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Risk Control Services: Occupancy

Waste & Recycling Facilities

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Standard recommendations based on recognized international standards and good practices are proposed. Moreover, very good NFPA (National Fire Protection Association) and FM Global Property Loss Prevention Data Sheets on these subjects exist. Since there is no need to reinvent the wheel, readers are referred to those references when relevant.

- NFPA free viewing at http://www.nfpa.org/
- FM Global Data Sheets free viewing and download available when registered at http://www.fmglobal.com/

Note that these materials are periodically revised and updated. Please monitor the above websites for updates and/or revisions.

Acknowledgment:

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- Frank Audenaerd, Chief Underwriting Officer Nordic Markets and the Benelux—SCOR Reinsurance Germany for raising this subject and providing loss report.

Technical documents:

- NFPA 13 Standard for the Installation of Sprinkler Systems
- NFPA 82 Standard on Incinerators and Waste and Linen Handling Systems and Equipment, 2019 Edition
- NFPA 850 Recommended Practice for Fire Protection for Electric Generating Plants and High Voltage Direct Current Converter Stations
- NFPA 855 Standard for the Installation of Stationary Energy Storage Systems
- FM Global Data Sheet 6-13 Waste Fuel-Fired Facilities
- FM Global Data Sheet 8-22 Storage of Baled Waste Paper
- Fire Rover https://firerover.com/
- Batteries News https://batteriesnews.com/
- SCOR Handbook "Stationary Batteries Energy Storage Systems" (ESS/BESS)

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This document is about waste and recycling facilities. SCOR Risk Control (non-energy property) has been providing technical support to our UW teams (both Reinsurance and Specialty Risks) about these risks for years now, but in the last few months, demand has been increasing. This short memo intends to give some basic, quick-reference guidance to Risk Engineers and Underwriters for risks in this class of occupancy, in terms of facility type, issues, layout, good practice and manual and fixed firefighting requirements.

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1. Types of waste and recycling facilities

These facilities include but are not limited to:

- Those that collect MSW (municipal solid waste) consisting of commonly occurring residential and light commercial waste.

- Those that process waste streams (i.e., MSW) as a fuel source and that burn those and other waste fuels in boilers. The term “incinerator” is primarily used in Europe as equivalent to the term “boiler” in the US.

- Recycling facilities including paper and plastic facilities; scrap metal facilities; construction and demolition (C&D) facilities, and hazardous waste operations such as industrial Hazmat and Lithium-Ion Batteries (LIBs).

2. Issues relating to waste and recycling facilities

Together with environmental considerations, more stress is being placed on waste and recycling infrastructure. There are almost 6,000 materials recovery facilities (MRFs) and transfer stations in the US alone.

Waste and recycling facilities are well known for regular fires and total losses. The fire issue is growing in size and scope every year. This relates to the growing number and larger size of waste and recycling facilities. Moreover, more hazardous waste is being handled (e.g., LIBs).

The final numbers are in, and 2022 officially surpassed all prior years in regard to waste and recycling facility fires. There were 390 unique fire incidents reported at waste and recycling facilities in the US and Canada. In December, 22 fire incidents in the US and Canada were publicly reported. Thirteen fire incidents occurred at waste, paper and plastic facilities; five occurred at scrap metal facilities; two occurred at a construction and demolition (C&D) facility, one at a hazmat operation and one at a rubber facility.

There is a clear need for greater awareness among waste and recycling facility operators about the inherent risk of fires in their operations, operational best practices, appropriate facility layouts for dividing the risk into different fire areas, investment in technology to safely operate within the constraints of their issues and the provision of a high level of automatic fixed fire protection.

LIB contamination in standard waste increases the industry’s fire risk. Educating the public about proper recycling is therefore key.

3. Note on fire protection requirement

3.1 Passive Fire Protection

Passive fire protection: buildings should be made of non-combustible construction materials (avoid highly combustible insulation such as PUR, PIR, EPS).

3.2 Fixed fire protection

- The US-based National Fire Protection Association (NFPA) provides Occupancy (process areas) and Commodity (storage areas) classifications (mostly established in the 1980s) that are intended to represent the norm for those occupancies/commodity types.
- These should be weighed with unusual or abnormal fuel loadings or combustible characteristics and susceptibility. For example, LIBs are considered as hazardous waste due to their chemical composition, which leads to thermal runaway hazards.
- The reliability of the automatic fixed fire protection system (and therefore its testing and maintenance program) is key.

4. Loss estimate considerations

- The layout of such facilities is basically of the single block type, resulting in one fire area.
- There is basically no fire separation (1-hour fire partitions in the best-case scenario), high combustible load and high continuity of combustible material.
- This results in 100% losses in most cases (worst-case scenario: all fixed fire protection systems are considered impaired and emergency response is not available).

5. Municipal solid waste and incinerator/boiler

This section addresses fire and explosion hazards that are unique to the use of MSW processing facilities, including those arising from using MSW as an incinerator/boiler fuel by means of a process that includes the hauling of MSW directly to a tipping floor or storage pit and burning without any special processing.

5.1 Waste fuel handling areas

- Ensure minimum 1-hour fire-resistive construction for all fuel storage and handling areas. This could include tipping halls (waste off-loading areas), bunker buildings and fuel transfer buildings, as well as separate buildings for fuel processing such as shredder, sorting and separation buildings.
- Between fuel storage and handling buildings and the facility's other areas, provide FM Approved fire doors with the same or greater fire rating as the walls in which they are installed.
- Locate fuel shredders in a separate building away from fuel storage and other combustibles.
- Provide dust collection systems on any dust-producing equipment such as hammer mills, flail mills or shredders associated with processing RDF (refuse derived fuel).
- Construct the fuel bunker control and crane operator rooms and windows with minimum one-hour fire-rated construction.

5.2 Fire protection requirement

- The tipping/receiving building should be provided with:
  - Automatic sprinkler protection throughout. Systems should be designed for a minimum of 10.2 mm/min/m² (0.25 gpm/ft²) over the most remote 280 m² (3,000 ft²) (increase by 30% for dry pipe systems) of the floor area, with the protection area per sprinkler not to exceed 12 m² (130 ft²). High-temperature sprinklers [121 °C to 149 °C (250 °F to 300 °F)] should be used. Minimum fire water supply duration: 120 min.
  - If the tipping/receiving floor is to be used as the charging storage area, additional protection should be provided, consisting of monitor nozzle protection designed to furnish a minimum of 946 L/min (250 gpm) at 689 kPa (100 psi) at the tip. Monitors should be located so as to allow for coverage of all pit areas with at least two streams operating simultaneously. Due to frequency of use and potential for operator fire exposure, oscillating monitor nozzles with manual override should be provided.

- The MSW storage pit, charging floor, and grapple laydown areas should be provided with:
  - Automatic sprinkler protection throughout the refuse enclosure to protect the entire roof area against structural damage. Systems should be designed for a minimum of 8.1 mm/min/m² (0.20 gpm/ft²) over the most remote 280 m²

(3,000 ft²) (increase by 30% for dry pipe systems) of the pit/floor area, with the protection area per sprinkler not to exceed 9.3 m² (100 ft²). High-temperature sprinklers [121 °C to 149 °C (250 °F to 300 °F)] should be used. Exposed steel column protection, where provided, should be designed in accordance with NFPA15 and may be connected to the overhead sprinkler system. Minimum fire water supply duration: 120 min.

- Due to the distance between the bottom of the refuse pit and the sprinkler system, manual hoses and monitor nozzles should be considered as the primary means of fighting an MSW storage pit fire.
- In addition to sprinkler protection, the storage pit should be provided with monitor nozzle protection designed to discharge a minimum of 946 L/min (250 gpm) at 689 kPa (100 psi) at the tip. Monitors should be located so as to allow for coverage of all pit areas with at least two streams operating simultaneously.
- Due to frequency of use and potential for operator fire exposure, oscillating monitor nozzles with manual override should be provided.
- The window separating the operator from the pit should be fire rated or a water curtain should be provided. Water curtains are used as a thermal screen to mitigate the radiant heat effect. They are typically installed as part of a deluge system to protect structures from heat radiation. The water spray will both reflect and absorb the heat radiation thus reducing the resultant level of heat reaching the protected surface. The purpose is not to control the fire, but to limit the fire spread from a burning area to another area. Sprinklers in a water curtain should be hydraulically designed to provide a minimum discharge of 37 L/min (10 gallons/min) per linear meter of water curtain, with no sprinkler head discharging less than 57 L/min (15 gallons/min) (minimum operating pressure of 0.5 bar (7 psi) for K80 (K5.6) sprinkler heads). For protection of windows or similar openings, sprinkler heads should be positioned within 5 cm (2 in.) of the top of the window and 30 cm (12 in.) from the window surface. For windows up to 1.5 m (5 ft) wide, only one sprinkler head is required to protect the openings. For windows from 1.5 m (5 ft) to 3.7 m (12 ft) wide, two sprinkler heads are required. FM-approved window-style sprinklers can be sourced from a number of suppliers and should be installed in accordance with their listing. The proper use of this protection system can achieve up to a 2-hour fire-resistance rating. Sprinkler heads can be Pendent Vertical Sidewall (VSW) and Horizontal Sidewall (HSW) sprinklers.

- Automatic sprinklers must be installed in:
  - Locations or rooms where waste handling systems and equipment are used for interim storage of waste only.
  - Rooms where waste handling systems and equipment are used to transport waste from interim storage areas to waste processing equipment such as incinerators.
- **Rubber belt conveyors should be protected with automatic sprinkler systems in accordance with NFPA The belt should be interlocked to the sprinkler system in order to stop automatically in case of fire. Manually activated systems are deemed less reliable than automatically activated fixed fire protection systems.**
- Waste compactors: all chute-fed compactors must have an automatic sprinkler with a minimum 13 mm (1⁄2 in.) orifice installed in the hopper of the compactor.

6. Cardboard/paper waste recycling facilities

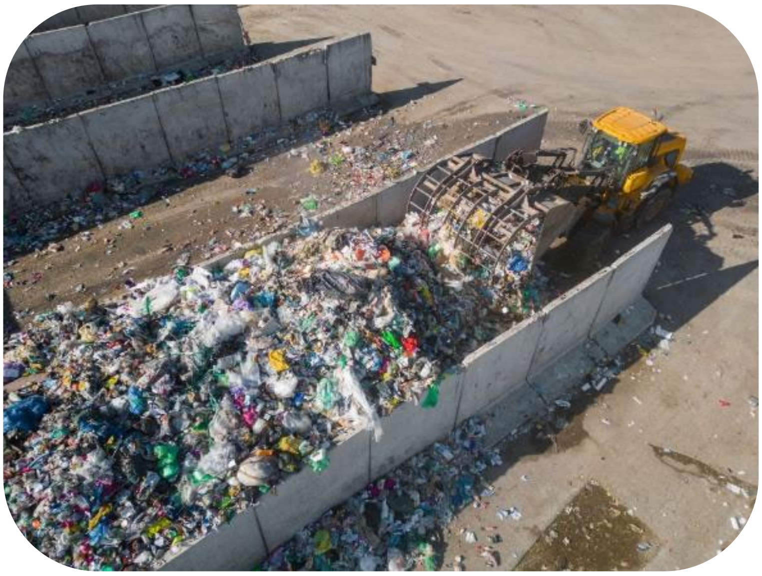
Fires in baled waste paper are of a burrowing nature and are difficult to extinguish. Firefighting efforts may require smoldering bales to be removed from the building to facilitate complete extinguishment. The removal may be difficult if the piles have become saturated with water from sprinklers and hoses. Waterlogged bales will fall apart if material-handling equipment such as a forklift is used. In addition, they produce smoke that complicates manual firefighting. General safeguards for storage should be applied, such as housekeeping, aisle spacing and human element considerations. Possible ignition sources could be from cutting and welding (hot work), spontaneous ignition, smoking or sparks from incinerators and other sources.

6.1 Indoor storage

Indoor storage should be protected as per FM Global Data sheet 8-22 Storage of Baled Waste Paper based on maximum storage height, maximum building or ceiling height or NFPA13 class III when no plasticized or waxed material is present. Provide 2,700 L/min (750 gpm) for hose demand and duration of 4 hours.

6.2 Outdoor storage

Outdoor storage provide at least 15 m (50 ft) clearance between outdoor storage and any buildings (25 m is best when the building is made of non-combustible material and 40 m in the case of combustible construction material). Limit pile size for outside storage to 750 tons and space piles a minimum of 15 m (50 ft) apart. Aisle separation is needed to provide access for firefighting. Pile height should be limited to a maximum of 6.1 m (20 ft). Hydrant and monitor nozzle protection should be located so as to allow for coverage of all storage areas with at least two streams operating simultaneously. Due to frequency of use and potential for operator fire exposure, oscillating monitor nozzles with manual override should be provided. Water supplies should be capable of supplying 5,700 L/min (1,500 gpm) for 5 hours.



6.3 Process area

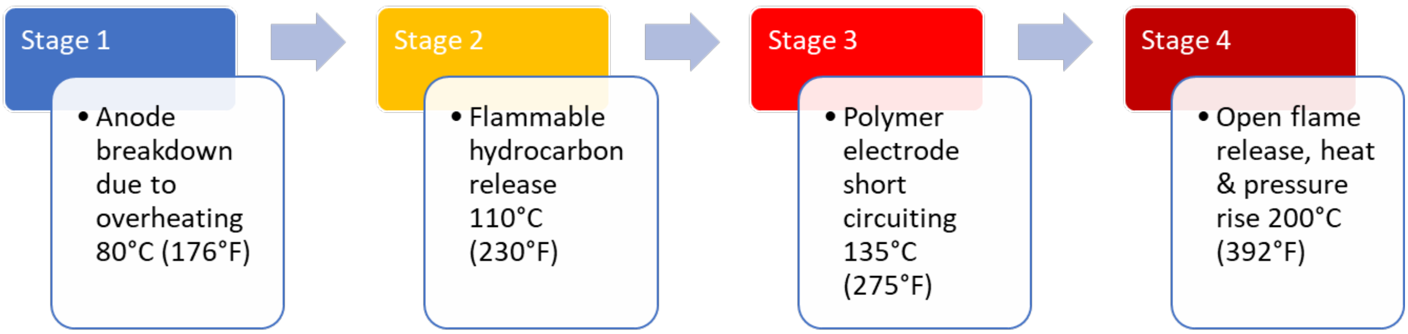
Process area provide sprinkler protection designed for Ordinary Hazard group 2 (OH2) as per NFPA13: 6.9 mm/min/m² (0.17 gpm/ft²) over 280 m² (3,000 ft²), hose allowance 950 L/min (250 gpm), duration 90 min.

6.4 Rubber belt conveyors

Rubber belt conveyors should be protected with automatic sprinkler system in accordance with NFPA. The belt should be interlocked to the sprinkler system in order to stop automatically in case of fire. Manually activated systems are deemed less reliable than automatically activated fixed fire protection systems.

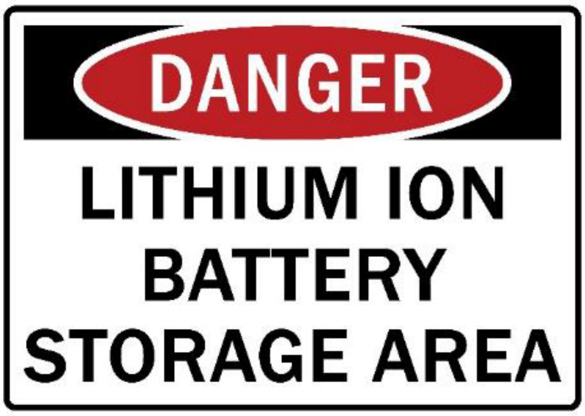
7. Lithium-Ion Battery (LIB) recycling facilities

- Most research and discussion around the dangers of LIBs have focused on large energy storage operations.
- Unlike in large storage operations, recycling facilities cause the batteries to explode by the way they are treated. The process uses compaction, shredding, heavy equipment and exposure to elements, which can cause batteries to become damaged.
- Note that these batteries are designated hazardous waste in the US and so are handled at these facilities according to the applicable Regulations and in compliance with the relevant Permits. For example, the US "Spoke Feedstock Permitting" document should be established at each facility, with enhanced rules and procedures regarding breached or leaking batteries.
- Lithium batteries are capable of spontaneous ignition and subsequent explosion from overheating. This may be caused by electrical shorting, rapid discharge, overcharging, manufacturer defect, poor design or mechanical damage, among other causes. Overheating results in a process called thermal runaway, which is a reaction within the battery causing internal temperature and pressure to rise at a quicker rate than can be dissipated. The thermal runaway process comprises four stages as shown below:



LIB recycling facilities may include:

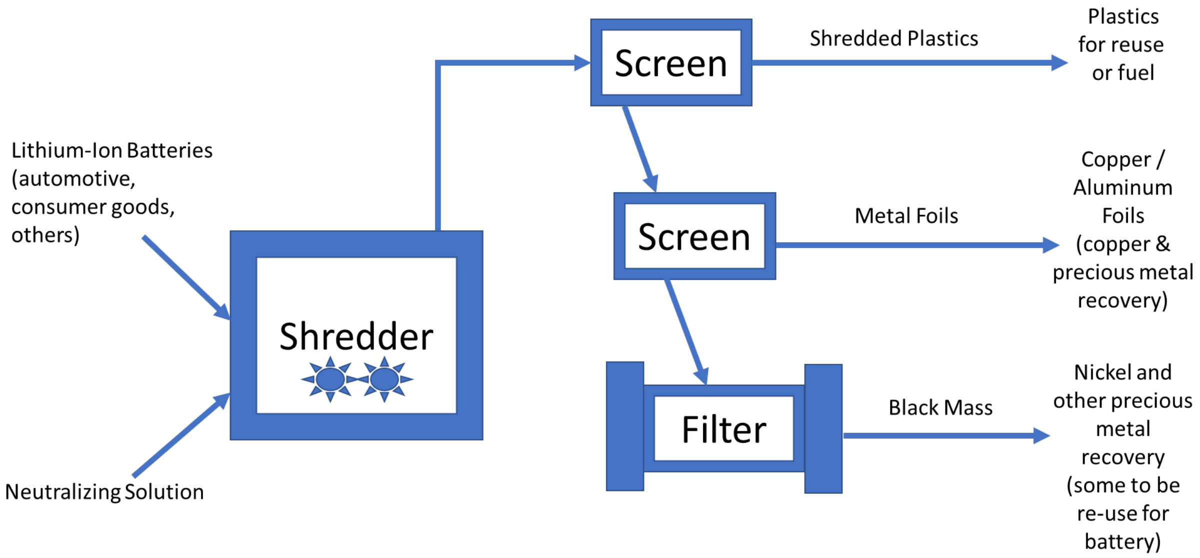
7.1 Warehouses where waste LIBs are stored



7.2 LIB recycling facilities that process spent, out of specification and/or waste LIBs…

… in all formats and power systems, along with anode and cathodes including electric vehicle batteries from original equipment manufacturers (OEMs) and battery companies and scrap that contains lithium. These facilities are occupied for battery disassembly and mechanical shredding operations completed in a 99% water solution that is modified by the addition of acid or base as the battery electrolyte drops out of the battery while the battery is being reduced. This water-based neutralizing solution in a tank basically de-risks hazards arising from the shredding process. Mechanical shredding consists of breaking the batteries into inert materials, which are then separated into three product lines:

- Plastics (part of wet black mass): the plastic and “foil”, along with lighter weight commodity metals like steel, aluminum, copper and stainless steel, float to the top and are pumped to common screens that remove the material from the water stream.
- Copper/aluminum foils (part of wet black mass): sold to brokers and large metals processing companies.
- Black mass composition: heavier metals unique to lithium-ion battery manufacturing like nickel, cobalt, manganese and lithium, plus the conductive nonmetal graphite, together are called black mass. The black mass remains in the solution and reaches the filter presses. Black mass is considered inert and non-combustible, even with the lithium content. The “black mass” is not processed further and is currently sold with some of the finished goods formerly stored back at the warehouse.



- A general breakdown of the commodities is 40% plastic maximum, with the black mass at a maximum of 55%. Approximately 10-15% of that black mass is normally lithium.
  - Solvent recovery plants separate the major commodities in the “black mass” stream. This commodity separation results in a much more desirable product.
- Specific and defined conditions for the storage of batteries:
  - cool and dry areas.
  - measures to limit the effects of battery to battery (internal) fire propagation: suppliers should incorporate protective measures when packaging batteries. These include taping electrical leads to the batteries and individually packaging each battery to prevent contact between batteries while in storage (in the US, requirements are determined by Department of Transportation (DOT) and Transportation of Dangerous Goods (TDG) regulations).
  - storage in containers to prevent damage to batteries.
  - measures to reduce the impact of container-to-container propagation in storage areas (external fire propagation from containers in adjacent pallets or storage racks): provide sufficient spacing between pallets and sufficient aisle spacing allowing emergency response access.
  - storage of small-format batteries in nonflammable containers, palletized for ease of transportation.
  - **storage height (low rack pile) should be limited to 3.7 m (12 ft) in height (i.e. “miscellaneous storage” or “low pile” as per NFPA).**
  - storage a reasonable distance away from combustible materials (at least 15 m (50 ft)),
  - the infeed of damaged packaging or leaking batteries (“damaged, defective and recall” stock) should not be permitted at the warehouse and should be trucked directly to the LIB recycling facility. This “irregular” infeed material must be processed within 24 hours of receipt by permit (in reality it is usually processed immediately). All other waste battery stock has to be processed within 72 hours. Alternatively, damaged/critical batteries should be stored in a separate, designated area. Enhanced rules and procedures regarding breached or leaking batteries should be established (e.g., Feedstock Permitting document),
  - no external heat sources should be present in the vicinity of the batteries (at least 15 m (50 ft)).

7.3 Monitoring requirement

- Monitored CCTV cameras should be used in storage areas (indoor).
- There should be daily checks on batteries in packaging with non-contact thermometers (always available at the facility) for early detection of thermal events. Note that infrared cameras in the warehouse can be instrumental in discovering hot loads prior to fire spreading in the building.

7.4 Fixed fire protection

7.4.1 Storage areas

Consider LIBs as Exposed Non-Expanded Plastic, storage limited to 3.7 m (12 ft) in height based on NFPA table 4.3.1.7.1 (solid-piled, palletized, shelves, racks) as a minimum requirement, weighed with unusual or abnormal fuel loadings or combustible characteristics and susceptibility as follows:

Maximum storage height	**Maximum ceiling height**	**NFPA classification**	**Design density**	**Hose allowance**	**Fire water supply duration (**)**
1.5 m (5 ft)	-	EH1(*)	12.2 mm/min/m^2 (0.3 gpm/ft^2) over 280 m^2 (3,000 ft^2)	1,900 L/min (500 gpm)	120 min
3 m (10 ft)	6.1 m (20 ft)	EH2	15.5 mm/min/m^2 ^{2} (0.38 gpm/ft^2) over 280 m^2 (3,000 ft^2)		
3.7 m (12 ft)	5.2 m (20 ft)				

(*) As per NFPA design requirement, this corresponds to OH2 6.9 L/m^2 (0.17 gpm/ft^2) over 280 m^2 (3,000 ft^2), Hose Allowance 950 L/min (250 gpm), duration 90 min. This design may not be adequate for controlling a fire involving LIBs.

(**) Prefer unlimited fire water supply when possible (e.g., strong city water grid in the US).

7.4.2 Processing areas

We recommend considering Extra Hazard group 1 (EH1) occupancy class (same design as for Energy Storage System - ESS/BESS) with a designed density of 12.2 mm/min/m² (0.3 gpm/ft²) over the entire area of the room or 232 m² (2,500 ft²), whichever is smaller. **Hose Allowance 1,900 L/min (500 gpm). Minimum fire water supply duration: 120 min. Prefer unlimited fire water supply when possible (e.g., strong city water grid in the US).** This density has been extrapolated from existing research, testing and understanding of suppression system performances for this hazard. Note that lithium-ion battery ESSs are becoming more and more popular, but there are additional specific hazards involved. To date, there is no publicly available test data that confirms the effectiveness of any active fire protection for Energy Storage Systems (ESS) involving lithium-ion batteries. One of the major concerns in extinguishing a lithium-ion battery ESS fire is cooling the energy storage system down below the autoignition temperature of the flammable gases the ESS may discharge in a thermal runaway event. However, automatic sprinkler protection is recommended to limit fire spread to the surrounding structures, equipment and building contents. Sprinkler systems are the recommended protection system for Energy Storage Systems (ESS). Alternate fire suppression methods are permitted if testing shows they are effective, but there is little available information or test data on ESS fire control with such systems.

Recycling facilities are usually considered as Ordinary Hazard Group 2 as per NFPA (required density: 6.9 mm/min/m² (0.17 gpm/ft²) over 280 m² (3,000 ft²)). This design may not be adequate for controlling a fire involving LIBs as shown in the following fire event: the building housing had a fire suppression system, it was only designed to control a small fire that could lead to thermal runaway, not batteries that were already in thermal runaway. So even though the fire suppression system discharged, the batteries continued to overheat with no flames. This eventually led to a buildup of flammable gases, which came into contact with a heat source or spark and then exploded when the firefighters opened the door to enter the building.

Rubber belt conveyors should be protected with automatic sprinkler system in accordance with NFPA. The belt should be interlocked to the sprinkler system in order to stop automatically in case of fire. Manually activated systems are deemed less reliable than automatically activated fixed fire protection systems.

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