

# **FIRE PROTECTION SITE DESIGN GUIDE**

for

Outdoor, Ground-Mounted  
Battery Energy Storage Systems

*January 29, 2024*

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# Introduction

This fire protection site design guide is intended to provide a high-level overview of fire protection requirements and best practices for Battery Energy Storage System (BESS) facility implementation. The site design guide references fire protection requirements contained within codes and standards published by the International Code Council (ICC) and National Fire Protection Association (NFPA). In addition, good engineering practices are provided, where applicable.

During project initiation, it is important to reference the versions of the ICC and NFPA standards adopted and/or amended by the state or local jurisdiction, as these versions may impose more stringent requirements. Some state and local jurisdiction versions of ICC and NFPA standards may lack BESS regulatory language. For such cases, it is recommended that the most recent edition of ICC and NFPA standards relevant to BESS be implemented to provide an adequate level of fire protection.

Dialogue with the local authority having jurisdiction (AHJ) should be established early in the project to ensure that all fire protection requirements have been identified. The initial exchange with the AHJ should address planned fire protection features, first responder safety, and local fire protection concerns.

UL verification service investigation tests (UL 9540A, 4th edition) are often required for installations seeking variances from the baseline requirements stipulated by the ICC and NFPA (i.e., maximum stored energy, spacing between units, etc.). UL 9540A is a standardized test method aimed at analyzing fire propagation behavior and conditions during a fire event.

General BESS facility site planning requires, at minimum, a Hazard Mitigation Analysis (HMA) be conducted by a fire protection consultant. The AHJ may require additional analysis prior to site approval such as a Community Risk Analysis (CRA), Fire Risk Assessment (FRA), and/or Emergency Response Plan (ERP).

This fire protection design guide is limited to the recommended design requirements for facilities utilizing outdoor, ground-mounted BESS. Fire protection requirements pertaining to indoor BESS facilities, electrical substations, electrical generating stations, and control buildings are not covered by this design guide.

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# Applicable Codes, Standards, And Reference Documents

The following publications represent the current industry codes and standards that may be applicable for BESS installations. The most recent editions of each publication (as of the date on this document) are included for reference.

## **International Code Council (ICC)**

ICC International Fire Code – 2021 Edition (IFC)

## **National Fire Protection Association (NFPA)**

NFPA 24, *Standard for the Installation of Private Fire Service Mains and Their Appurtenances* – 2022 Edition

NFPA 25, *Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems* – 2023 Edition

NFPA 68, *Standard on Explosion Prevention by Deflagration Venting* – 2023 Edition

NFPA 69, *Standard on Explosion Prevention Systems* – 2019 Edition

NFPA 70, *National Electric Code* – 2023 Edition

NFPA 72, *National Fire Alarm and Signaling Code* – 2022 Edition

NFPA 291, *Recommended Practice for Fire Flow Testing and Marking of Hydrants* – 2022 Edition

NFPA 850, *Recommended Practice for Fire Protection for electric Generating Plants and High Voltage Direct Current Converter Stations* – 2020 Edition

NFPA 855, *Standard for the Installation of Stationary Energy Storage Systems* – 2023 Edition

NFPA 1142, *Standard on Water Supplies for Suburban and Rural Firefighting* – 2022 Edition

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**Institute of Electrical and Electronics Engineers (IEEE)**

IEEE 979, *Guide for Substation Fire Protection* – 2012 Edition

IEEE 2030.2.1, *Guide for the Design, Operation, and Maintenance of Battery Energy Storage Systems, both Stationary and Mobile, and Application Integrated with Electric Power Systems* – 2019 Edition

**Underwriters Laboratories (UL)**

UL 1973, *Batteries for Use in Stationary and Motive Auxiliary Power Applications* – 2022 Edition

UL 9540, *Energy Storage Systems and Equipment* – 2020 2nd Edition

UL 9540A, *Test Method for Evaluating Thermal Runaway Fire Propagation in Battery Energy Storage Systems* – 2019 4th Edition

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# Definitions

**Battery Energy Storage System (BESS) [UL 9540A §4.2]:** Stationary equipment that receives electrical energy and then utilizes batteries to store that energy to supply electrical energy at some future time. The BESS, at a minimum, consists of one or more modules, a power conditioning system (PCS), battery management system (BMS) and balance of plant components. (Underwriters Laboratories, 2019).

**Battery Management System (BMS) [NFPA 855 §3.3.3]:** A system that monitors, controls, and optimizes performance of an individual or multiple battery modules. (National Fire Protection Association, 2023)

**Cell [UL 9540A §4.3]:** The basic functional electrochemical unit containing an assembly of electrodes, electrolyte, separators, container, and terminals. It is a source of electrical energy by direct conversion of chemical energy. (Underwriters Laboratories, 2019)

**Combustible:** Readily or easily ignitable material. Specific definitions vary depending on material; dust, fibers, liquids.

**Combustible Liquid, Class II [IFC §202]:** Liquids having a closed cup flash point at or above 100 degrees F, and below 140 degrees F. [E.G. Diesel Fuel] (International Code Council, 2021)

**Emergency Alarm System [IFC §202]:** A system to provide indication and warning of emergency situations involving hazardous materials. [3]

**Energy Storage Management System (ESMS) [NFPA 855 §3.3.8]:** A system that monitors, controls, and optimizes the performance and safety of an energy storage system. (National Fire Protection Association, 2023)

**Energy Storage Systems (ESS) [NFPA 855 §3.3.9]:** One or more devices, assembled together, capable of storing energy in order to supply electrical energy at a future time. (National Fire Protection Association, 2023)

**Energy Storage System Cabinet [NFPA 855 §3.3.9.2]:** An enclosure containing components of the energy storage system where personnel cannot enter the enclosure other than reaching in to access components for maintenance purposes. (National Fire Protection Association, 2023)

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**Fire Resistance [IFC §202]:** That property of materials or their assemblies that prevents or retards the passage of excessive heat, hot gasses or flames under conditions of use. (International Code Council, 2021)

**Fire-Resistance Rating [IFC §202]:** The period of time a building element, component or assembly maintains the ability to confine a fire, continues to perform a given structural function, or both, as determined by the tests, or the methods based on tests prescribed in Section 703 of the International Building Code. (International Code Council, 2021)

**Flammable Gas [IFC §202]:** A material which is a gas at 68° F (20° C) or less at 14.7 pounds per square inch atmosphere (psia) (101 kPa) of pressure [a material that has a boiling point of 68° F (20° C) or less at 14.7 psia (101 kPa) which:

1. Is ignitable at 14.7 psia (101 kPa) when in a mixture of 13 percent or less by volume with air; or
2. Has a flammable range at 14.7 psia (101 kPa) with air of at least 12 percent, regardless of the lower limit.

The limits specified shall be determined at 14.7 psi (101 kPa) of pressure and a temperature of 68° F (20° C) in accordance with ASTM E681. (International Code Council, 2021)

**Lithium-ion battery [IFC §202]:** A storage battery with lithium ions serving as the charge carriers of the battery. The electrolyte is a polymer mixture of carbonates with an inorganic salt and can be in a liquid or a gelled polymer form. Lithiated metal oxide is typically a cathode and forms of carbon or graphite typically form the anode. (International Code Council, 2021)

**Module [UL 9540A §4.9]:** A subassembly that is a component of a BESS that consists of a group of cells or electrochemical capacitors connected together either in a series and/or parallel configuration (sometimes referred to as a block) with or without protective devices and monitoring circuitry. (Underwriters Laboratories, 2019)

**Stationary Energy Storage System [NFPA 855 §3.3.9.7]:** An energy storage system that is permanently installed as fixed equipment. (National Fire Protection Association, 2023)

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**Thermal runaway [UL 9540A §4.11]:** The incident when an electrochemical cell's temperature increases at an accelerating rate in an uncontrollable fashion sufficient to result in damage to the cell. The thermal runaway progresses when the cell's generation of heat is at a higher rate than the heat it can dissipate. This may lead to fire, explosion and gas and smoke evolution. (Underwriters Laboratories, 2019)

**Unit [UL 9540A §4.12]:** A frame, rack, or enclosure that consists of a functional BESS which includes components and subassemblies such as cells, modules, battery management systems, ventilation devices and other ancillary equipment. (Underwriters Laboratories, 2019)

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# Fire Protection Site Design

BESS equipment often consists of pre-assembled units grouped together for easy delivery and installation. Most common units are unoccupiable, non-walk-in (NWI) style with all internal components accessible via exterior doors and cabinets. These style units are considered for this guide.

## BESS Installation Classifications

For outdoor BESS installations, the IFC and NFPA 855 provide code requirements based on the proximity and location of the BESS equipment from adjacent exposures. The two outdoor installation classifications are as follows:

- **Remote Locations:** BESS 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.
- **Locations Near Exposures:** BESS locations that do not comply with remote outdoor location requirements.

The code requirements for remote locations classification are less stringent compared to locations near exposures classification. Site design planning to meet the remote locations classification is advantageous from a fire protection standpoint.

In rural applications, some project sites may not meet the definition of remote locations classification but have no significant exposure hazards. For such cases, dialogue with the AHJ may permit re-classification of the BESS facility.

Indoor BESS installations, whether dedicated-use or nondedicated-use, often require additional construction and occupancy considerations. This may necessitate additional design analysis that is not considered as part of this guide.

## BESS Spatial Separations

Spatial separation distance is measured as a straight line from the BESS equipment edge to the exposure of concern or to the anticipated flame front. Spatial separation is an effective method for reducing the fire spread damage.

## BESS Clearance to Exposures

BESS equipment is required to be separated from adjacent exposures as shown in [Table 1](#).

Note: NFPA 855 does not require clearance to exposures for remote locations classification.

**Table 1. BESS Clearance to Exposures**

<b>Adjacent Exposures</b>	<b>Minimum Clearance IFC §1207.8.3</b>	<b>Minimum Clearance NFPA 855 §9.5.2.6.1</b>
Lot Lines	10 feet (3 m)	10 feet (3 m)
Public Way	10 feet (3 m)	10 feet (3 m)
Buildings	10 feet (3 m)	10 feet (3 m)
Stored combustible materials	10 feet (3 m)	10 feet (3 m)
Hazardous Materials	10 feet (3 m)	10 feet (3 m)
High-Piled Stock	10 feet (3 m)	10 feet (3 m)
Other Exposure Hazards	10 feet (3 m)	10 feet (3 m)

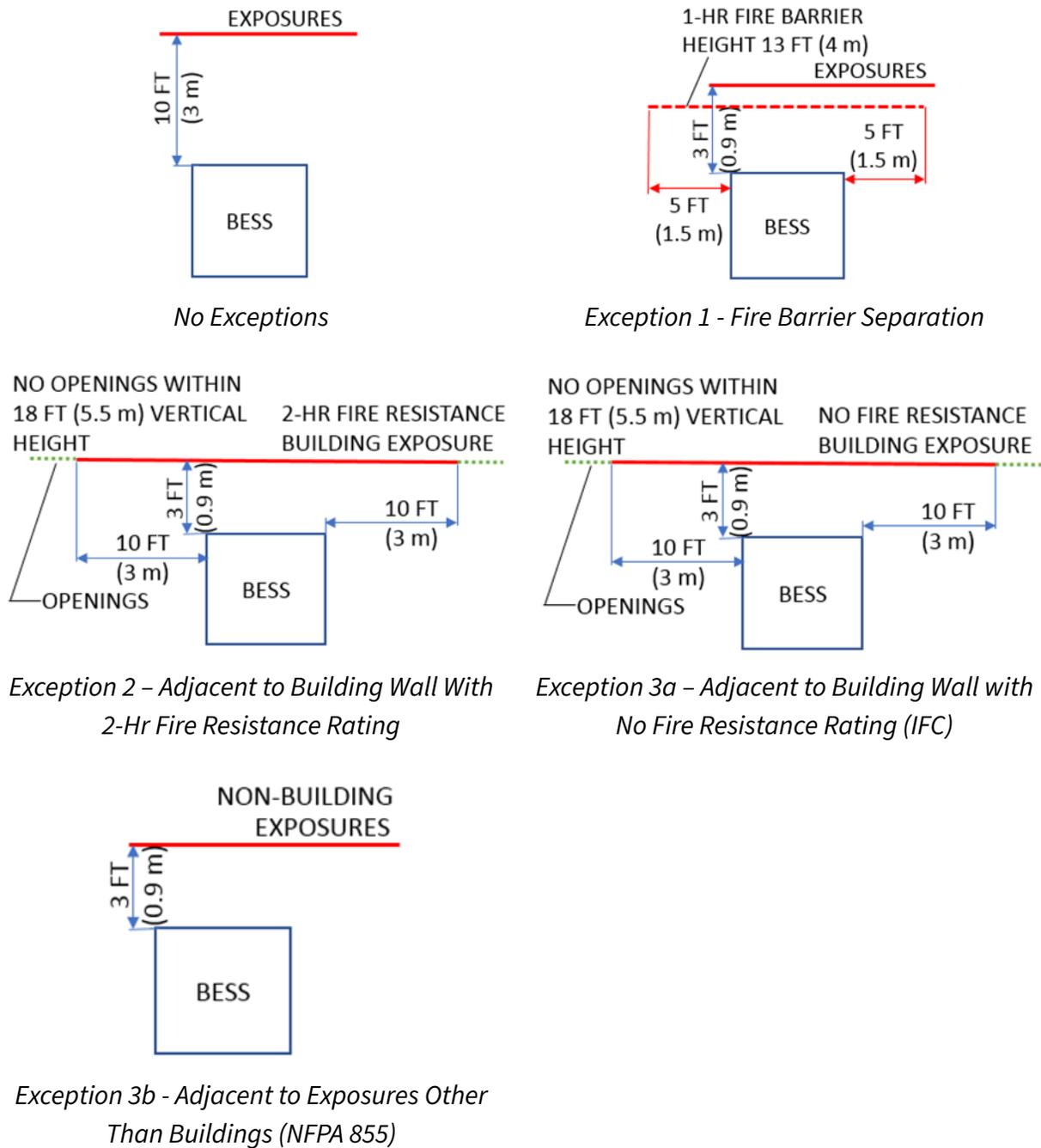
The following exceptions can be used to reduce the clearance limit for BESS facilities with limited spacing.

- **Exception 1 [IFC §1207.8.3(1) & NFPA 855 §9.5.2.6.1.1]:** Clearances are permitted to be reduced to 3 feet (0.9 m) where a 1-hour free-standing fire barrier suitable for exterior use and extending 5 feet (1.5 m) above and 5 feet (1.5 m) beyond the physical boundary of the BESS installation is provided to protect the exposure.
- **Exception 2 [IFC §1207.8.3(2) & NFPA 855 §9.5.2.6.1.2]:** Clearances to buildings are permitted to be reduced to 3 feet (0.9 m) where noncombustible exterior walls with no openings or combustible overhangs are provided on the wall adjacent to the BESS and the fire-resistance rating of the exterior wall is a minimum of 2 hours. Openings consist of doors, windows, vents, louvers, etc.

IFC and NFPA 855 provide different interpretations for Exception 3. Jurisdictions that adopt IFC can utilize Exception 3a and reduce spacing to 3 feet (0.9 m) to all exposures. Jurisdictions that adopt NFPA 855 can utilize Exception 3b and reduce spacing to 3 feet (0.9 m) to all exposures other than buildings.

- **Exception 3a [IFC §1207.8.3(3)]:** Clearances to buildings are permitted to be reduced to 3 feet (0.9 m) where a weatherproof enclosure constructed of noncombustible materials is provided over the BESS, 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.
- **Exception 3b [NFPA 855 §9.5.2.6.1.4 & §9.5.2.6.1.5]:** Clearance to exposures other than buildings shall be permitted to be reduced to 3 feet where fire and explosion testing of the BESS demonstrates that a fire within the BESS enclosure will not generate radiant heat flux sufficient to ignite exposures. Clearances to buildings and exposures shall be permitted to be reduced to 3 ft (0.9 m) where the enclosure of the ESS has a 2-hour fire resistance rating established in accordance with ASTM E119 or UL 263.

Figure 1 illustrates Exceptions 1, 2, and 3.

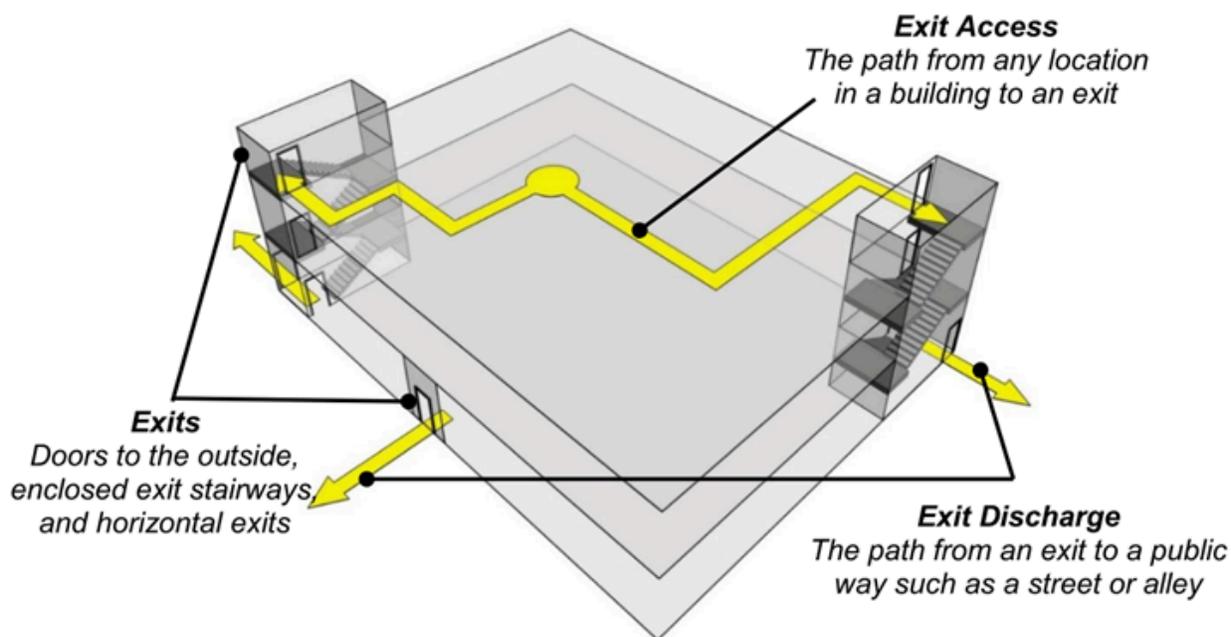


**Figure 1. BESS Clearance Exceptions**

## BESS Means of Egress Separation

Outdoor BESS are to be separated from any means of egress component from buildings as required by the code official to ensure safe egress under fire conditions, but never less than 10 feet (3 m) [IFC §1207.5.8 & NFPA 855 §9.5.2.6.1.6]. The separation code requirement includes the exterior exit discharge path.

Means of egress consists of three distinct components: exit access, exit, and exit discharge, [Figure 2](#). Where BESS units are installed adjacent to occupiable buildings (i.e., office buildings, warehouses, factories, etc.) close attention to means of egress separation is required to ensure safe passage of the building occupants. BESS facilities with unmanned electrical grid infrastructure buildings typically do not need to account for means of egress separation.



**Figure 2. Components of a Means of Egress from a Building**

Where approved by the AHJ, clearances are permitted to be reduced to 3 feet (0.9 m) where fire and explosion testing demonstrates that a fire within the ESS will not adversely impact the means of egress [IFC §1207.5.8 & NFPA 855 §9.5.2.6.1.7].

The 10 feet (3 m) minimum separation to means of egress components should be adhered to for all BESS installations. Where 10 feet (3 m) separation is not possible, the BESS equipment

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may utilize a reduced 3 feet (0.9 m) separation if supported by the HMA and approved by the AHJ.

## **Vegetation**

Forest and grass fires can expose the BESS equipment to conductive smoke, fire plumes, radiant heat, and soot. Similarly, BESS equipment failure may expose the surrounding forested area to radiant heat.

Areas within 10 feet (3 m) on each side of outdoor BESS shall be cleared of combustible vegetation and other combustible growth [IFC §1207.5.7 & NFPA 855 §9.5.2.2.1]. 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 [IFC §1207.5.7 & NFPA 855 §9.5.2.2.2].

In addition, the surrounding vertical vegetation (i.e., trees) heights should be analyzed to minimize fall potential that may impact the BESS facility.

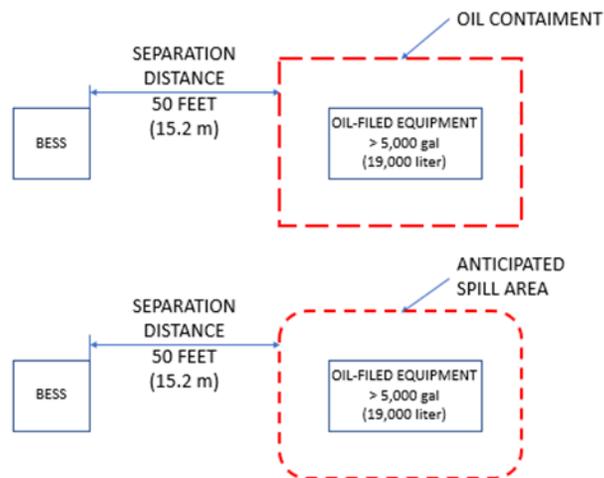
## **General Spatial Separation of Oil-Insulated Equipment**

Equipment and buildings should be separated from oil-insulated equipment to minimize the impact of a major fire. The spatial separation between the electrical equipment and oil-insulated equipment should be taken from the equipment edge to the anticipated flame front for large oil-filled equipment (i.e. greater than 500 gallons (1,900 liters)). The grid transformers are typically the largest oil-insulated equipment found in an electrical substation with a typical oil capacity of 3,000 – 7,000 gallons (11,400 – 26,500 liters). The recommended oil-insulated equipment separation distances are provided in [Table 2](#).

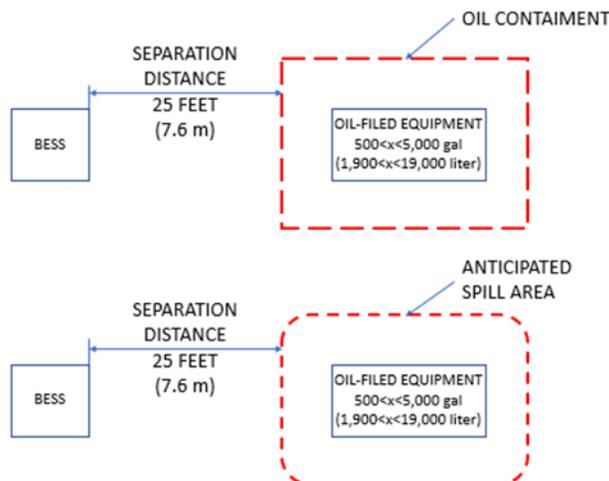
**Table 2. Recommended Oil-Insulated Equipment Separation Distance [NFPA 850 Table 6.1.4.3]**

Equipment Oil Volume	Minimum Line-of-Sight Separation Without Firewall
< 500 gallons (1,900 liters)	5 feet (1.5 m) 10 feet (3.0 m) for BESS
500–5,000 gallons (1,900–19,000 liters)	25 feet (7.6 m)
> 5,000 (19,000 liters)	50 feet (15.2 m)

Where oil containment is provided, the boundary of the oil containment should be considered as the anticipated flame front. Where oil containment is not provided, the spatial separation should consider the resulting anticipated flame spill area with permeability of the ground surface material. For equipment with oil volume more than 500 gallons (1,900 liters), the spatial separation should be taken from the equipment edge. See [Figure 3](#).



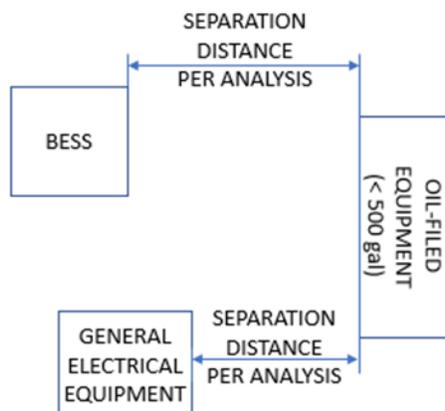
**Figure 3. Spatial Separation of Large Oil-Insulated Equipment Greater than 5,000 Gallons (19,000 liters)**



**Figure 4. Spatial Separation of Large Oil-Insulated Equipment Between 500 and 5000 Gallons (1,900 and 19,000 liters)**

Where oil containment pits are provided with stone flame suppression with stone sizes 0.75 – 1.5 inch (20 – 40 mm) in diameter, the spatial separation may be reduced to 15 feet (4.6 m), given that the stone flame suppression surface is well maintained and free of dirt, debris, and organic matter that could prevent oil absorption.

The spatial separation between electrical equipment and small oil-filled equipment greater than 500 gallons (1,900 liters) should be taken from equipment edge to equipment edge. Small, oil-filled equipment commonly found in BESS facilities consists of inverter transformers, medium voltage skids, and auxiliary transformers. General electrical equipment should be provided with 5 feet (1.5 m) minimum separation. Spatial separation of BESS should be provided based on the analysis of UL 9540A tests, large-scale fire testing, and heat flux modeling.



**Figure 5. Spatial Separation of Large Oil-Insulated Equipment Greater than 500 Gallons (1,900 liters)**

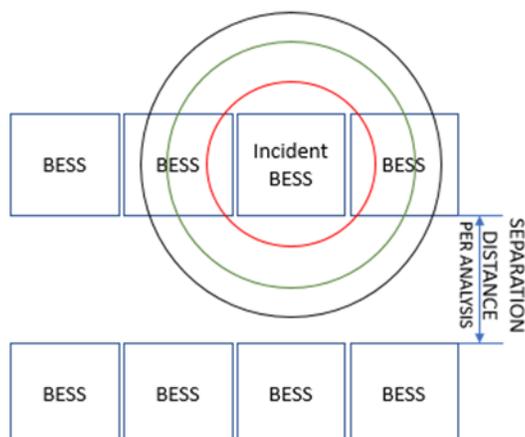
As a good engineering practice, BESS equipment and other critical buildings should not be installed down slope of large oil-insulated equipment where failure of equipment or oil containment could engulf BESS equipment and critical buildings with combustible liquids.

For BESS sites where spatial separations to large oil-insulated equipment greater than 500 gallons (1,900 liters) cannot be provided due to site restrictions or limitations, the following options could be used:

- Fire barriers
- Calculated spatial separation

## Spatial Separation of BESS Equipment to Equipment

Heat flux analysis and large-scale fire testing should be used as a basis to determine BESS equipment-to-equipment separation. The analysis should take into account a worst-case scenario with fully involved BESS equipment or rows of BESS equipment.

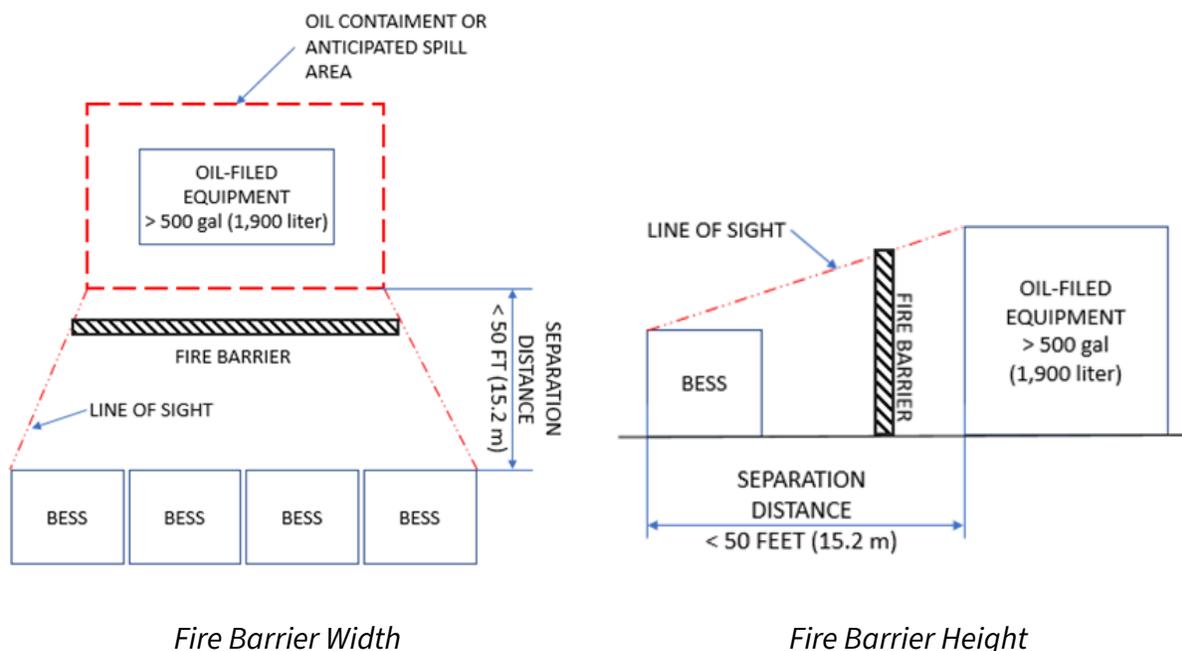


**Figure 6. Spatial Separation of BESS to BESS Based on Radiative Heat Contours**

## Fire Barriers

Passive fire protection using fire barriers of suitable construction may be installed as a means of spatial separation protection when the recommended separation distances cannot be achieved. Suitable construction may involve fire-resistive materials such as reinforced concrete, CMU, composite materials, or masonry.

For separation of units to oil-insulated equipment greater than 500 gal (1,900 liters), a 2-hour fire barrier is recommended. The fire barrier construction should extend vertically and horizontally to block the line of site between the unit and the exposure hazard.



**Figure 7. Fire Barrier Examples**

**Calculated Spatial Separation**

As an alternative to prescriptive methods and separation distances, the minimum spatial separation may be derived from deterministic heat flux calculations. This method of calculated spatial separations is unique to the project site and requires involvement of fire protection consultants and AHJ approval. This method is only recommended where the project site limitations do not permit prescriptive separation.

Examples of project site-specific parameters taken into account for calculated spatial separation analysis are:

- Type and quantity of oil in the equipment
- Size of postulated oil spill (surface area and depth)
- Type of construction of adjacent structures
- Type and amount of exposed equipment
- Power rating of the transformer
- Provided fire protection systems
- Provided oil-filled equipment passive protection systems

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Additional site-specific parameters may be needed for analysis depending on the site conditions.

## Fire Department Access

Fire department access roads should be designed to accommodate all-weather access of emergency response vehicles. The local fire code and/or AHJ should be consulted to determine if any modifications to the base requirements of the IFC are required, which could include additional access roads, increased road widths, and a larger minimum turning radius. For large BESS facilities, the AHJ should be consulted to determine if multiple points of emergency access will be required.

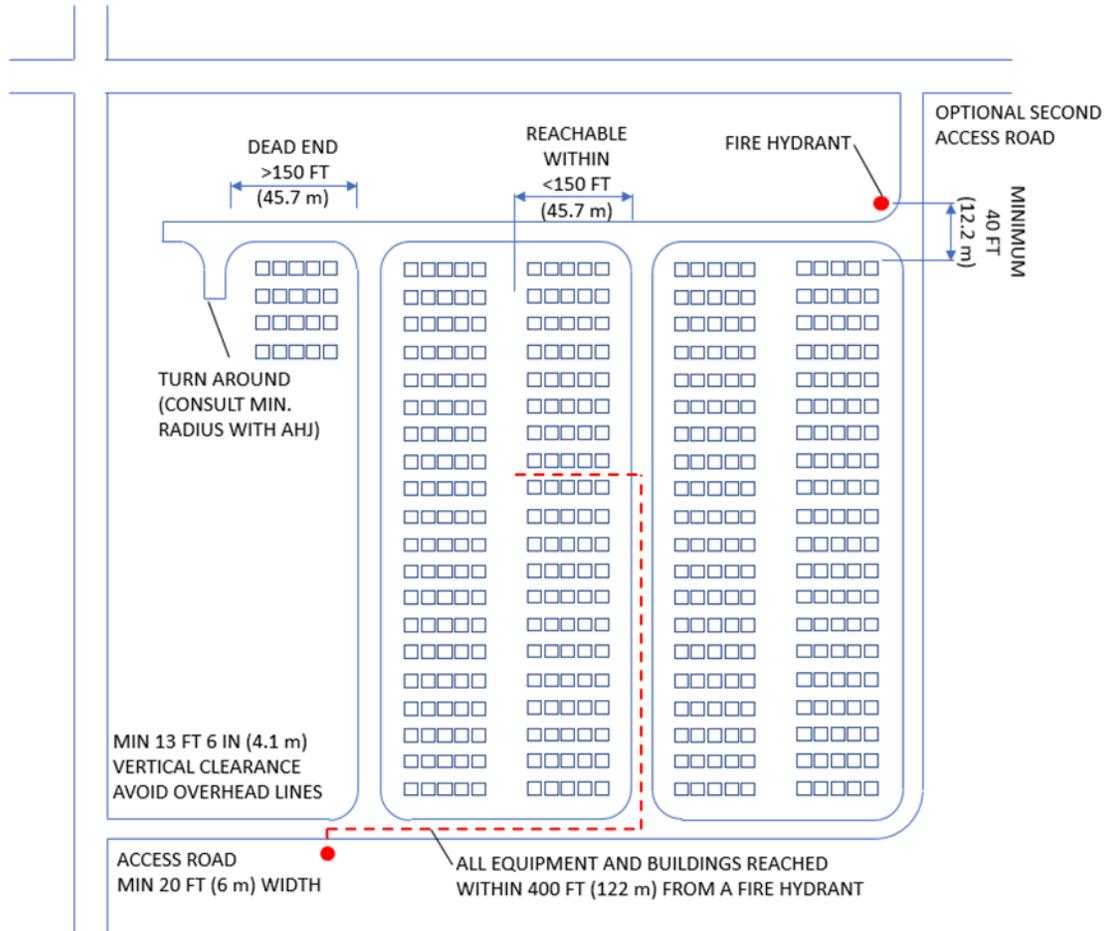
At a minimum, the fire department access shall be constructed to meet all of the following requirements:

- All equipment and buildings shall be reached within 150 feet (45.7 m) from an access road [IFC §503.1.1]
- Access roads shall have an unobstructed width of not less than 20 feet (6 m) [IFC §503.2]
- Access roads shall have an unobstructed vertical clearance of not less than 13 feet 6 inches (4.1 m) [IFC §503.2]
- Dead-end access roads in excess of 150 feet (45.7 m) in length shall be provided with an approved area of turning around the fire apparatus [IFC §503.2.5]
- The local fire department should be consulted to determine the required turning radius of the responding fire apparatus [IFC §503.2.4]
- The access roads shall be designed and maintained to support the imposed loads of fire apparatus and shall be surfaced so as to provide all-weather driving capabilities [IFC §503.2.3]

As a recommended best practice, the fire department access should:

- Not be located beneath overhead power lines
- Not be located adjacent to fire hazards (such as oil filled equipment and close proximity to BESS equipment) that could inhibit access during an incident
- (Where two or more emergency access points are provided) be located as far away from each other as practical. Additionally, at least one access point should be positioned upwind of the prevailing wind direction.

Figure 8, below, illustrates an example fire department access layout. Fire hydrant layout requirements are discussed later.



**Figure 8. Fire Department Access Road Example Arrangement**

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## Detection And Alarm Systems

Rooms, indoor areas, and walk-in units containing BESS shall be provided with a smoke detection or radiant energy-sensing system [IFC §1207.5.4 & NFPA 855 §9.6.1].

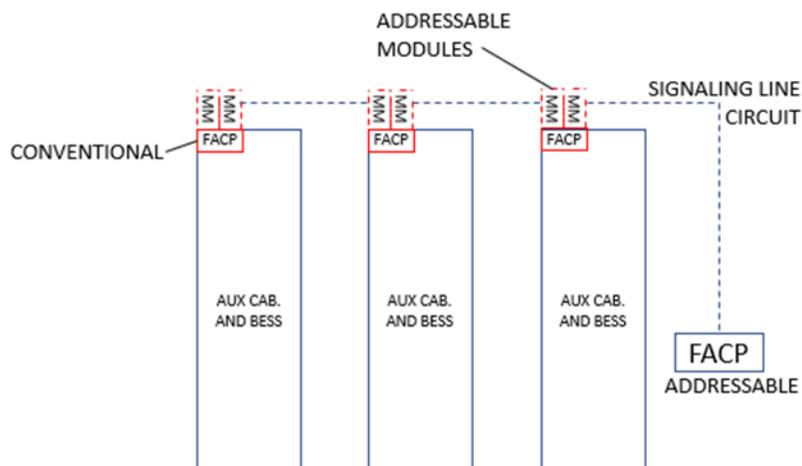
Exterior visual annunciation on the enclosure exterior or other desired locations can be required by the fire code official to indicate that potentially hazardous conditions associated with the ESS exist [IFC §1207.5.4.1]. Visual and audible notification are commonly provided on the exterior of BESS units.

The overall fire alarm system can be configured as an addressable or conventional system:

- **Addressable Fire Alarm System:** Fire alarm devices are configured using a digital signal. Each device is given an address that conveys different information. The fire alarm system will be able to pinpoint the activating fire alarm device.
- **Conventional Fire Alarm System:** Fire alarm devices are configured using analog zones. The fire alarm system will not be able to pinpoint the activating fire alarm device.

## Conventional Fire Alarm Control Panel Integration

An addressable master fire alarm control panel (FACP) can be provided to integrate multiple conventional FACP systems to a single point. This method requires addition of addressable modules to monitor fire alarm, trouble, and supervisory conditions by the master FACP via a Signaling Line Circuit (SLC), [Figure 9](#).



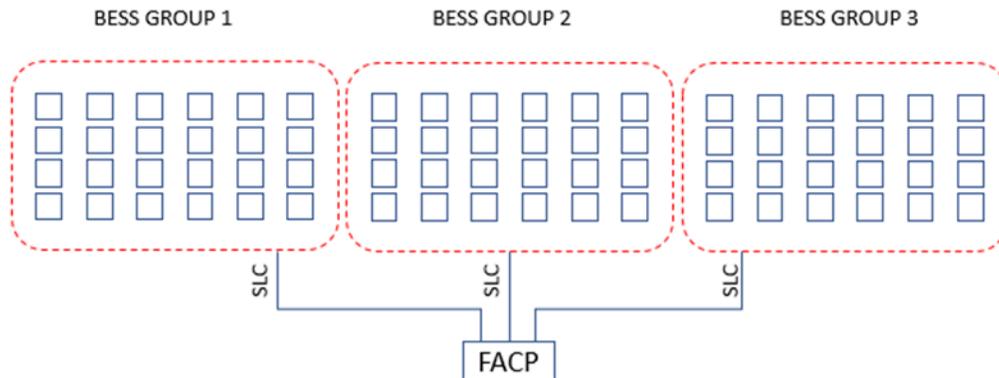
**Figure 9. Addressable Master FACP Integration of Conventional FACP**

## Addressable Fire Alarm Control Panel Integration

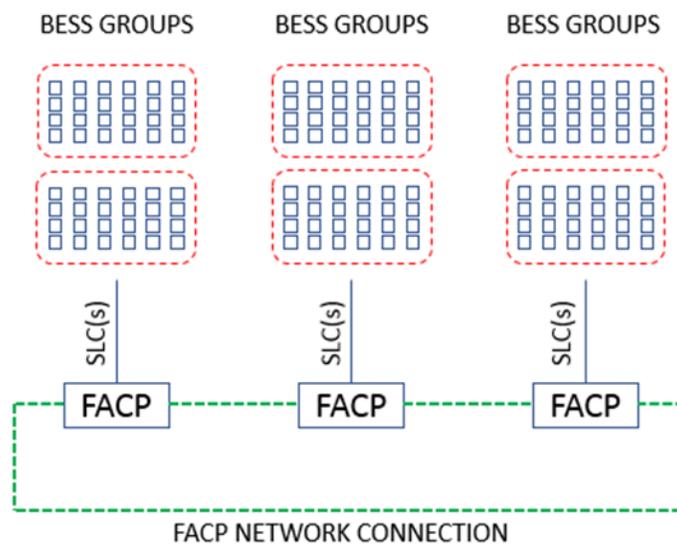
A single FACP may be sufficient for small BESS facilities using addressable or conventional fire alarm systems, [Figure 10](#). For large sites, multiple FACP may be required for BESS system integration, [Figure 11](#). The quantity of addressable FACP can be estimated based on the quantity BESS units provided. The number of fire alarm detectors and modules depends on the site configuration.

Where multiple networked FACP are used, the FACP can be grouped to a central location or can be distributed throughout the BESS site. Approximately 30 inches (76 cm) of clear wall space is required for installation of a single FACP cabinet. Multiple FACP will require additional wall space as appropriate.

Integration of conventional FACP systems requires a distinct site level master FACP. Addressable systems using networked FACP are equal in alarm and signal priority; the FACP with signal transmission equipment is often distinguished as the master FACP panel.



**Figure 10. Single Addressable FACP With Multiple SLC Loops**



**Figure 11. Multiple Networked Addressable FACP With Multiple SLC Loops**

FACP network connection must be provided with a high-speed network communication module using twisted-pair copper wire, single-mode fiber, multi-mode fiber, or any combination of the three.

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## Fire Alarm Control Panel Installation Considerations

The FACP shall be installed in accordance with the applicable code and standards acceptable to the jurisdiction. At a minimum, NFPA 72 should be followed in North American markets and EN 54 should be followed in European markets.

The power to the FACP shall be provided from a dedicated breaker on the electrical service panel. The breaker should be a minimum of 20 A. The dedicated breaker shall be labeled and provided with a breaker lock.

The FACP power supply that corresponds to the application nominal VAC must be provided, such as 120 VAC for North America and 240 VAC for Europe. The power supply connection should be provided with a surge protection device.

The room or space where the FACP is installed must be protected with a ceiling mounted smoke detector at minimum. The local fire code and/or AHJ should be consulted on the requirement of manual pull stations. Some AHJ will require at least one manual pull station to be provided for the facility to initiate a fire alarm signal.

The backup battery for the master FACP shall be provided in accordance with applicable codes and standards. The backup battery for the master FACP shall be able to provide 24 hours in standby and 2 hours in alarm. FACP's installed in geographic areas subject to seismic disturbance should be provided with battery brackets for restraining movement.

## Conduit and Wiring

Conduit and wiring for fire alarm systems shall be in accordance with NFPA 70 Article 760, Fire Alarm Systems. Fire alarm signaling line circuit communication wirings may be shielded type where allowed by the fire alarm control manufacturer. Ensure all manufacturer guidelines such as maximum wire distances, type, etc. are adhered to during system design and installation.

Electric Metallic Tubing (EMT) should be used for interior installations and should be red in color for all fire alarm 24 VDC wiring. Rigid Metallic Tubing (RMT) should be used for all exterior wiring. Connections and interface locations should be designed to prevent water intrusion. FACP power supply (120/240 VAC) should use EMT in silver/natural galvanized color. The VAC FACP power supply and 24 VDC fire alarm wiring shall not share the same conduit.

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Where a FACP is located within a building or control house, all fire alarm circuits exiting or entering the building must be provided with a 24 VDC surge protection device. The same practice should be followed for SLCs entering individual BESS auxiliary cabinets or units.

Special care should be taken where fire alarm SLCs are located near inverters or similar electrical equipment capable of generating electrical interference. The SLCs should be routed at least 10 feet away from such equipment.

## Fire Alarm Circuit Pathway

Two types of fire alarm circuit pathways are available for communication between BESS units and a site level master FACP:

- Class B Pathway: No redundant pathway is provided. Equipment past a single open circuit will not operate.
- Class A Pathway: A physically-separate, redundant pathway is provided. All devices on the pathway will continue to operate with a single open circuit.

Where a Class A pathway is used, the fire alarm conduit loops should be separated and, if required, the return loops should be routed exterior of the BESS equipment. This option provides a physical separation where a complete loss of a single BESS unit does not disrupt the FACP communication. Due to the construction of BESS cabinets, a true Class A pathway may not be feasible. If additional assurance is required, a fault isolation module may be used to isolate a specific string of fire alarm devices to protect the fire alarm pathway in the event of a complete loss of a BESS cabinet fire alarm system.

Fire alarm systems using Class A wiring are more reliable compared to those using Class B wiring, as they provide a redundant pathway that enables the system to function even when a pathway is compromised during a fire. In general, a Class A wiring pathway is recommended when connected to a large number of BESS groups. A Class B wiring pathway can provide effective protection when connected to a limited number of groups.

## Fire Alarm Monitoring

The FACP must be provided with means to send out fire alarm, trouble, and supervisory (where applicable) signals to a fire alarm supervising station. Multiple methods of signal transmission are available depending on project conditions and customer needs. Three

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common transmission methods often used for electrical grid infrastructure are:

- Digital Alarm Communication Transmitter (DACT) using primary and secondary Plain Old Telephone Service (POTS).
- DACT using primary phone line and secondary performance-based technology (e.g., internet protocol (IP) communication, cellular dialer, radio)
- Substation SCADA-RTU

Consult with the customer on the appropriate signal transmission application at the start of the project. Fire alarm signal transmission through the substation SCADA-RTU requires additional engineering and programming from both fire alarm designer and customer SCADA-RTU engineer.

Various fire alarm manufacturers now offer cloud monitoring of fire alarm equipment through the internet. If this function is desired, a listed cloud connection gateway must be provided to the FACP, for the fire alarm information to be accessible by desktop computers or mobile devices.

The local fire code and/or AHJ should be consulted to determine if a secondary phone line transmission method is required for fire alarm signals.

For rural applications with weak cellular signal, an antenna may be necessary to compensate for weak cellular signal strength.

## **First Responder Panel (FRP)**

The first responder panel (FRP) is a standalone cabinet located remote from the BESS installation intended to annunciate fire alarm system status for use by the first responders.

The FRP location should factor the following:

- Anticipated first responder approach path to the BESS facility
- Anticipated first responder staging location
- Potential exposure hazards from substation or BESS equipment

The FRP can be located on the exterior of the facility fence or behind a gate accessible by the first responders. It is recommended that the location of the FRP be determined through consultation with the AHJ or local fire department.

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The FRP must provide a textual annunciator at minimum. A large-format annunciator is recommended to allow for more information and functionality of the system, but is not required. If a graphical annunciator or interactive display option is provided, the equipment must provide a separate distinct smoke detector activation and gas detector activation.

Consideration should be given to the use of interactive firefighter displays for large BESS sites. Interactive systems can be provided for greater control of the fire alarm system by providing the operator ability to disable and activate individual fire alarm components. Further, a site plan can be uploaded and populated with fire alarm points, giving the operator the ability to pinpoint the area of concern.

Where the FRP is located on the exterior, a weatherproof enclosure shall be provided to house the FRP components. The weatherproof enclosure should be equipped with heaters and/or air conditioners to maintain the enclosure within the listed environmental conditions of the FRP components. The enclosure heating and air conditioning system will require a 120/240 VAC power source.

The communication between the FRP and FACP shall be hardwired. The FACP communication and 24 VDC wires shall not share the same conduit with the 120/240 VAC wires.

Where a graphical annunciator or interactive firefighter display is provided for the BESS facility, the fire alarm system design must include review and approval of the site plan graphics intended to be used.

## **Manual Purge System**

Some jurisdictions may require the installation of a manual purge system to ventilate the BESS enclosure. During thermal runaway, highly combustible gasses accumulate inside the units, introducing the risk of an explosion event. The purge system can be used to flush combustible gasses from the enclosure after a thermal runaway event to minimize risk to nearby personnel, emergency responders, and surrounding equipment.

# Fire Suppression Systems

## Water Supply

BESS sites shall be provided with a permanent source of water for fire protection. Where a water supply is required, at least one reliable water supply should be provided. A site fire hydrant connected to an approved public or private water works is the most common method to provide reliable water supply. For remote locations, where agreeable with the ESS owner and approved by the AHJ, fire suppression systems and water supply shall not be required [NFPA 855 §9.5.2.5].

Where no permanent adequate and reliable water supply exists for firefighting purposes, the requirements of NFPA 1142 shall apply [NFPA 855 §4.9.4.2]. NFPA 1142 is not directly applicable for outdoor BESS installations and additional site-specific conditions may need to be factored into the water supply quantity. Where the intent is to provide water supply per NFPA 1142, the final on-site water storage volume must be negotiated with the AHJ during the planning stages, and not solely rely on the prescriptive volume as described below.

The following equation estimates the minimum required water supply based on volume of the BESS unit and hazard/construction classification [NFPA 1142 §4.3.1]:

$$WS_{min} = \frac{VS_{tot}}{OHC} (CC) * 1.5$$

where,

$WS_{min}$  = Minimum water supply in gallons

$VS_{tot}$  = Total volume of structure in  $ft^3$

OHC = Occupancy hazard classification number

CC = Classification of construction

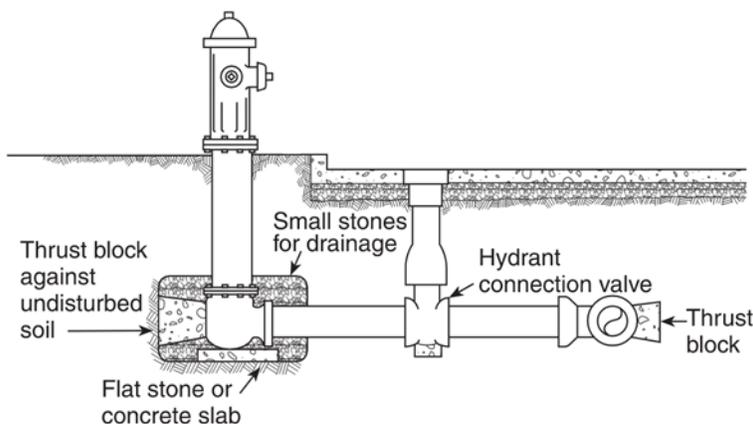
Where required, the minimum NFPA 1142 accepted water supply is 3,000 gallons (11,360 liters) [NFPA 1142 §4.3.2.2]. The most common method to provide the required water supply is using an above ground fire water storage tank. Other water supply arrangements can be provided if acceptable by the AHJ such as pond reservoir or cistern. Where a fire water storage tank is provided, the installation, testing, and maintenance shall be in accordance with NFPA 25.

## Fire Hydrants

The local fire code and/or AHJ should be consulted to determine if there are any modifications to the base IFC requirements. The final private fire hydrant location(s) should be determined through consultation with the AHJ and/or responding fire department.

New fire hydrants are required where a portion of the BESS facility is more than 400 feet (122 m) from a fire hydrant on a fire apparatus access road or if on-site fire hydrants and mains are required by the AHJ [IFC §507.5.1]. New fire hydrants shall be located not less than 40 feet (12.2 m) from the BESS facility to be protected [NFPA 24 §7.2.3].

Fire hydrants installed on private fire service mains shall be installed in accordance with NFPA 24. All new fire hydrants shall be provided with a control valve [NFPA 24 §7.1.1.2].



**Figure 12. Typical Fire Hydrant Installation Detail**

The top of buried piping shall be not less than 1 feet (0.3 m) below the frost line for the locality [NFPA 24 §10.4.2.1.1]. In locations where freezing is not a factor, the depth of cover shall be less than 30 inches (76 cm) below grade [NFPA 24 §10.4.2.2.1]. Piping mains installed under driveways, roadways, or drivable surface shall be buried at minimum depth of 3 feet (0.9 m) [NFPA 24 §10.4.2.2.3]. Where listed piping is used and the bury depth differs from this standard, the listing limitations shall apply [NFPA 24 §10.4.2.2.1].

## Fire Suppression System

Rooms or areas within buildings and walk-in units containing BESS shall be protected by automatic fire suppression system [IFC §1207.5.5 & NFPA 855 §9.6.2.1]. Furthermore, IFC Table

1207.8(c) permits omission of a fire suppression system for walk-in units with approval by the fire code official. Common forms of BESS fire suppression systems are automatic aerosol extinguishing systems and automatic/manual sprinkler systems.

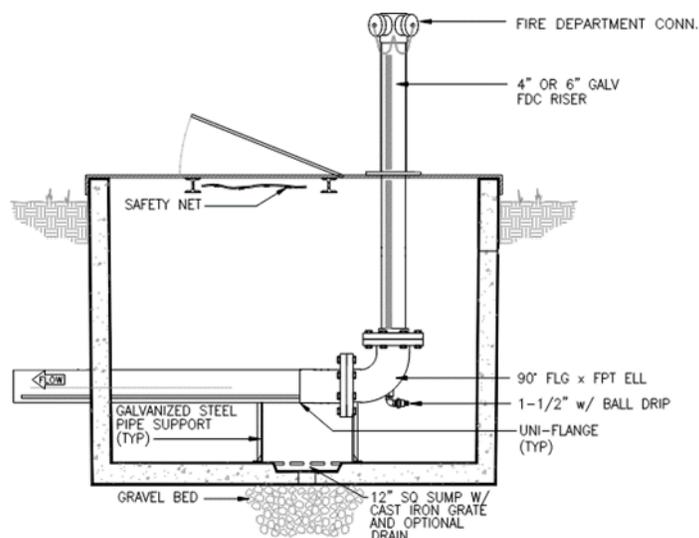
NFPA 855 requires a permanent source of water for fire protection for sites with BESS installation [NFPA 855 §9.6.2.3]. However, when agreeable with the BESS owner and approved by the AHJ, fire suppression systems and water supply shall not be required for outdoor remote installations [NFPA 855 §9.5.2.5].

The water supply to the sprinkler system can be provided in a number of ways, such as:

- Dry fire department connection (FDC)
- Municipal (or fire pump) water supply with post indicator valve (PIV)
- Municipal (or fire pump) water supply with pre-action valve
- Other alternate code compliant sprinkler system arrangements are permitted.

Where a dry FDC is used, the number of connected units served by a single FDC should be limited to avoid introduction of water filled piping to unaffected units. The underground piping shall be installed in accordance with NFPA 24.

A means to drain the sprinkler pipe should be provided. One means to provide drainage is to use an automatic ball drip valve. Consult with the local AHJ for automatic ball drip access. Automatic ball drip valves are commonly buried, but some AHJ will require installation within an accessible pit. A typical FDC ball drip accessible pit installation detail is shown in [Figure 13](#).



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**Figure 13. Dry FDC Ball Drip Inspection Pit**

Where connection to a municipal water supply with an above ground valve is used, the number of units served by a single valve should be limited. The above ground valve should be monitored for normally closed state by the site FACP.

## **Fire Water Containment**

A firewater discharge risk assessment should be considered that includes spatial analysis for sensitive areas, drinking water sources, surface runoff, and local regulations.

Where risk assessment shows sensitive areas within the vicinity and potential impacts from firewater runoff discharges, a fire water containment should be provided to collect firewater discharge. The collected firewater runoff should be treated prior to discharge.

Where risk assessment does not show sensitive areas within the vicinity and a low impact to non-sensitive areas, the fire water containment is not required.

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# Explosion Prevention Systems

BESS explosion control measures complying with NFPA 68 or NFPA 69 are required for BESS units containing lithium-ion technology unless waived by the AHJ based on the results of a UL 9540A large-scale fire test demonstrating that flammable gasses are not liberated from the BESS cells or modules, or where it demonstrates that the BESS does not have the potential to release flammable gas concentrations in excess of 25% LFL anywhere in the room, area, or structure under thermal runaway or other fault conditions [IFC §1207.6.3 & NFPA 855 §9.6.5.6].

## Deflagration Venting

Deflagration venting is commonly achieved using pressure-sensitive panels located at the top of the BESS units. The panels can either be activated via an overpressure event or via smoke or gas detection in the unit.

Where BESS is installed in geographic locations with routine ice and snow, any accumulation should be removed to ensure proper function of the deflagration vents. For these locations, it is recommended to provide a flammable gas ventilation system as the primary explosion protection system.

## Flammable Gas Ventilation System

BESS units can be provided with an NFPA 69 flammable gas ventilation system. The ventilation system is activated upon gas sensor activation. The AHJ or the customer should be consulted if a gas ventilation system will be required.

NFPA 855 (2023 edition) requires 2 hours of mandatory backup power for the ventilation fans. The site level UPS should be sized based on fire protection consultant input and acceptance by the AHJ. The power feeding the UPS should be provided via two independent electrical utility grid connections or via an automatic transfer switch connected to a single electrical utility grid connection and a backup generator.

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# Review And Acceptance Of Fire Protection Systems

For any new site or modification to an existing fire protection system, a full design review and/or acceptance testing should be performed. The design review should be performed by a qualified third-party designee.

The AHJ must be notified with the opportunity to witness the acceptance of fire protection systems. In many cases, the initial acceptance testing may be the only opportunity for the AHJ to see the system operate as required by the approved design documents and Code requirements.

Many AHJs will require that specific procedures be followed when they are requested to attend an acceptance test. This may include a minimum number of days of advance notice, submittal of system documentation, submission of acceptance testing plan, and/or a certificate that the installer has already conducted a complete pretest of the system. Some AHJs will require a system acceptance sign-off by a qualified third-party designee in lieu of AHJ attendance.

## Design Review

A full fire protection design review should be performed for any new site or modification to an existing fire protection system. The design review should be performed by a qualified third-party designee. The design review is intended to verify compliance with the applicable codes.

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At a minimum, the following items should be included in the design review package:

1. Cover Sheet
  - a. Applicable Codes
  - b. Short Description of Work
2. Shop Drawings
3. All Applicable Calculations
  - a. Fire Alarm
    - i. Battery Calculations
    - ii. Voltage Drop Calculations
    - iii. Conduit Fill Calculations
  - b. Fire Suppression System
    - i. Water Supply Graph
    - ii. Fire Hydrant Flow Test
    - iii. System Hydraulic Calculations
4. Manufacturer Cut Sheets

## Acceptance Testing

The procedures and requirements for acceptance testing vary between AHJs. The acceptance testing requirements should be verified with the AHJ at the start of the project. Some AHJs will require they be notified and witness all fire protection system acceptance tests. Other AHJs may allow or permit requests for qualified third-parties to witness acceptance testing.

Prior to the final acceptance testing, the installing contractor should provide a written acknowledgement or certificate that a complete pretest of the system has been conducted and that all deficiencies found during pretest have been corrected.

## Record of Completion

The installing contractor shall furnish a signed Record of Completion for final signoff by the AHJ, AHJ-designated inspector, or qualified third party after the successful completion of the final acceptance test.

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## **Inspection, Testing, And Maintenance**

Inspection, testing, and maintenance (ITM) is critical to continuing proper function of fire protection features provided for the BESS facility. All fire protection features should be inspected, tested, and maintained according to applicable NFPA standards and vendor recommendations. Fire alarm and gas detector ITM should follow recommendations provided in NFPA 72. All water-based fire protection systems should follow recommendations provided in NFPA 25.