act on Standards with “Certified Amending Motions” (certified NITMAMs)
- Committee(s) vote on any successful amendments to the Technical Committee Reports made by the NFPA membership at the NFPA Technical Meeting

Step 4 – Council Appeals and Issuance of Standard

- Notification of intent to file an appeal to the Standards Council on Technical Meeting action must be filed within 20 days of the NFPA Technical Meeting
- Standards Council decides, based on all evidence, whether to issue the standard or to take other action

Notes:

1. Time periods are approximate; refer to published schedules for actual dates.
2. Annual revision cycle documents with certified amending motions take approximately 101 weeks to complete.
3. Fall revision cycle documents receiving certified amending motions take approximately 141 weeks to complete.

Committee Membership Classifications[1,2,3,4]

The following classifications apply to Committee members and represent their principal interest in the activity of the Committee.

1. M *Manufacturer:* A representative of a maker or marketer of a product, assembly, or system, or portion thereof, that is affected by the standard.
2. U *User:* A representative of an entity that is subject to the provisions of the standard or that voluntarily uses the standard.
3. IM *Installer/Maintainer:* A representative of an entity that is in the business of installing or maintaining a product, assembly, or system affected by the standard.
4. L *Labor:* A labor representative or employee concerned with safety in the workplace.
5. RT *Applied Research/Testing Laboratory:* A representative of an independent testing laboratory or independent applied research organization that promulgates and/or enforces standards.
6. E *Enforcing Authority:* A representative of an agency or an organization that promulgates and/or enforces standards.
7. I *Insurance:* A representative of an insurance company, broker, agent, bureau, or inspection agency.
8. C *Consumer:* A person who is or represents the ultimate purchaser of a product, system, or service affected by the standard, but who is not included in (2).
9. SE *Special Expert:* A person not representing (1) through (8) and who has special expertise in the scope of the standard or portion thereof.

NOTE 1: “Standard” connotes code, standard, recommended practice, or guide.

NOTE 2: A representative includes an employee.

NOTE 3: While these classifications will be used by the Standards Council to achieve a balance for Technical Committees, the Standards Council may determine that new classifications of member or unique interests need representation in order to foster the best possible Committee deliberations on any project. In this connection, the Standards Council may make such appointments as it deems appropriate in the public interest, such as the classification of “Utilities” in the National Electrical Code Committee.

NOTE 4: Representatives of subsidiaries of any group are generally considered to have the same classification as the parent organization.

Submitting Public Input / Public Comment Through the Online Submission System

Following publication of the current edition of an NFPA standard, the development of the next edition begins and the standard is open for Public Input.

Submit a Public Input

NFPA accepts Public Input on documents through our online submission system at www.nfpa.org. To use the online submission system:

- Choose a document from the List of NFPA codes & standards or filter by Development Stage for "codes accepting public input."
- Once you are on the document page, select the "Next Edition" tab.
- Choose the link "The next edition of this standard is now open for Public Input." You will be asked to sign in or create a free online account with NFPA before using this system.
- Follow the online instructions to submit your Public Input (see www.nfpa.org/publicinput for detailed instructions).
- Once a Public Input is saved or submitted in the system, it can be located on the "My Profile" page by selecting the "My Public Inputs/Comments/NITMAMs" section.

Submit a Public Comment

Once the First Draft Report becomes available there is a Public Comment period. Any objections or further related changes to the content of the First Draft must be submitted at the Comment Stage. To submit a Public Comment follow the same steps as previously explained for the submission of Public Input.

Other Resources Available on the Document Information Pages

Header: View document title and scope, access to our codes and standards or NFCSS subscription, and sign up to receive email alerts.

Current & Prior Editions	Research current and previous edition information.
Next Edition	Follow the committee's progress in the processing of a standard in its next revision cycle.
Technical Committee	View current committee rosters or apply to a committee.
Ask a Technical Question	For members, officials, and AHJs to submit standards questions to NFPA staff. Our Technical Questions Service provides a convenient way to receive timely and consistent technical assistance when you need to know more about NFPA standards relevant to your work.
News	Provides links to available articles and research and statistical reports related to our standards.
Purchase Products & Training	Discover and purchase the latest products and training.
Related Products	View related publications, training, and other resources available for purchase.

Information on the NFPA Standards Development Process

I. Applicable Regulations. The primary rules governing the processing of NFPA standards (codes, standards, recommended practices, and guides) are the NFPA *Regulations Governing the Development of NFPA Standards (Regs)*. Other applicable rules include NFPA *Bylaws*, NFPA *Technical Meeting Convention Rules*, NFPA *Guide for the Conduct of Participants in the NFPA Standards Development Process*, and the NFPA *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council*. Most of these rules and regulations are contained in the *NFPA Standards Directory*. For copies of the *Directory*, contact Codes and Standards Administration at NFPA headquarters; all these documents are also available on the NFPA website at "www.nfpa.org/regs."

The following is general information on the NFPA process. All participants, however, should refer to the actual rules and regulations for a full understanding of this process and for the criteria that govern participation.

II. Technical Committee Report. The Technical Committee Report is defined as "the Report of the responsible Committee(s), in accordance with the Regulations, in preparation of a new or revised NFPA Standard." The Technical Committee Report is in two parts and consists of the First Draft Report and the Second Draft Report. (See *Regs* at Section 1.4.)

III. Step 1: First Draft Report. The First Draft Report is defined as "Part one of the Technical Committee Report, which documents the Input Stage." The First Draft Report consists of the First Draft, Public Input, Committee Input, Committee and Correlating Committee Statements, Correlating Notes, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.3.) Any objection to an action in the First Draft Report must be raised through the filing of an appropriate Comment for consideration in the Second Draft Report or the objection will be considered resolved. [See *Regs* at 4.3.1(b).]

IV. Step 2: Second Draft Report. The Second Draft Report is defined as "Part two of the Technical Committee Report, which documents the Comment Stage." The Second Draft Report consists of the Second Draft, Public Comments with corresponding Committee Actions and Committee Statements, Correlating Notes and their respective Committee Statements, Committee Comments, Correlating Revisions, and Ballot Statements. (See *Regs* at 4.2.5.2 and Section 4.4.) The First Draft Report and the Second Draft Report together constitute the Technical Committee Report. Any outstanding objection following the Second Draft Report must be raised through an appropriate Amending Motion at the NFPA Technical Meeting or the objection will be considered resolved. [See *Regs* at 4.4.1(b).]

V. Step 3a: Action at NFPA Technical Meeting. Following the publication of the Second Draft Report, there is a period during which those wishing to make proper Amending Motions on the Technical Committee Reports must signal their intention by submitting a Notice of Intent to Make a Motion (NITMAM). (See *Regs* at 4.5.2.) Standards that receive notice of proper Amending Motions (Certified Amending Motions) will be presented for action at the annual June NFPA Technical Meeting. At the meeting, the NFPA membership can consider and act on these Certified Amending Motions as well as Follow-up Amending Motions, that is, motions that become necessary as a result of a previous successful Amending Motion. (See 4.5.3.2 through 4.5.3.6 and Table 1, Columns 1-3 of *Regs* for a summary of the available Amending Motions and who may make them.) Any outstanding objection following action at an NFPA Technical Meeting (and any further Technical Committee consideration following successful Amending Motions, see *Regs* at 4.5.3.7 through 4.6.5) must be raised through an appeal to the Standards Council or it will be considered to be resolved.

VI. Step 3b: Documents Forwarded Directly to the Council. Where no NITMAM is received and certified in accordance with the *Technical Meeting Convention Rules*, the standard is forwarded directly to the Standards Council for action on issuance. Objections are deemed to be resolved for these documents. (See *Regs* at 4.5.2.5.)

VII. Step 4a: Council Appeals. Anyone can appeal to the Standards Council concerning procedural or substantive matters related to the development, content, or issuance of any document of the NFPA or on matters within the purview of the authority of the Council, as established by the *Bylaws* and as determined by the Board of Directors. Such appeals must be in written form and filed with the Secretary of the Standards Council (see *Regs* at Section 1.6). Time constraints for filing an appeal must be in accordance with 1.6.2 of the *Regs*. Objections are deemed to be resolved if not pursued at this level.

VIII. Step 4b: Document Issuance. The Standards Council is the issuer of all documents (see Article 8 of *Bylaws*). The Council acts on the issuance of a document presented for action at an NFPA Technical Meeting within 75 days from the date of the recommendation from the NFPA Technical Meeting, unless this period is extended by the Council (see *Regs* at 4.7.2). For documents forwarded directly to the Standards Council, the Council acts on the issuance of the document at its next scheduled meeting, or at such other meeting as the Council may determine (see *Regs* at 4.5.2.5 and 4.7.4).

IX. Petitions to the Board of Directors. The Standards Council has been delegated the responsibility for the administration of the codes and standards development process and the issuance of documents. However, where extraordinary circumstances requiring the intervention of the Board of Directors exist, the Board of Directors may take any action necessary to fulfill its obligations to preserve the integrity of the codes and standards development process and to protect the interests of the NFPA. The rules for petitioning the Board of Directors can be found in the *Regulations Governing Petitions to the Board of Directors from Decisions of the Standards Council* and in Section 1.7 of the *Regs*.

X. For More Information. The program for the NFPA Technical Meeting (as well as the NFPA website as information becomes available) should be consulted for the date on which each report scheduled for consideration at the meeting will be presented. To view the First Draft Report and Second Draft Report as well as information on NFPA rules and for up-to-date information on schedules and deadlines for processing NFPA documents, check the NFPA website (www.nfpa.org/docinfo) or contact NFPA Codes & Standards Administration at (617) 984-7246.