ENERGY STORAGE SYSTEMS (ESS)

Code Sections:

The California Fire Code (CFC) defines Energy Storage Systems (ESS) as one or more devices assembled together and capable of storing energy in order to supply electrical energy at a future time (CFC §202). The CFC also requires that all ESS be "***listed***" per UL 9540 (CFC §1207.3.1). Our CFC amendment CFC §202 adopts the national standard NFPA 855, Installation of Stationary Emergency Storage Systems (2020 edition) definition as referenced below.

> ***Large-Scale Fire Testing (LSFT)****. Testing 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 (CFC §202).*
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> ***Note****: Testing of just a Cell, Module, or Unit is not considered a large-scale test. A large-scale test must include a representative Installation Level test with the introduction of a fire.*

Large-Scale Fire Testing:

Large-scale fire testing is not a new concept in the construction industry. It is the only method for the Fire Department to evaluate the performance of products or systems like Energy Storage Systems (ESS) under actual fire conditions.

Large-Scale ESS Test @ Fire Protection Research Foundation

Large-Scale Fire Testing Requirements:

1. Large-scale fire testing per NFPA 855, must be conducted on a representative ESS following UL 9540A or equivalent test methodology (NFPA 855 §4.1.5.1).
2. The testing must be conducted, witnessed, and reported by an approved testing laboratory, showing that a fire involving one ESS unit will not propagate to an adjacent unit (NFPA 855 §4.1.5.2).
3. Where proposed to be installed within buildings, the fire test must be within a room or enclosed area within a minimum fire-resistance rating 2 or 3 hours as specified in CFC 1207.5.2 as amended (NFPA 855 §4.3.6).
4. ESS rooms or areas shall be separated from other building areas by 2-hour or 3-hour fire barriers per the California Building Code and CFC Table 1207.5.1 as amended.
5. The test report must be provided to the Fire Department for review and approval (NFPA 855 §4.1.5.4).

Alternative Materials, Design, and Methods of Construction and Equipment Requests (AM&M):

If your ESS has undergone large-scale fire testing in compliance with the abovementioned requirements, the Fire Department will review alternatives to the prescriptive requirements contained within Chapter 12 of the California Fire Code as amended.

FAQ:

Does your city have more restrictive requirements than the California Fire Code (CFC)?

Yes. In collaboration with the County Fire Marshal's Association, the SCFD has developed and adopted regulations to address the hazards of this emerging and rapidly changing technology. A summary of our code amendments is contained in Exhibit #1 in this document.

Why are local amendments vital to the safety of the community, firefighters, and the environment?

The CFC allows the Fire Code Official to alter the prescriptive code requirements when large-scale fire testing has shown the equivalent of the prescriptive requirements in quality, strength, effectiveness, fire resistance, durability, and safety of a "specific ESS technology" under real-life fire conditions. While ESS is an essential and reliable emergency source, ESS can also expose our community, firefighters, and environment to unnecessary risk from poorly manufactured components, inadequate system design, or insufficient passive and active fire protection.

What is UL 9540A?

UL 9540A is the "Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems". UL 9540A is ***NOT*** a Standard, unlike NFPA 855, which is the National Standard for the Installation of Stationary Energy Storage Systems.

UL 9540A is a specific type of testing for ESS developed by Underwriters Laboratories to ensure a consistent test and evaluation for Thermal Runaway. Thermal Runaway is a 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. UL 9540A includes a series of progressive tests beginning at the cell level and progressing to the module, unit, and installation levels. The type of testing conducted is determined by the battery manufacturer requesting the testing. Many manufacturers choose to stop at the module or unit levels. If they proceed to the installation level, they do not share that information with the industry or AHJs.

What are the UL 9540A Test Levels, and what data is gathered?

UL 9540A TEST LEVEL (4th Edition)	
TEST LEVEL	**DATA DEVELOPED**
Cell	1. The methodology required to initiate thermal runaway for testing. 2. Cell surface temperature at the onset of gas venting and thermal runaway. 3. Gas composition, volume, and explosibility parameters.
Module	1. Number of initiating cells required for propagation of thermal runaway. 2. Heat, smoke, and flammable gas release rates and total release quantity.

	3. Observations of external flame extension. d. Observations of deflagration and debris hazards.
Unit	1. The extent of thermal runaway propagation. 2. Heat, smoke, and flammable gas release rates and total release quantity. 3. Observations of external flame extension, deflagration, debris hazards, and re-ignition hazards. 4. Thermal exposure (temperature on adjacent walls and target units; heat flux to adjacent walls, target units, and egress pathways)
Installation	1. Evaluation of fire protection method. 2. Fire growth control. 3. The extent of thermal runaway propagation. 4. Design features related to the containment of thermal runaway gases and heat that create an explosion hazard. 5. Deflagration protection system. 6. Egress protection. 7. Thermal exposure to adjacent surfaces. 8. Observations of flaming outside the installation. 9. Observations of reignition. 10. Deflagration and debris

What does the testing involve?

Below are two large-scale tests of Lithium-Ion ESS. The critical thing to consider when watching is the scale of large-scale fire testing, fire intensity, toxic atmosphere development, fire suppression impacts, and the sheer duration of the fires.

https://www.youtube.com/watch?v=yIH9ED0j5dQ

https://www.youtube.com/watch?v=Fc-eJFIT-bo

Are uninterruptable power supplies (UPSs) considered Energy Storage Systems (ESS)?

Yes. The CFC defines an Energy Storage System (ESS) as one or more devices, assembled together, capable of storing energy to supply electrical energy at a future time.

Do Energy Storage Systems (ESS) have to be "listed" in California?

Yes. California Fire Code §1207.3 requires the Energy Storage System to be listed per UL 9540. The only exception is lead-acid and nickel-cadmium battery systems installed in facilities under the exclusive control of communications utilities and operating at less than 50 VAC and 60 VDC per NFPA 76. They are not required to be listed.

Our ESS has undergone UL9540A testing but is not UL 9540 listed. Can it be installed?

No. The CFC §1207.3.1 requires systems to be listed. UL 9540A is not intended to be a substitute for listing.

Our ESS is UL9540 listed and has undergone UL 9540A Unit Level testing, so can we exceed the Maximum Allowable Quantities of Electrochemical permitted by the CFC?

For the Fire Department to consider a waiver of minimum code requirements, large-scale fire testing (Installation Level) must have been conducted and found not to pose a hazard to the community, firefighters, or the environment.

Our ESS is UL9540 listed and has undergone UL 9540A Unit Level testing. Can we reduce the Minimum Spacing Requirements from 36 inches to 6 inches?

For the Fire Department to consider a waiver of minimum code requirements, large-scale fire testing (Installation Level) must have been conducted and found not to pose a hazard to the community, firefighters, or the environment.

Our ESS is UL9540 listed and undergone UL 9540A, Unit Level testing. Do we still need to provide Explosion Prevention?

For the Fire Department to consider a waiver of minimum code requirements, large-scale fire testing (Installation Level) must have been conducted and found not to pose a hazard to the community, firefighters, or the environment.

Our ESS is listed UL9540 listed and has undergone UL 9540A, Unit Level testing. Do we still need to provide Explosion Control?

For the Fire Department to consider a waiver of minimum code requirements, large-scale fire testing (Installation Level) must have been conducted and found not to pose a hazard to the community, firefighters, or the environment.

Our ESS is UL9540 listed and we provided a substantial mechanical ventilation design sufficient to mitigate any explosion concerns. Do we still need to provide Explosion Prevention following NFPA 69?

As outlined in NFPA 855, the code intends to provide adequate ventilation and explosion control. Mechanical ventilation protects against flammable gases released during normal charging and discharging of battery systems. 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, including mixtures of CO, H2, 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 minimize this hazard.

Our energy storage systems are small units placed in racks, so the hazard is low. Are the requirements the same?

Yes. Vertically or horizontally stacked units can significantly impact fire dynamics, the spread of thermal runaway, and the level of fire protection required to control a fire.

Is a Fire Permit required to install, upgrade, or modify an ESS installation?

Yes. CFC §105.6.5 requires a construction permit from the fire department to install, upgrade, or modify an ESS.

Is an Operational Fire Permit required for ESS?

Yes. CFC §105.5.14 requires an operating permit for both stationary and mobile energy storage systems. Operational permits, when issued, renew automatically on an annual basis.

Exhibit #1 - CFC Code Amendments:

Amendments to CFC – 2022 Edition, Chapter 2

CFC §202 - Large-scale Fire Testing involves testing 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.

Amendments to CFC – 2022 Edition, Chapter 12

CFC §1207.1.5 Large-scale fire test. Where required elsewhere in Section 1207, large scale fire testing shall be conducted in accordance with NFPA 855, and UL 9540A. The testing shall be conducted or witnessed and reported by an approved testing laboratory and show that a fire involving one ESS will not propagate to an adjacent ESS, and where installed within buildings, enclosed areas and walk-in units will be contained within the room, enclosed area or walk-in unit for a duration equal to the fire-resistance rating of the room separation specified in Section 1207.7.4. The test report shall be provided to the fire code official for review and approval in accordance with Section 104.8.2.

CFC §1207.2.2.1 Ongoing inspection and testing. Systems that monitor and protect the ESS installation shall be inspected and tested in accordance with the manufacturer's ins instructions and the operation and maintenance manual. Inspection and testing records shall be maintained in the operation and maintenance manual and made available to the fire code official upon request.

CFC §1207.5.2 Maximum allowable quantities. Fire areas within rooms, areas and walk-in units containing electrochemical ESS shall not exceed the maximum allowable quantities in Table 1207.5. The allowable number of fire areas, maximum allowable quantity, and fire-resistance rating of fire-barriers shall comply with Table 1207.5.1.

> **Exceptions**: Where approved by the fire code official, rooms, areas and walk-in units containing electrochemical ESS that exceed the amounts in Table 1207.5 shall be permitted based on a hazardous mitigation analysis in accordance with Section 1207.1.4 and large-scale fire testing complying with Section 1207.1.5.
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> 1. Lead-acid and nickel-cadmium battery systems installed in facilities under the exclusive control of communications utilities and operating at less than 50 VAC and 60 VDC in accordance with NFPA 76.
> 2. Dedicated-use buildings in compliance with Section 1207.7.1.

TABLE 1207.5.1
DESIGN AND NUMBER OF ESS FIRE AREAS

STORY		PERCENTAGE OF MAXIMUM ALLOWABLE QUANTITY PER FIRE AREA	NUMBER OF FIRE AREAS PER STORY	FIRE-RESISTANCE RATING FOR FIRE BARRIERS IN HOURS
Above grade plan	Higher than 9	25	1	3
	7-9	50	2	2
	6	50	2	2
	5	50	2	2
	4	75	4	2
	3	100	6	2
	2	100	6	2
	1	100	6	2
Below grade plan	1	100	4	3
	2	50	2	3
	Lower than 2	Not Allowed	Not Allowed	Not Allowed

CFC §1207.5.5 Fire suppression systems. Rooms and areas within buildings and walk-in units containing electrochemical ESS shall be protected by an automatic fire suppression system designed and installed in accordance with one of the following:

1. An automatic sprinkler system designed and installed in accordance with Section 903.3.1.1 with a minimum density of 0.3 gpm/ft2 (1.14 L/min) based on the fire area or 2,500 square-foot (232 m2) design area, whichever is **larger**.
2. Where approved, an automatic sprinkler system designed and installed in accordance with Section 903.3.1.1 with a sprinkler hazard classification based on large-scale fire testing complying with Section 1207.1.5.
3. The following alternative automatic fire-extinguishing systems designed and installed in accordance with Section 904, provided that the installation is approved by the fire code official based on large-scale fire testing complying with Section 1207.1.5:
    3.1 NFPA 12, Standard on Carbon Dioxide Extinguishing Systems.
    3.2 NFPA 15, Standard for Water Spray Fixed Systems for Fire Protection.
    3.3 NFPA 750, Standard on Water Mist Fire Protection Systems.
    3.4 NFPA 2001, Standard on Clean Agent Fire-Extinguishing Systems.
    3.5 NFPA 2010, Standard for Fixed Aerosol Fire-Extinguishing Systems.

    Exception: Fire suppression systems for lead-acid and nickel-cadmium battery systems at facilities under the exclusive control of communications utilities that operate at less than 50 VAC and 60 VDC shall be provided where required by NFPA 76.

CFC §1207.11.3 Location. ESS shall be installed only in the following locations:

1. Detached garages and detached accessory structures.
2. Attached garages separated from the dwelling unit living space and sleeping units in accordance with Section R302.6.
3. Outdoors or on the exterior side of the exterior walls not less than 3 feet (914 mm) from doors and windows directly entering the dwelling unit and not below or above any emergency escape and rescue openings.
4. Enclosed utility closets, basements, storage or utility spaces within dwelling units with finished or noncombustible walls and ceilings. Walls and ceilings of unfinished wood-framed construction shall be provided with not less than 5/8-inch (15.9 mm) Type X gypsum wallboard.
5. ESS shall not be installed in sleeping rooms, closets, spaces opening directly into sleeping rooms or in habitable spaces of dwelling units.

CFC §1207.11.6 Fire detection. ESS installed in Group R-3 and R-4 occupancies shall comply with *one of* the following:

1. Rooms and areas within dwellings units, sleeping units, basements and attached garages in which ESS are installed shall be protected by smoke alarms in accordance with Section 907.2.11.
2. A listed heat alarm interconnected to the smoke alarms shall be installed in locations within dwelling units, sleeping units and attached garages where smoke alarms cannot be installed based on their listing.

    Exceptions:
    1. A listed heat detector may be used in place of a heat alarm, so long as it is interconnected with devices that provide an audible alarm at all sleeping areas.
    2. A fire sprinkler associated with an approved automatic sprinkler system that triggers an audible alarm upon activation of the waterflow switch, may be used in place of a heat alarm.