AES – Global Insurance

Property (Fire and Associated Perils) Risk

BESS FIRE PROTECTION GUIDANCE DOCUMENT

Revision	Description	Date	Developed by	Approved
0	Initial Submittal Issue	5/1/2016	R. Woodfin	R. Woodfin / J. Voss
1	Editorial changes & comment resolutions	9/1/2016	R. Woodfin	R. Woodfin / J. Voss
2	Transformer configuration allowances & editorial changes	10/25/2016	R. Woodfin	R. Woodfin / J. Voss
3	Updated NFPA 855 (2020); additional design requirements, suppression research & detailed First Responder Protocols	11/22/2021	R. Woodfin	R. Woodfin / J. Voss
Any questions or comments regarding this document should be sent via email to (agic.standards@aes.com) for response to any inquiries.				

Purpose

The purpose of this document is to facilitate implementation of requirements in the AES Corporation (AES) Global Fire Protection Program (AESGFPP). This document will provide criteria and guidance for a standard and an acceptable approach to meet AES Global Insurance Company (AGIC) requirements and National Consensus Standards for the AESGFPP.

This AES Global BESS Fire Protection Guidelines Document was developed to provide an acceptable methodology. The AESGFPP requirements address special or unique fire protection issues at AES facilities that may not be comprehensively or adequately addressed in national consensus standards or other design criteria.

The requirements and guidelines set forth in this document will help AES minimize costly change orders by providing the Engineering, Procurement and Construction (EPC) Contractor with accurate and compliant data upon the conceptual design review process or the Front-End Engineering Design (FEED) phase.

Applicability

The provisions of this document apply to Battery Energy Storage Systems (BESS) with Lithium-Ion Batteries.

National Consensus Standards

National Fire Protection Association (NFPA) Codes and Standards (Minimum Requirements); “should” will be designated as “shall”

- NFPA 1, *Fire Code* (Current Version)
- NFPA 3, *Standard for Commissioning of Fire Protection and Life Safety Systems* (Current Version)
- NFPA 13, *Standard for the Installation of Sprinkler Systems* (Current Version)
- NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection* (Current Version)
- NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection* (Current Version)
- NFPA 22, *Standard for Water Tanks for Private Fire Protection* (Current Version)
- NFPA 24*, Standard for the Installation of Private Fire Service Mains and Their Appurtenances* (Current Version)
- NFPA 30: Flammable and Combustible Liquids Code (Current Version)
- NFPA 70, *National Electrical Code (NEC)* (Current Version)
- NFPA 72, *National Fire Alarm and Signaling Code* (Current Version)
- NFPA 90A, *Standard for the Installation of Air-Conditioning and Ventilating Systems* (Current Version)
- NFPA 68, *Standard on Explosion Protection by Deflagration Venting* (Current Version)
- NFPA 69, *Standard on Explosion Prevention Systems* (Current Version)
- NFPA 101, *Life Safety Code* (Current Version)
- NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations
- NFPA 780, *Standard for the Installation of Lightning Protection Systems* (Current Version)
- NFPA 850, *Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations* (Current Version)
- NFPA 855, Standard for Installation of Energy Storage Systems (Current Version)
- NFPA 1620 (1660), *Pre-Incident Planning* (Current Version)
- NFPA 2001, Standard on Clean Agent Fire Extinguishing Systems (Current Version)
- International Building & Fire Code (IBC/IFC) (Current version)
- Factory Mutual Data Sheets (FMDS) and Underwriters Laboratory (UL) Guidelines
- UL 9540A, Standard for Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems

- Other associated requirements as deemed necessary by AGIC, when applicable

Responsibility

To ensure adequate protection is provided and to avoid the costly mistakes during the bidding, design, construction, and commissioning phases, the Fire Protection guidelines, design requirements, and specifications contained in NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems* (current version) and within this document shall not be changed or modified without first consulting with the AGIC Risk Engineering or designated approved Fire Protection Consultant. Once the project moves from the development phase to the construction phase the Construction Management Team (CMT) shall retain a Qualified (as defined by the Society of Fire Protection Engineers [SFPE]) Fire Protection Consultant. AGIC is considered the Authority Having Jurisdiction (AHJ).

Throughout the construction phase and up to the operational phase, adhere to the requirements of NFPA 241, Standard for Safeguarding Construction, Alteration, and Demolition Operations (current version).

Each BESS Project shall be provided a Pre-Incident Plan per the requirements of NFPA 1620, *Standard for Pre-Incident Planning* to assist personnel in effectively managing and mitigating incidents and events for the protection of occupants, responding personnel, property, and the environment.

All energy sources shall be documented in the pre-incident plan to identify potentially hazardous exposure to energized electrical sources. All sources of alternative electrical energy shall be identified. The location of control circuitry, disconnection methods, lock out procedures, and isolation methods shall be documented. Any special tools, information, responder training, and on-site contacts able to assist with rendering these systems safe shall be contained in the planning documents. The location and method of storing the electrical energy produced and system voltages (dc and ac) shall be documented. The location of the inverter system for converting the dc current to ac current shall be identified.

BESS Commissioning

Commissioning of the BESS shall be per Chapter 6 of NFPA 855 and NFPA 3.

BESS Decommissioning

Decommissioning of the BESS shall be per Chapter 8 of NFPA 855.

Fire Protection Design Basis

- A Hazard Mitigation Analysis shall be performed to evaluate the potential energy storage system failure modes and the safety-related consequences attributed to the failures, per NFPA 855, Chapter 4 and/or AGIC).

- The design, construction, and installation of ESS and related equipment shall comply with, Chapter 4 and be supplemented or modified by the technology-specific provisions in Chapters 9 through 13 of NFPA 855, Standard for the Installation of Stationery Energy Storage Systems

- A Pre-Incident Plan shall be developed for the BESS before operations commence per NFPA 1620 (1660), Pre-Incident Planning

- Sprinkler systems for BESS Facilities (not cubes or containers) shall be designed using a High Hazard Group 1 minimum density of 0.3 gpm/ft^2 (12.2 mm/min) based over the area of the room, or a 2500 ft^2 (230m^2) design area , whichever is smaller. The sprinkler system shall include a double interlocked preaction. Alternate density shall be permitted based on large-scale fire testing. Other than battery control areas, separate mechanical areas shall be provided sprinkler systems meeting NFPA 13.
- The BESS Fire Protection design requirements shall be based upon High Hazard Group H3 Occupancy per the IBC / IFC
- Recommendations from the UL Report, Four Firefighters Injured In Lithium-Ion Battery Energy Storage System Explosion - Arizona– Sunrise, AZ (UL Firefighter Safety Research Institute, 2020, March) – Recommendations Applied (Lessons Learned)
- Recommendations from the Technical Support for APS Related to McMicken Thermal Runaway and Explosion, McMicken Battery Energy Storage System Event Technical Analysis and Recommendations (Arizona Public Service, Document No.: 10209302-HOU-R-01 Issue: A, Status: Final Date: July 18, 2020) Recommendations Applied (Lessons Learned)
- Life Safety (NFPA 101) Occupancy Classification: High Hazard Storage, with a maximum travel distance of 150 ft (46 m) per NFPA 101, *Life Safety Code*
- Fire Separations (2-hour Fire Barriers) shall be utilized to minimize a single loss incident to a maximum MW as determined by the BESS Project Team
- All equipment and components shall be FM Approved and/or UL Listed or as directed in this document and by AGIC
- Provide deflagration venting per NFPA 68, Standard on Explosion Protection by Deflagration Venting or mechanical ventilation per NFPA 69, Standard on Explosion Prevention Systems to prevent accumulation of flammable gases above explosive concentrations.

Water Supply (when available and required)

A reliable and adequate water supply and distribution system shall be provided for fire suppression, as documented through appropriate analysis. Redundant water supplies (storage and pumping systems) are necessary when the maximum possible fire loss exceeds (deemed per AGIC) in any site facility.

Adequacy – The water supply shall be designed to meet the following combined demands for a period of not less than 1.5 hours: 1) largest single fire suppression system; 2) 500 gallons per minute (gpm) for fire hose streams; and 3) uninterruptable domestic and process demands.

Reliability – The water supply and distribution system shall be designed to prevent a single failure from causing the system to fail to meet its demand. Design features shall include looped and gridded distribution piping with sectional valves and redundant supplies (pumps and tanks or elevated water sources).

- Tanks – NFPA 22, *Standard for Water Tanks for Private Fire Protection*, is the applicable NFPA standard for design and installation of fire water tanks.
- Water Supply Mains – NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances*, is the applicable NFPA standard for design and installation of water supply mains.
- Facility Fire Protection Water Service – Fire protection water service piping shall be run and controlled separately from any domestic or process water piping that enters the facility from a combination of fire and domestic-process water supply source. Fire protection risers and

valves shall be located as close as practical to the facility's exterior walls.

- Fire Hydrants – Hydrants shall be provided so that they are no closer than 40 feet to the facility and hose runs from hydrants are no more than 300 feet to all exterior portions of the facility. There shall be adequate hydrants per building (not less than two) and branch piping between the water main and a hydrant shall not be greater than 300 feet.

- Listed and/or Approved Control Valves – Shall be installed per NFPA 24.
- Fire Pumps – Shall be designed and installed per NFPA 20, *Standard for the Installation of Stationary Pumps for Fire Protection.*

Design and Construction – AES facilities shall have a level of fire protection sufficient to fulfill the requirements of the best protected class of industrial risks (commonly referred to as "highly protected risk" or "improved risk") and shall provide protection to achieve "defense-in-depth." Design requirements contained in the NFPA Codes and Standards shall be utilized and FM Global Property Loss Prevention Data Sheets may be used as guidance for design activities.

- Construction, Alteration, and Demolition Operations shall meet the requirements of NFPA 855, Standard for the Installation of Stationery Energy Storage Systems and NFPA 241, *Standard for Safeguard Construction, Alteration, and Demolition Operations*.
- AES requires that new facilities (non-relocatable) be of Fire Resistive or Noncombustible materials, as defined by applicable building codes and AGIC.
- Natural Phenomena Hazards (NPH) [i.e., earthquake, wind, flood, wildland fire, lightning, snow, and volcanic eruption, etc.] shall be taken into consideration when locating, designing, and constructing AES facilities.

Facility / Cube / Container Layout and Construction

- Fire Area Determination – Facilities shall be subdivided into separate fire areas as determined by appropriate design documentation. Fire areas can be separated from each other by fire walls, adequate distance, and separation from exterior fire exposure, or other approved means.

  There shall be separation of fire areas between the Control Room and the Battery Room using fire barrier walls, with a minimum two-hour fire resistance rating. Windows in fire barrier walls (e.g., control rooms or computer rooms) shall be of a listed glazing material with a fire rating equal to that of the wall or be provided with rated fire shutters, or an automatic water curtain.

- Fire Barriers - Fire barriers used to separate hazards shall have adequate fire resistance to achieve the intended fire separation including protection of openings and penetrations and shall have a minimum two-hour fire resistance rating (or as required by the IFC/IBC or NFPA) or be demonstrated as adequate by documented analysis.

- Structural Materials – Construction materials shall be of Fire Resistive or Noncombustible materials, as defined by applicable building codes and AGIC.

- Roof Covering – Roof coverings shall be Class A per ASTM E108, *Standard Test Methods for Fire Tests of Roof Coverings,* or Underwriters Laboratories (UL) 790, *Standard Test Methods for Fire Tests of Roof Coverings*. Metal deck roof systems shall meet the requirements of Class I construction as defined in FM Global Property Loss Prevention Data

Sheets 1-28R, *Roof Systems,* and 1-31, *Metal Roof Systems*.

- Flooring – Flooring shall be configured to ensure there is no pooling of water within the facility; thereby preventing possible electrocution or shock hazards and damage to batteries.
- Interior Finishes – Interior finishes in AES facilities shall be Class A as defined in NFPA 101, *Life Safety Code*.
- Life Safety – Life Safety per NFPA 101, *Life Safety Code* shall be adhered to and as deemed necessary by AGIC.
- Battery racks (if applicable); shall be configured to allow suppression or extinguishing agents to readily access batteries and configure to allow for heat to dissipate (i.e., mesh design, etc.).

Suppression System(s)

"Although fires involving Lithium Batteries can be extinguished by many methods, the effects of thermal runaway are more difficult to manage, and continued cooling is required." (MDPI)

Water-based extinguishants provide the most cost-effective method to fight fires. Water is an excellent cooling medium due to its high heat capacity and latent heat of vaporization and may be able to mitigate or halt the propagation of thermal runaway to surrounding batteries.

"Based on current knowledge and infrastructure, a water-based fire suppression system is the strongest candidate for the protection of stored lithium-ion cells and batteries." (The Fire Protection Research Foundation, 2011, July)

"….robust sprinkler protection system design incorporating features effective for high-hazard commodities, such as Level 3 aerosols are recommended."

There are three main types of water-based suppressants to be considered for the BESS:

• Water spray or sprinkler: Water spray or sprinkler suppressants use a spray of fine water droplets, each droplet is surrounded by air, which is non-conductive. The spray has enough momentum for droplets to penetrate the fire plume and cool surfaces, as well as expanding some energy through vaporization to cool the air.

• Water with added surfactants: Adding surfactants to the water can improve the efficacy of water extinguishment. Surfactants decrease the water's surface tension so that it coats the burning materials and cools more efficiently.

• Water mist: Water mist comprises a range of droplet sizes under 1000 µm, droplets that are much smaller than those from a sprinkler. Finer droplets have a larger surface area to volume ratio compared to larger droplets resulting in a greater absorption of heat energy from the hot air for the same volume of water, while the larger drops within the drop size distribution can penetrate the fire plume and cool the burning material.

Sprinkler system installations shall consist of double interlocked pre-action systems, actuated by air sampling detection systems. System design, as a minimum, shall meet High Hazard Group 1 requirements, providing a minimum design density of 0.30 gpm/ft^2 over the area of the room, or a 2,500 ft^2 design area, whichever is smaller.

AGIC may require the design to be of a greater density on a case-by-case basis, based on large scale testing and battery type and chemistry.

This system is arranged so that the deluge valve will open only when each pressure is reduced in the sprinkler piping and the detection system operates. If the detection system operates due to damage

or malfunction, the valve will not open, but an alarm will sound. If the sprinkler piping is damaged or sprinkler is broken, the valve will not open, but a supervisory alarm will sound. The operation of both a sprinkler and a detector (or release) is required before the valve will open, allowing water to enter the system piping.

Suppression considerations for Containerized BESS configurations shall be analyzed on a case-by-case basis. CO2 SHALL NOT be used in areas that can be fully entered. Gaseous and aerosol fire suppression systems shall be analyzed by AGIC on a case-by-case basis for Containerized BESS configurations.

The Fluence Cube and other BESS Containers shall employ the following:

1. Emergency Shutdown (E-Stop)
2. Fire Detection and Suppression System
3. Gas Detection: Carbon Monoxide
4. Deflagration Panels
5. Lockable Disconnect Switch
6. Open Door Sensor
7. Gas Spring Damper
8. Sliding Door Lock
9. Fire Department Connection (FDC), where practicable

Fire Detection, Off Gas Detection and Alarm Systems

- A fire alarm system shall be provided for AES facilities to monitor fire suppression and detection systems, to notify occupants, to perform safety functions, and to notify emergency responders. NFPA 72, *National Fire Alarm and Signaling Code*, is the applicable NFPA standard for design, installation, and maintenance of fire detection and alarm systems and as recommended by NFPA 855 or as determined by AGIC.
- BESS projects shall provide a Very Early Smoke Detection Apparatus (i.e., VESDA) and thermal smoke detection, with the capability of providing two alarm points.
- Provide off-gas detection (i.e., Li-ion Tamer Gas Detection System)
- Provide deflagration venting per NFPA 68, Standard on Explosion Protection by Deflagration Venting or mechanical ventilation per NFPA 69, Standard on Explosion Prevention Systems to prevent accumulation of flammable gases above explosive concentrations.
- Provide gas monitoring that can be accessed remotely (i.e., remote annunciation).

Emergency Response Protocols & Management

First Responder Safety Design Attributes and Fire Protection Protocols

- Provide First Responders with a NFPA 1620 (1660) compliant Pre-Incident Plan
- Provide First Responders with site specific First Responder Mitigation Guidelines

- First Responders shall tour the BESS on an annual basis
- Emergency response times of first responders shall be validated via a PIP
- Ensure First responders have the capability to mitigate BESS incidents with current training, manpower and equipment
- Ensure Fire Responders utilize proper PPE within any designated Hot Zones
- Provide remote accessible Fire Alarm Control Panel (FACP) / Annunciator that indicates current temperature, LEL and off gas of the BESS
- If not otherwise provided, a manual means to check Facility Atmosphere – A Sampling Port and/or Off-gas detection shall be provided to measure LEL levels within the BESS before entry.
- Provide Explosion Protection by Deflagration Venting, per NFPA 68 or provide Explosion Prevention Systems, per NFPA 69, as required by NFPA 855
- Provide the ability to exhaust / ventilate remotely
- Provide signage in accordance with NFPA 855. Effective signage can alert emergency responders to the hazards associated with incidents in the ESS installation and help to inform the precautions and operations that emergency responders should take while interacting with the ESS. Although NFPA 855 does not require signage to be installed retroactively, it is recommended that signage compliant with NFPA 855 be provided for all lithium-ion battery ESS, regardless of commissioning date.
    - Provide Caution Signage to include NO ENTRY without AES escort and hazards associated with the BESS
    - Provide signage that identifies the contents of an ESS installations to alert first responders to the potential hazards associated with the installation
- Provide Knox Box – containing PIP, First Responder Mitigation Guidelines
- Provide installation of Dry-Pipe Fire Department Connection (FDC) on ALL BESS facilities and containers
- Provide CCTV for interior (facilities) and exterior of the BESS to aid the Incident Commander and control room

Building Services

- Vegetation & Wildland Exposure – Implement vegetation control per the AGIC Ground Mounted Solar PV Document
- Operation and Maintenance – Implement operation and maintenance activities for the BESS per Chapter 7 of NFPA 855.
- Electrical Systems – All electrical systems shall be installed in accordance with *NFPA 70*, *National Electrical Code*.
    - Ensure Emergency Shutoff capabilities are provided.

- Ventilation Systems – NFPA 90A, *Standard for the Installation of Air Conditioning and Ventilation Systems*, is the applicable NFPA standard for design and installation of ventilation systems. Ventilation systems that do not recirculate air (e.g., once through systems) do not require shutdown from duct smoke detectors, unless determined by the Fire Analysis or other documented analysis, as necessary, to prevent the spread of fire or for emergency management. Per NFPA 90A, duct smoke detectors are required in ducted air distribution systems that exceed 2000 CFM capacity.

- Lightning Protection – NFPA 780, *Standard for the Installation of Lightning Protection Systems*, is the applicable NFPA standard for lightning protection. NFPA 780 describes how to determine the need for lightning protection and how to install and maintain lightning protection when required.

- Drainage – When high-value property, safety structures systems and components, or critical process equipment is subject to flooding from the discharge of automatic sprinkler systems and/or use of manual hose streams, protection against water damage shall be provided by one or more of the following methods:

  - Floor drains.
  - Pits, sumps, and sump pumps.
  - Equipment pedestals.
  - Floor slope and curbing; or
  - Other acceptable alternatives.

  - Per NFPA 850: The provisions for drainage and any associated drainage facilities shall be sized to accommodate all the following:

    - The maximum expected number of fire hose operating for a minimum of 10 minutes
    - The maximum design discharge of fixed fire suppression systems operating for a minimum of 10 minutes

- Transformers – Transformers installed inside buildings shall be of a dry type, or those with FM approved or equivalent less-hazardous dielectric fluids (less-flammable or fire resistive).

  Outside transformers shall be located and protected in accordance with FM Global Property Loss Prevention Data Sheet 5-4, *Transformers,* AGIC Outdoor Transformer Fire Protection Guideline, and NFPA 850. Outdoor oil-insulated transformers shall be separated from adjacent structures and from each other by firewalls, spatial separation, or other approved means for the purpose of limiting the damage and potential spread of fire from a transformer failure.

  When adequate separations and fire barriers are not possible to protect (and protect from) oil filled transformers; they shall be provided with water spray protection (deluge system) in accordance with NFPA 15, *Standard for Water Spray Fixed Systems for Fire Protection* (not less than 0.25 gpm/ft2).

  See Appendix A, *Basic Transformer Fire Protection Design Specifications,* for input to basic design specifications and as deemed by AGIC.

Appendix A

Basic Transformer Fire Protection Design Specifications (Outdoors – Between Transformers and Buildings & Other Transformers)

Requirements are a compilation from NFPA 850, FMDS 5.4, and other AGIC sources

Liquid	FM or AGIC Approved Transformer or Equivalent	Liquid Volume gal/(m3)	Horizontal Distance (1)			Vertical Distance ft/(m)	Transformer Equipment Distance ft/(m)
			Fire Resistant (2 Hours) ft/(m)	Non-Combustible ft/(m)	Combustible ft/(m)		
Less-Flammable (FM Approved) (3)	Yes (2)	< 500 (1.9)	5 (1.5)	5 (1.5)	5 (1.5)	5 (1.5)	5 (1.5)
	No	≤10,000 (38)	5 (1.5)	5 (1.5)	25 (7.6)	25 (7.6)	5 (1.5)
		>10,000 (38)	15 (4.6)	15 (4.6)	50 (15.2)	50 (15.2)	25 (4.6)
Mineral Oil or (unapproved fluid)	N/A	<500 (1.9)	5 (1.5)	15 (4.6)	25 (7.6)	25 (7.6)	6 (1.5)
		500-5,000 (1.9-19)	15 (4.6)	25 (7.6)	50 (15.2)	50 (15.2)	25 (7.6)
		>5,000 (19)	25 (7.6)	50 (15.2)	100 (30.5)	100 (30.5)	50 (15.2)

NFPA 850 Outdoor Oil-Insulated Transformers.	
Transformer Oil Capacity gal/(m3)	Minimum (Line-of-Sight) Separation Without Firewall
<500 / 1893	5 ft. (1.5 m)
500-5000 / 1893–18,925	25 ft. (7.6 m)
>5000 / >18,925	50 ft. (15.2 m)

(1) Horizontal distances are measured from inside edge of the oil containment basin wall to the exterior surface of the adjacent building or transformer, unless otherwise allowed per AGIC.

(2) This Entire Row will be the minimum AES standardized distances permissible, unless otherwise allowed per AGIC.

(3) FM Approved less-flammable fluids are required (i.e., FR3 – natural ester dielectric coolant), unless otherwise allowed per AGIC.

NOTE: Outdoor oil-insulated transformers shall be separated from adjacent structures and from each other by firewalls, spatial separation, or other approved means deemed by AGIC for the purpose of limiting the damage and potential spread of fire from a transformer failure.

NOTE: Deluge systems and fire barriers may also be required, if deemed necessary by AGIC.

NOTE: For transformers with less than 500 gal (1893 L) of oil and where a firewall is not provided, the edge of the postulated oil spill (i.e., containment basin, if provided) shall be separated by a minimum of 5 ft (1.5 m) from the exposed structure to prevent direct flame impingement on the structure.

NOTE: Unless otherwise allowed by AGIC, any oil-insulated transformer containing 500 gal (1893 L) or more of oil shall be separated from adjacent structures by a 2-hour–rated firewall or by spatial separation in accordance with the Table above. Where a firewall is provided between structures and a transformer, it shall extend vertically and horizontally as indicated in NFPA 850 (Figure 5.1.4.3).

NOTE: Where a firewall is provided, it shall be designed to withstand the effects of projectiles from exploding transformer bushings or lightning arresters.

NOTE: It is preferred oil containment basins be independent of each other, with adequate volume containment and shall not merge with each other; however, AGIC is providing latitude to allow BESS related transformers with FM Approved less-flammable fluid (i.e., FR3 – natural ester dielectric coolant) to share a single containment basin, with sump pumping capabilities.