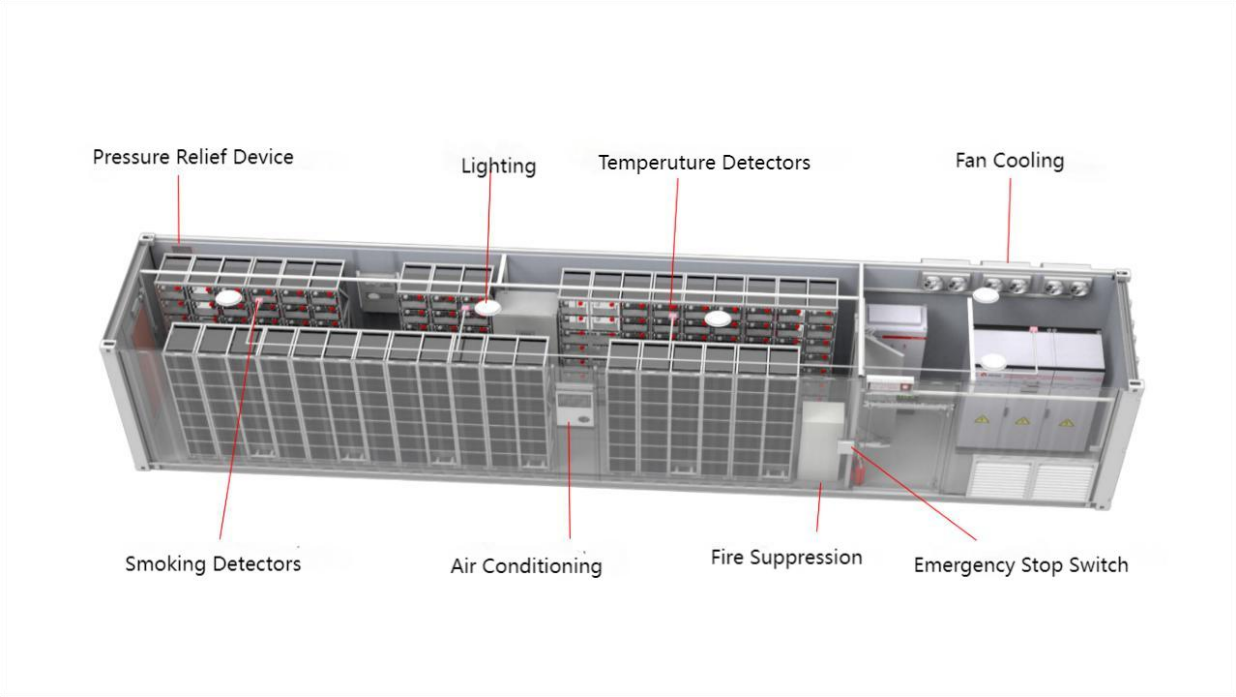
Essentials on Containerized BESS Fire Safety System

Introduction

With the rapid development of global renewable energy and energy storage technologies, Battery Energy Storage Systems (BESS) in containers have been widely applied in areas such as grid peak shaving, microgrids, and industrial-commercial energy storage. However, the risk of thermal runaway in lithium batteries makes fire protection systems a critical safeguard for energy storage safety. This white paper delves into the design principles, key technologies, and industry standards for fire protection systems in energy storage containers.



ATESS Energy Storage Container's Structure

Fire Risks of Energy Storage Containers

Lithium batteries (e.g., $LiFePO_4$, NMC) may experience thermal runaway under conditions such as overcharging, short-circuiting, mechanical damage, or high temperatures, accompanied by the following hazards:

- High-temperature jet flames (electrolyte combustion inside the battery, reaching temperatures above 800°C)

- Combustible gas explosions (e.g., hydrogen, methane)

- Re-ignition risk (even after flames are extinguished, internal heat generation may persist)

Thus, fire protection systems for energy storage containers must possess capabilities for rapid suppression, sustained cooling, and prevention of re-ignition. The design of these systems primarily focuses on three aspects: fire protection system components, fire suppression systems, and integrated control.

1. Fire Protection System Components

A complete fire protection system for energy storage containers typically includes:

- Detection System

- Temperature sensors (monitoring the ambient temperature of the battery compartment)

- Smoke detectors (VESDA very early smoke detection or photoelectric smoke detection)

- Gas detection (monitoring combustible gases such as CO and H_2)

- Thermal runaway early warning (AI analysis of parameters like voltage and temperature)

2. Fire Suppression System

- Total flooding gas suppression (e.g., HFC-227ea, Novec 1230)

- Water spray/fine water mist system (for sustained cooling)

- PACK-level targeted suppression (precision spraying for individual battery modules)

3.Integrated Control

- Automatic power disconnection (cutting off the connection between battery clusters and PCS during a fire)

- Smoke exhaust ventilation (preventing the accumulation of combustible gases)

- Alarm and remote monitoring (uploading data to SCADA or cloud platforms)

Comparison of Mainstream Fire Suppression Agents

Currently, the four primary fire suppression agents are: HFC-227ea, Novec 1230, Water Mist, and Aerosol. Their advantages, disadvantages, and applications are as follows:

HFC-227ea

Novec 1230

Aerosol

Water Mist

Their advantages, disadvantages, and applications are as follows:

Fire Suppression Agent	Advantages	Disadvantages	Applications
HFC-227ea	Clean, non-conductive, no damage to equipment	High greenhouse effect, requires sealed environment	Early-stage fire suppression
Novec 1230	Environmentally friendly, efficient, suitable for localized application	Relatively high cost, suitable for localized application	Early-stage thermal runaway
Water Mist	Continuous cooling, prevents reignition	May cause electrical short-circuits	Post-thermal runaway cooling
Aerosol	Rapid suppression, compact system footprint	Residue may affect equipment	Small-scale energy storage systems

ATESS energy storage containers primarily utilize HFC-227ea (heptafluoropropane) for fire suppression, ensuring optimal fire extinguishing performance while maximizing equipment protection.

Industry Standards and Certifications

Fire protection systems for energy storage must comply with the following international and domestic standards:

- NFPA 855 (National Fire Protection Association Standard for Energy Storage Systems)

- UL 9540A (Thermal Runaway Propagation Test for Energy Storage Systems)

- IEC 62933-5-2 (Safety Requirements for Energy Storage)

- GB 51048-2014 (Chinese Design Code for Electrochemical Energy Storage Power Stations)

Certification bodies (e.g., UL, TÜV, CNAS) conduct tests on thermal runaway, fire suppression efficiency, and system reliability.

Future Trends

- AI Early Warning and Smart Fire Protection

- Leveraging big data analysis to predict thermal runaway risks in advance.

- Multi-level Integrated Fire Suppression

- Collaborative use of gas suppression, fine water mist, and phase change materials (PCM).

- Standardized and Modular Design

Prefabricated fire protection solutions to reduce deployment costs.

Conclusion

Fire protection systems for energy storage containers are critical to ensuring the safe operation of energy storage power stations. As batteries with higher energy densities become more prevalent, fire protection technologies must evolve toward intelligence, precision, and environmental sustainability. Enterprises should adopt fire protection solutions that meet international standards and optimize designs based on specific scenarios to minimize fire risks effectively.

ATESS EnerMatrix containerized energy storage systems are equipped with comprehensive and advanced fire protection, suppression, and integrated control systems, providing a robust safeguard for the safe operation of energy storage power stations. We deeply understand the potential risks of lithium battery thermal runaway, which is why we embed extreme safety into every aspect of our system design from the outset.

As discussed in this white paper, from high-precision smoke and temperature sensors and intelligent thermal runaway early warning to total flooding fire suppression systems utilizing efficient and

clean agents like HFC-227ea, and further to emergency automatic power disconnection, smoke exhaust ventilation, and remote monitoring linkage with cloud platforms, ATESS's solutions achieve industry-leading standards. They strictly comply with multiple international standards such as NFPA 855 and UL 9540A. ATESS not only strives for excellence in technology but also significantly simplifies on-site installation and operation and maintenance through pre-assembly and modular design. This ensures stable system operation under a high protection level (IP54), performing exceptionally even in harsh environments.