



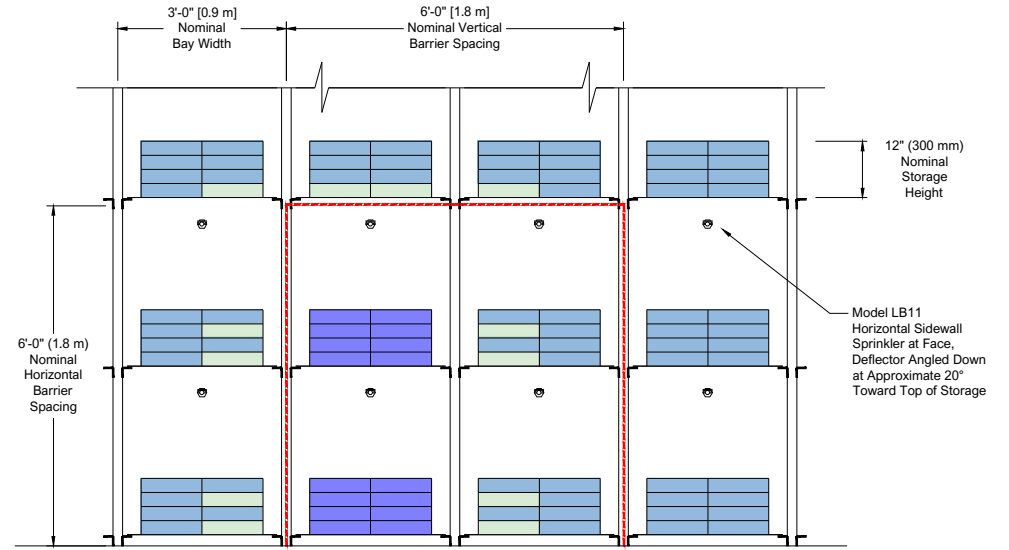
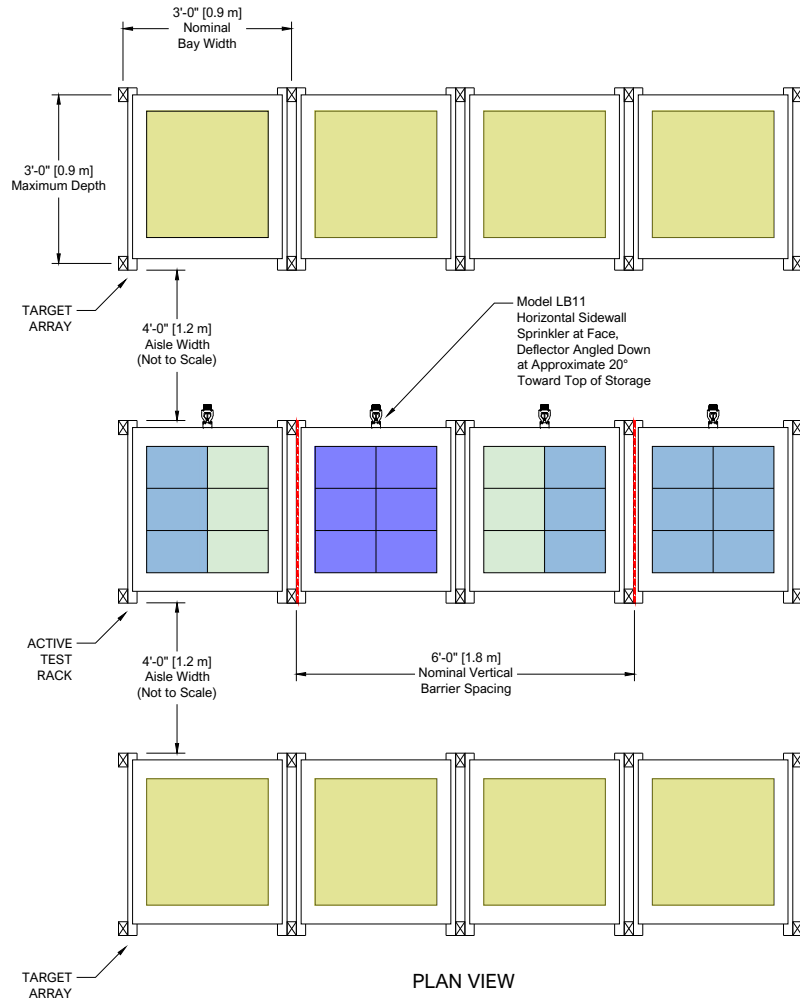
## Model LB11 Lithium-ion Battery Large-Scale Fire Test

### 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**

<b>LB11 Lithium-ion Battery Large Scale Test Parameters</b>	
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
<b>In Rack Sprinkler System</b>	
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 <sup>1/2</sup> (K160 L/min/bar <sup>1/2</sup> )
Nominal Discharge Pressure	28.7 psi (2 bar)
Nominal Water Flow Rate per Sprinkler	60 gpm (227 L/min)
<b>Test Results</b>	
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



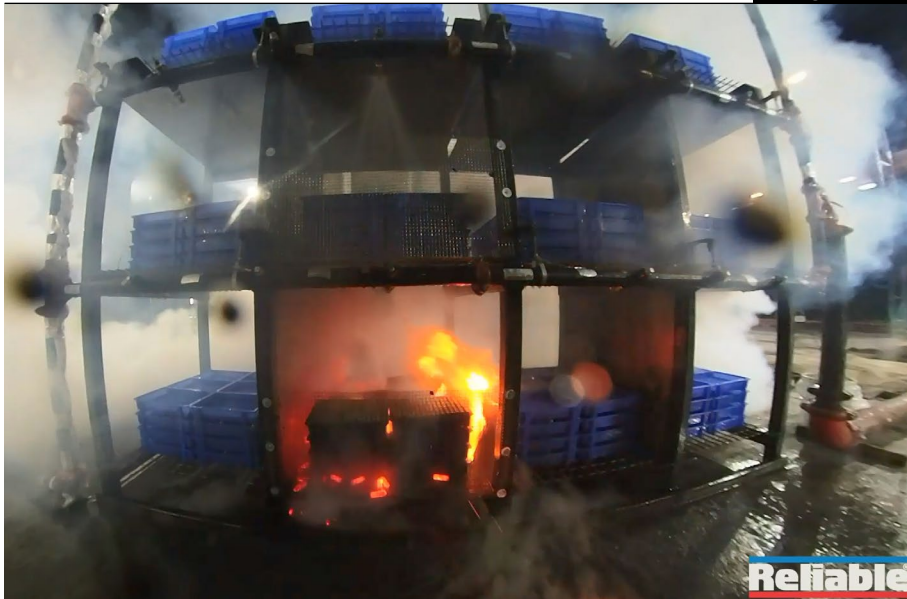
Thermal Runaway Propagation

Figure 3



Suppression

Figure 4



Extinguishment

Figure 5

