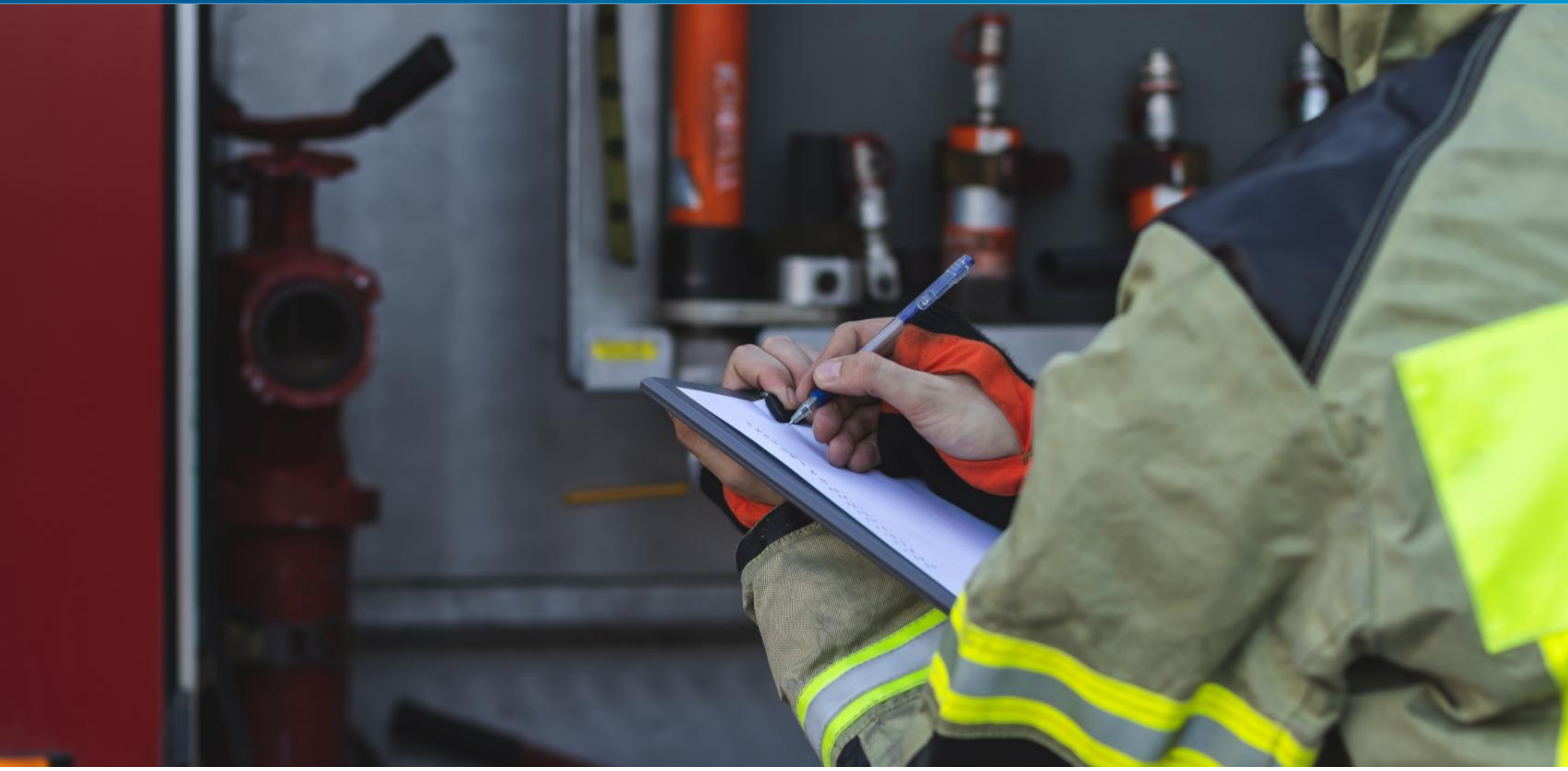

Firefighter Checklist for BESS Thermal Incidents

1 Introduction & Purpose

In the evolving landscape of renewable energy and energy storage, firefighters are increasingly met with unique challenges to ensure the safety and well-being of their community. While technology continues to improve, lithium-ion (Li-ion) batteries present new challenges for firefighters and other emergency responders. Recognizing the need for specialized knowledge and actions, this checklist aims to provide firefighters with specific instructions and approaches to respond to and manage thermal incidents safely respond to.

This checklist builds upon ACP's safety best practices in accordance with NFPA 855, Standard for the Installation of Stationary Energy Storage Systems. Further, it aims to equip firefighting teams with a concise set of guidelines that address the specific risks associated with Li-ion battery thermal incidents. This includes identifying and containing fires while minimizing risk to responders and the surrounding community. By guiding response procedures, the checklist aims to enhance the effectiveness of emergency operations and improve safety outcomes during these complex situations.

This document should be considered as an informational guide for firefighting. This approach should be adjusted based on the unique battery energy storage systems (BESS) and circumstances, including but not limited to geography, system design, resources on-site, and emergency response capabilities.

2 Firefighting Response Strategy

The philosophy of monitoring and containing a BESS fire is the recommended approach to thermal incidents involving Li-ion batteries. Priority should be given to explosion prevention, typically using emergency ventilation for combustible concentration reduction, and the containment of the thermal incident as the fire consumes itself in a contained manner. As explained in the First Draft Report of the 2026 edition of NFPA 855,[1] if used, ESS fire suppression, other than water-based, should not impede the operation of the combustible gas concentration reduction system.

Large-scale batteries connected to the electricity grid are distinct in size or design from other commercial battery technologies. Responding to thermal incidents involving batteries requires a specific approach that is distinct from traditional methods that use water application on structure fires. Traditional methods, including attempting to extinguish a Li-ion battery fire prematurely with water, can expose firefighters to hazards and result in stranded energy, ongoing propagation of thermal runaway, a prolonged event, and risk of reignition. BESS enclosures are designed to burn out within the fence line and limit the event to a single unit. Firefighting water can also introduce the risk of contaminated runoff, which is mitigated by limiting water use to defensive measures. This recommended strategy minimizes the potential for stranded energy, reducing hazards to personnel involved in the post-incident recovery, but results in combustion plumes for which personnel and public exposure must be considered.

Allowing the fire to consume itself while ensuring it is contained to the affected unit and constantly monitored for off-gassing and air quality, minimizes the risks associated with these incidents. This approach ensures that the fire burns out completely while ensuring the impact of the incident is minimized and localized within the secure battery energy storage site.

While any fire can produce toxic compounds, the compounds produced by Li-ion cells in thermal runaway in laboratory settings, including hydrogen fluoride, hydrogen chloride, hydrogen cyanide, nitrogen oxides, and sulfur dioxide, may demonstrate to be mitigated by this recommended firefighting strategy. When using this firefighting response strategy, the heat of a fully involved enclosure fire breaks down these compounds. Recent testing and studies in New York[2] and California[3,4] show no harmful levels of toxins being found during or after battery energy storage fire incidents.

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[1] NFPA 855 Standard for the Installation of Stationary Energy Storage Systems, https://www.nfpa.org/codes-and-standards/nfpa-855-standard-development/855

[2] Initial Findings Released From Inter-Agency Fire Safety Working Group On Emergency Response, https://www.nyserda.ny.gov/About/Newsroom/2023-Announcements/2023-12-21-Governor-Hochul-Announces-Results-of-Fire-Safety-Working-Group

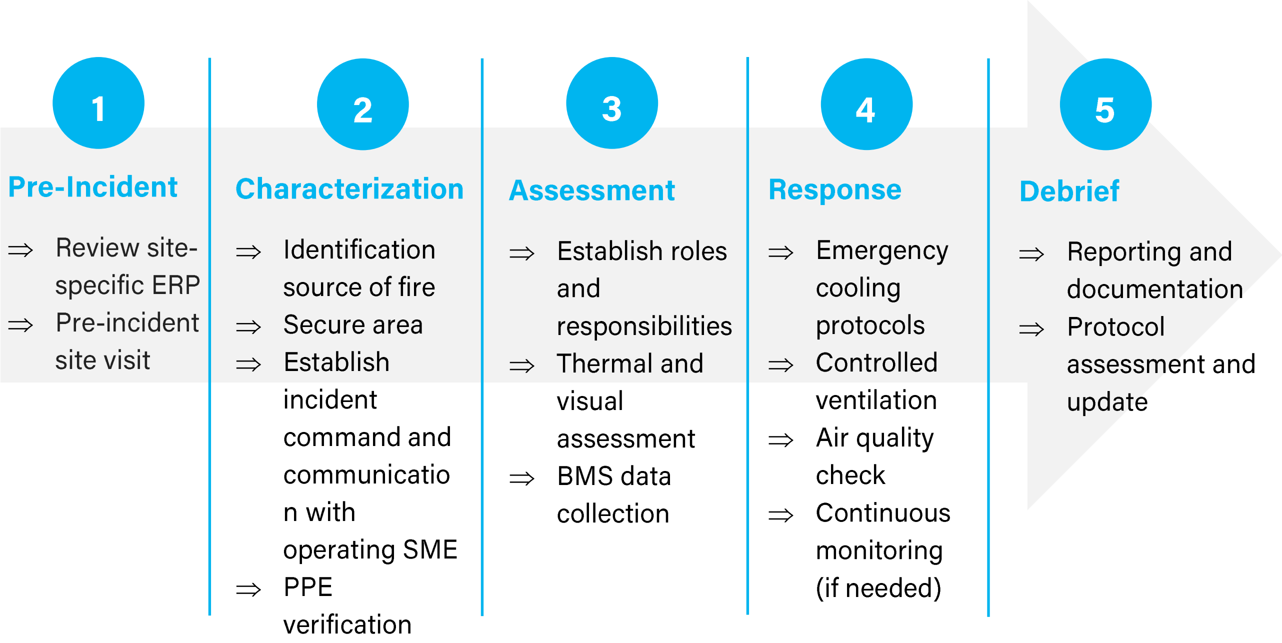
[3] County of Monterey Environmental Health Shares Air Quality Testing Information and Process During Moss Landing Fire Incident, https://www.countyofmonterey.gov/Home/Components/News/News/9345/1336

[4] Air Quality Report and Water Run Off Report for the SDG&E Battery Storage Fire, https://www.escondido.gov/CivicAlerts.aspx?AID=96

3 Thermal Incident Response Checklist

This checklist can be summarized by the graphic below, highlighting the key provisions in each step when responding to a Li-ion battery fire.

Each part of the checklist has unique characteristics which will be detailed in the following sections.



1

Pre-Incident

- ⇒ Review site-specific ERP
- ⇒ Pre-incident site visit

2

Characterization

- ⇒ Identification source of fire
- ⇒ Secure area
- ⇒ Establish incident command and communication with operating SME
- ⇒ PPE verification

3

Assessment

- ⇒ Establish roles and responsibilities
- ⇒ Thermal and visual assessment
- ⇒ BMS data collection

4

Response

- ⇒ Emergency cooling protocols
- ⇒ Controlled ventilation
- ⇒ Air quality check
- ⇒ Continuous monitoring (if needed)

5

Debrief

- ⇒ Reporting and documentation
- ⇒ Protocol assessment and update

3.1 Pre-Incident Planning

Active engagement between the local fire department and site operator before the facility is online, and continuously through operations, is critical to managing any potential incident. Pre-incident planning can help improve coordination between operating personnel and firefighters and overall safety practices. Firefighters are encouraged to coordinate with the operator to review the site-specific Emergency Response Plan (ERP), First Responder's Guide, and/or Fire Safety Plan. These site-specific plans should detail firefighter access points, emergency contacts, key equipment locations, and hazard awareness procedures which should inform their firefighting approach.

Firefighters are also encouraged to conduct pre-incident visits with the site operator and to participate in training sessions for facility personnel responsible for emergency response. Firefighters should familiarize themselves with the layout of the facility and site-specific characteristics and determine the location of critical safety systems such as fire suppression equipment, ventilation controls, and emergency shutoffs.

3.2 Characterization of the Incident & Preparation

Upon arriving at the ESS site, firefighters should coordinate with the operator to appropriately characterize the incident and reference the site's ERP. Coordinate, as needed, with hazardous materials teams and environmental agencies.

The off-gas from Li-ion thermal runaway can be flammable and potentially toxic, like many fires, making it a critical safety concern. It is important to monitor the environmental conditions that lead to thermal runaway incidents (i.e., a Class B Fire). If the source of a fire can be quickly identified as a non-battery component, it can be extinguished before it causes severe damage to the batteries, minimizing or even preventing thermal runaway.

Though these scenarios may not lead to large flames or even an ignition, each scenario could require firefighter dispatch. If not managed properly, damaged Li-ion cells and modules can reignite hours or even days later due to gradual or prolonged thermal heat transfer. As such, a comprehensive approach to characterize, manage, and resolve the incident is important.

Completed?	Task
	Secure the Area • Coordinate with the operator to ensure the system and adjacent equipment are de-energized safely, if necessary. Confirm with the network operations center (NOC) that equipment has been shut down. **Note that even if the system is shut down, the battery cells still contain energy and should be treated as if energized.* • Secure the site and establish an initial approach distance of at least 75 feet from venting points to avoid exposure to deflagration hazards. The approach distance should be informed by actual conditions. Establish a boundary to protect personnel and identify nearby at-risk equipment,

	such as oil-filled transformers, for possible application of defensive measures. The boundary around the equipment should consider the size of the fire, types of batteries, scenario (if chemical or off-gassing results), prevailing wind conditions, and locality to schools and communities.
	System Type Identification • Consult the ERP and necessary construction documents to determine equipment-specific response procedures. • Obtain copies of the Safety Data Sheets for all affected equipment.
	Establish Incident Command • Set up a command post to coordinate assessment efforts safely outside the potential hazard zone. • Clarify the firefighting team responsible for decision-making (Fire IC, Operator SME, Hazmat Team, etc.). • Contact the operator to confirm the subject matter expert (SME) who will provide support in decision-making and response activities. • Acquire battery management system (BMS) and/or energy management system data[5], as available, for any adjacent cabinets to continually monitor the temperature of the surrounding equipment. • Require establishing a firefighter rehabilitation area for personnel recovery.[6] • Establish necessary shelter-in-place advisories or evacuation orders informed by the firefighting approach and consider locality to schools and communities.
	Safety Gear Check • Confirm that all firefighters are equipped with NFPA-compliant PPE and self-contained breathing apparatus (SCBA), including thermal imaging cameras, gas detectors, and specialized gloves for electrical hazards.

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[5] This information may be accessible via a local human machine interface (HMI), cloud-based database, or from the NOC.

[6] NFPA 1584, Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises, https://www.nfpa.org/codes-and-standards/nfpa-1584-standard-development/1584

3.3 Operation Assessment

Thermal runaway is an exothermic reaction and presents complex issues that can cause a continually escalating fire. While arcs from ground faults are the primary source for ignition, potential exacerbating factors after ignition could be from several different places:

- Arcing from ground faults
- Wire coverings, polymer components from cells, modules, and BOS components
- Electrolytes, solvents, and flammable gases (e.g., hydrogen, carbon monoxide)
- Voltage from unscorched batteries
- State of charge (SOC) of the unit when the incident occurred.

Completed?	Task
	Thermal Risk Assessment • Utilize thermal imaging to identify overheating components or failing thermal management areas. Be aware that battery enclosures are well insulated, which may mask temperature increases. Do not approach or open containers to get a better thermal scan. • Supplement thermal scans with BMS temperature data.
	De-energizing Equipment • Open the associated BESS feeder breaker and lockout/tagout (LOTO), if possible, to reduce risk. Note that the batteries still have inherent electrical potential even after isolation.

3.4 Onsite Incident Response

After the incident command has been established and all assessments have been completed, the incident must be addressed. Below are the key tasks to consider when working onsite at the incident. It is important to note that these are recommended steps and may not be necessary as deemed by local fire officials.

Completed?	Task
	Emergency Cooling Measures • Do not force entry into cabinets and keep all doors closed unless deflagration prevention allows the doors to open. • Verify onsite water supply capacity before using defensive water applications. • Implement emergency cooling tactics on adjacent equipment and other occupied facilities (depending on proximity) using controlled water application as needed. Apply water to any battery cabinets where battery

	temperatures are elevated (typically at 80°C or above).[7] Note that fire suppression methods must not inhibit the function of the combustible gas concentration reduction system. • Assess the facility size, type, configuration, thermal hazard, and potential impact on adjacent exposures to determine the minimum defensive water flow rate. The water application rate must be sufficient to prevent fire spread to nearby structures or equipment and support exposure protection.[8] Note that water should not be applied directly to the battery fire, as it may prolong the event and create contaminated runoff.
	Continuous Air Quality Monitoring and Contaminated Runoff • Utilize gas detection equipment (examples listed in Appendix A) to continuously monitor hazardous gas levels. Real-time monitoring should occur at multiple locations (incident perimeter, firefighter staging, downwind locations). Adjust firefighting tactics dynamically based on real-time data to ensure the safety of personnel and the effectiveness of the response. • Conform with Occupational Safety and Health Administration (OSHA) and National Institute for Occupational Safety and Health (NIOSH) exposure limits for hydrogen fluoride (HF), hydrogen cyanide (HCN), and volatile organic compounds (VOCs).[9] • If it has been necessary to apply water directly to the battery fire, Establish site-specific containment strategies, such as temporary barriers or runoff collection, to mitigate any contaminated runoff.

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[7] Assumes that normal operation is inhibited above 50-60°C and solid electrolyte interphase (SEI) breakdown starts around 100-110°C. Proposing 80°C as a halfway point.

[8] NFPA 855 (Standard for the Installation of Stationary Energy Storage Systems) provides guidance on fire protection requirements for BESS facilities and refers to NFPA 13 (Standard for the Installation of Sprinkler Systems) and NFPA 15 (Standard for Water Spray Fixed Systems) for detailed fire suppression system design.

[9] OSHA permissible exposure limits, https://www.osha.gov/annotated-pels/table-z-1; NIOSH Pocket Guide to Chemical Hazards, https://www.cdc.gov/niosh/npg/default.html.

3.5 Debrief & Post-Incident Procedures

The following tasks are good practices that all parties should conduct.

Completed?	Task
	Post-Incident Management • Consult with the operator's SME to assess the presence of stranded energy and the possibility of reignition, as the BMS within the container may be damaged. When it is determined that these risks are low, perform handover procedures to the operator's qualified technical representatives. • Clean PPE.
	Incident Reporting and Documentation • All parties should document all actions, findings, and equipment statuses during and after the incident with timestamps to assist in post-incident analysis. • Refine response strategies and training for future incidents involving ventilation and exhaust systems. • Use standardized reporting for clarity and future reference.
	Review and Update Response Protocols • Based on the incident findings, all parties should update response strategies and training programs to enhance future safety and effectiveness.
	Team Debrief • All parties should conduct a thorough briefing with all involved personnel to discuss the incident, the effectiveness of the response, and areas for improvement.

4 Appendices

4.1 Appendix A: PPE and Other Equipment

The list below is representative of personal protective equipment (PPE) that firefighters will typically use when responding to Li-ion battery facility thermal incidents. This equipment is chosen based on the specific hazards associated with Li-ion battery fires, including toxic gas emissions and excessively hot flames produced by batteries in thermal runaway. PPE usage is essential to ensure the safety and effectiveness of emergency responders in these potentially hazardous environments.

PPE	Function
Fire-Resistant Suits	Full turnout gear that is NFPA-compliant for thermal protection, including a helmet with a face shield to protect against falling debris and radiant heat.
Self-Contained Breathing Apparatus (SCBA)	Protect against toxic gases and oxygen-deficient environments
Heat Resistant Hoods	Provides additional protection for the neck and head areas
Personal Gas Detectors	Monitors for carbon monoxide, hydrogen gas, volatile organic compounds (VOCs), and other toxic gases commonly released in Li-ion battery fires
Drones	Aerial surveillance and real time data to monitor the spread of the fire, identify hotspots, and deliver tools to inaccessible areas
Thermal/IR Imaging Cameras	Identify sources of heat and locate hotspots through walls and barriers

4.2 Appendix B: Scenario-Specific Considerations

4.2.1 Approaches to Fire Suppression

The table below provides background information and a comparison of pros and cons in cases where fire suppression must be used to protect adjacent equipment or maintain the boundary of the site. The risk of not letting the fire consume itself may introduce added risks. Please note that the direction here is not to suppress fire, but to provide background information if the use of fire suppression is unavoidable.

Flame retardants are subject to local regulations and logistics of emergency respondents. Incident approaches utilizing fire suppression should be confirmed by the operator SME.

Flame Retardant	Pros	Cons
Water	Effective in cooling and diluting flammable electrolyte solutions; used most often in large Li-ion fires. Can stop thermal runaway only if brought into direct contact with affected battery cells and in sufficient volumes.	Can cause short circuits and may not be effective because of structures surrounding battery cells. Can create toxic runoff (which is a hazard in any fire scenario). Li-ion batteries have metal oxides that could run off into the surrounding environment.
Dry Chemical Powders	Standard ABC dry chemical extinguishers can help smother flames by creating a layer of powder between the fuel and oxygen.	May not cool the battery sufficiently to prevent re-ignition; dust from the extinguisher can contaminate sensitive areas and equipment.
Carbon Dioxide (CO2)	CO2 displaces oxygen, helping to suffocate the fire without leaving residue.	Limited cooling effect; ineffective in open areas due to rapid dispersion. Ineffective for NMC cells, which produce oxygen in thermal runaway.
Aqueous Film Forming Foam (AFFF)	Creates a film over the surface of the flammable materials, blocking oxygen supply and cools fire.	Environmental hazards of PFAs; not all foams are suitable for use on Li-ion batteries and could affect heat dissipation of other cells. Will not stop thermal runaway. Gas evolution and possible buildup may ensue.
Halogenated Agents	Contains halogens like bromine or chlorine which interfere with the combustion reactions that sustain fires.	Environmental concerns on ozone depletion; regulatory restrictions based on local laws. Halon presents an asphyxiation hazard.
Class D Fire Extinguisher	Designed for fires involving metals, including lithium; can smother and cool effectively.	Specifically for lithium metal, not applicable for Li-ion.

Sand or Salts	Can be leveraged to smother smaller or contained fires	Not effective for cooling; handling is labor intensive Will not stop thermal runaway. Gas evolution and possible buildup may ensue

4.2.2 Location

There are certain precautions to take based on whether the ESS is located inside a building or outside in its integrated system. When high-voltage Li-ion batteries are exposed to water, such as from sprinkler systems, coolant leaks, or stormwater intrusion, there's a risk of electrical short-circuiting which can lead to arcing. Arcing occurs when electricity jumps through the air from one conductive surface to another; in the context of energy storage systems, the intense heat of the arc will drive cells into thermal runaway, and the arc will ignite the resulting flammable vent gases. Further, the racking equipment utilized to string modules together often impedes the water (or other aqueous agents) from reaching the involved cells.

It is therefore critical to use caution when deploying sprinkler systems around Li-ion cell technologies, as the combination of water and damaged cells can exacerbate fire hazards instead of mitigating them. Indoor and outdoor ESSs come with their characteristic considerations:

- **Indoor Battery Rooms**
    - ***Ventilation*****:** Ensure proper airflow to the outside to manage gas buildup. This may include gas detection and fans or other automated systems in a controlled manner.
    - ***Access and Egress*****:** Identify multiple entry and exit points to ensure safe and quick access as needed.
    - ***Structural Integrity*****:** Evaluate the building and/or room's structural integrity to ensure the fire does not compromise load-bearing elements. NFPA 855 requires indoor BESSs to be in a fire area with a fire resistance of at least one hour; this will help contain the fire, but, when constructed with concrete, may expose firefighters to high heat conditions if access to the building is needed. Note that the recommended approach is to let the fire burn completely before entry.
    - ***Wind:*** Monitor wind direction, as the combustion plume will travel.
- **Outdoor ESS Containers**
    - ***Isolation*****:** Keep people and non-essential personnel away from the thermal event. Set up a perimeter that accounts for proper ventilation, possible deflagrations, or spreading of the fire.
    - ***Wind Direction*****:** Monitor wind patterns, as they can significantly influence the spread of flames, debris, smoke, and toxic gases.

4.3 Appendix III: References

- ACP Energy Storage Emergency Response Template
- International Fire Chiefs Association Recommended Fire Department Response to Energy Storage Systems (ESS) Part 1
- Los Angeles County Fire Department, Fire Prevention Division, ESS, PV & Disconnects for R-3/R-4 Requirements Guide
- NFPA 14 Standard for the Installation of Sprinkler Systems
- NFPA 15 Standard for Water Spray Fixed Systems
- NFPA 70E Standard for Electrical Safety in the Workplace
- NFPA 472 Standard for Competence of Responders to Hazardous Materials/Weapons of Mass Destruction Incidents
- NFPA 855 Standard for the Installation of Stationary Energy Storage Systems (2023 & 2026 draft updates)
- NFPA 1584 Standard on the Rehabilitation Process for Members During Emergency Operations and Training Exercises
- NIOSH Pocket Guide to Chemical Hazards
- OSHA 1910.120 Hazardous Waste Operations and Emergency Response
- OSHA Permissible Exposure Limits