



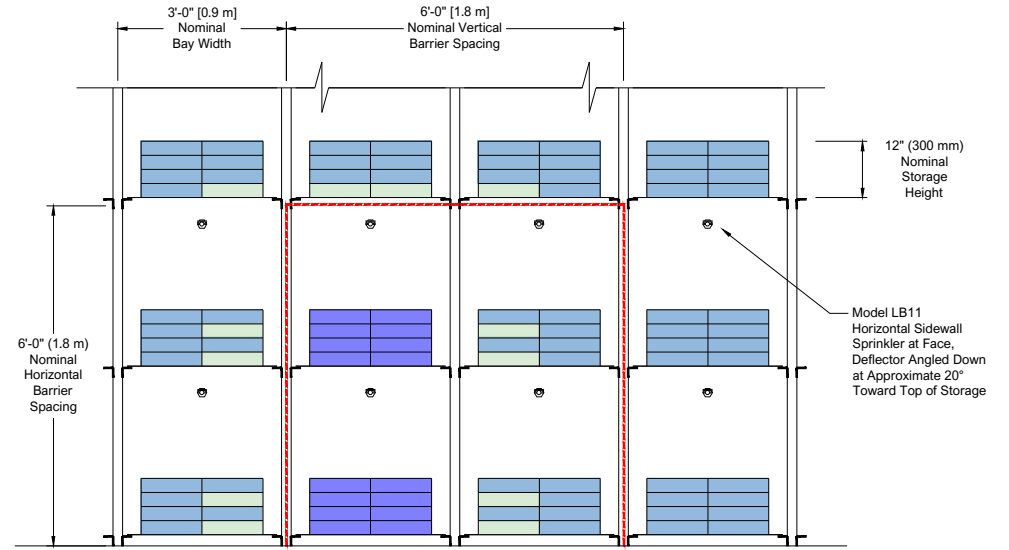
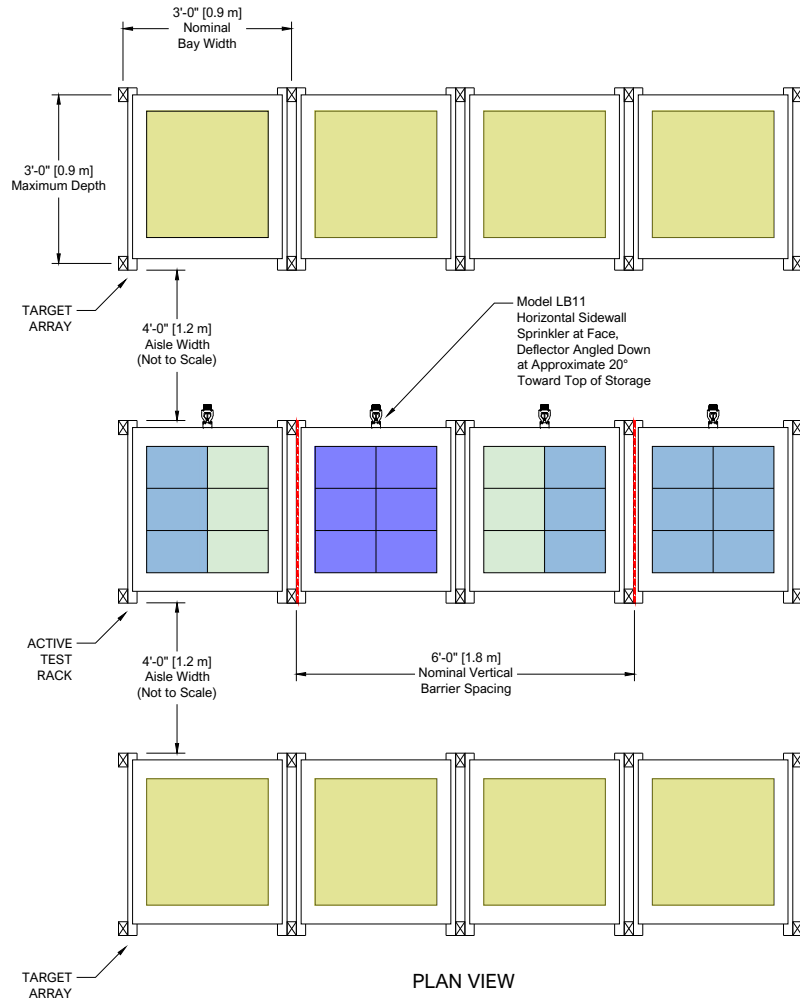
Model LB11 Lithium-ion Battery Large-Scale Fire Test

Overview

The Model LB11 sprinkler was developed for protection of lithium-ion batteries in battery manufacturing facilities; specifically in formation, aging, and shipping/staging racks. There is currently no standard test commodity for lithium-ion batteries. Thus, standard exposed expanded Group A plastic commodity was used in listing tests. Further testing of the Model LB11 HSW sprinkler, beyond the listing, was conducted with lithium-ion batteries as described in this document. Please contact Reliable Technical Services at 1-800-55-RASCO or techserv@reliablesprinkler.com for additional information.

Table A

LB11 Lithium-ion Battery Large Scale Test Parameters	
Storage Type	Single Row Racks
Cell Configuration	18650
Cell Quantity	8000
Cell State of Charge	100%
Cell Cathode Chemistry	Nickel Cobalt Aluminum (NCA)
Cell Capacity	3500 mAh
Storage Configuration	Non-reinforced Polypropylene Formation Trays (160 cells per tray); 24 trays per storage level.
Barriers Within the Rack	Vertical and Horizontal Barriers Spaced 6 ft apart; 2 in. (50 mm) gaps at rack uprights
Aisle Width	4 ft (1.2 m)
Ceiling Sprinklers	None
In Rack Sprinkler System	
Sprinkler Type	Reliable Model LB11 HSW sprinkler, SIN R505
Sprinkler Locations	LB11 HSW sprinklers installed in-rack at a face, adjacent to each commodity load as shown in Figure 1
Temperature Rating	212°F (100°C)
Sprinkler Response Type	QR (link)
Nominal Discharge Coefficient K	K11.2 gpm/psi ^{1/2} (K160 L/min/bar ^{1/2})
Nominal Discharge Pressure	28.7 psi (2 bar)
Nominal Water Flow Rate per Sprinkler	60 gpm (227 L/min)
Test Results	
Length of Test	34 minutes
Fire Travel to Extremities of Test Array	No
Ignition of Target Commodity	No
Ignition of Adjacent Cells or Trays	No
First Sprinkler Operation Time	2:12
Last Sprinkler Operation Time	2:20
Number of Sprinklers Operated	2



ELEVATION (ACTIVE TEST RACK)

BATTERY LOADING LEGEND

- Full Tray (160 Cells)
- (8) Cell Tray
- Empty Tray
- Cartoned Unexpanded Plastic Commodity
- Horizontal or Vertical Barrier

Supplemental Information - Lithium-Ion Battery Test

Large scale fire testing has been conducted with lithium-ion batteries as described below and shown on this page.

1. Cell Configuration: Cylindrical 18650
2. Cell Quantity: 8,000
3. Cell Cathode Chemistry: Nickel Cobalt Aluminum (NCA)
4. Cell State of charge: 100%
5. Cell Capacity: 3,500 mAh
6. Storage Configuration: Non-reinforced Polypropylene Formation Trays (160 cells per tray)
7. Test Observations and Results: Two (2) LB11 Sprinklers Activated within the barrier area following the initiation of thermal runaway cell-to-cell propagation. The cell-to-cell thermal runaway propagation was arrested. No damage to the target trays or target racks.

NOTE: Use of the Model LB11 for the protection of Lithium-ion batteries is currently not included in the cULus Listing of the product. Contact Reliable for additional information about Lithium-ion battery testing.

Test Setup



Figure 2

Thermal Runaway Propagation



Figure 3

Suppression

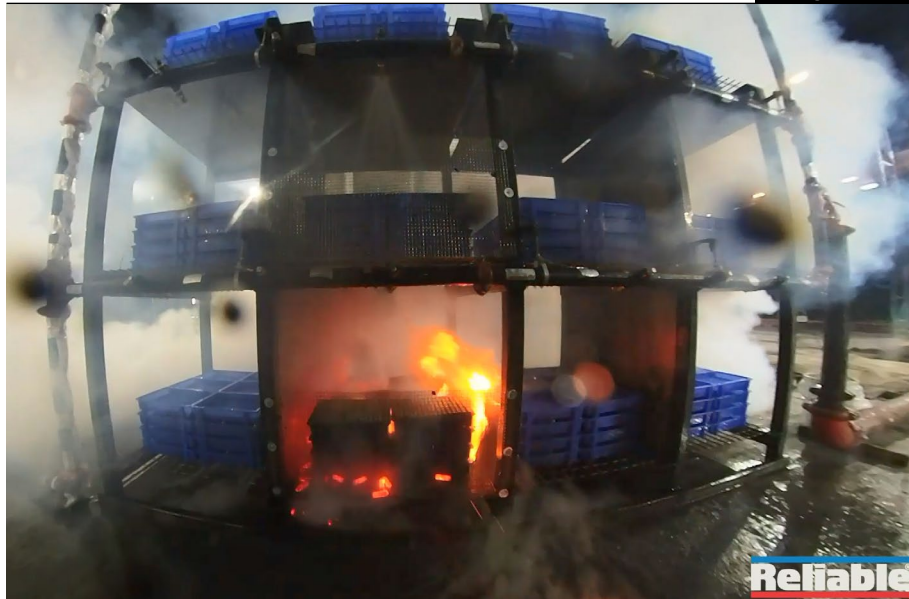


Figure 4

Extinguishment



Figure 5