



expo**fuego**

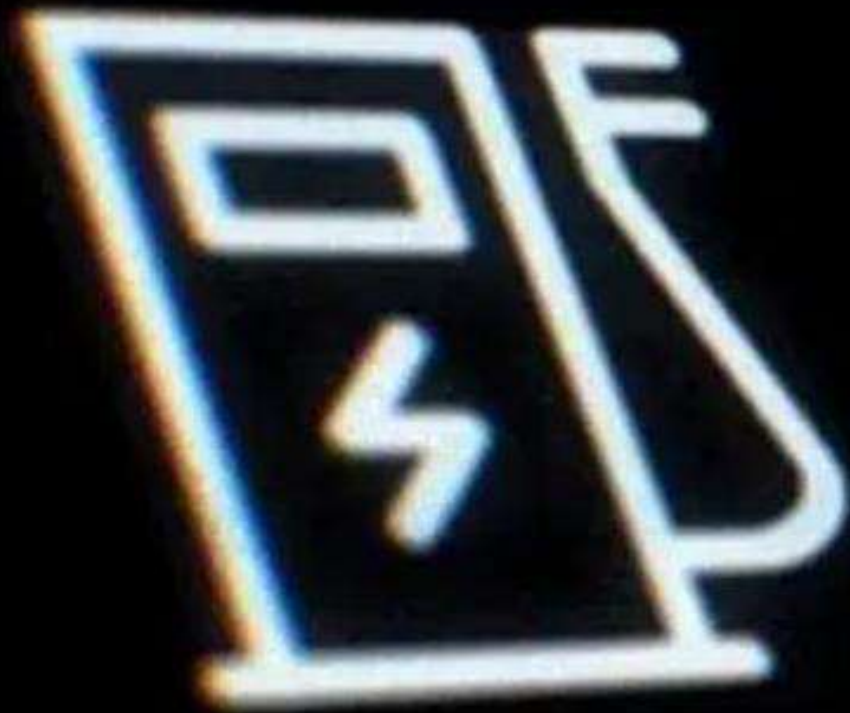
CHILE 2023

CONGRESO INTERNACIONAL
DE PROTECCIÓN CONTRA INCENDIO



Protección Contra Incendio de Baterías de Litio con base a FM Global Data Sheets

David Morales



95%

Charge plug is connected

Li-ion Battery



$10^{-3} - 10^{-1}$ (m)
~100 kJ



$10^{-1} - 10^0$ (m)
~ 10 MJ



$10^0 - 10^1$ (m)
~10 GJ



$10^0 - 10^2$ (m)

Battery ESS: Hazard Evaluation



$10^{-3} - 10^{-1}$ (m)
~100 kJ



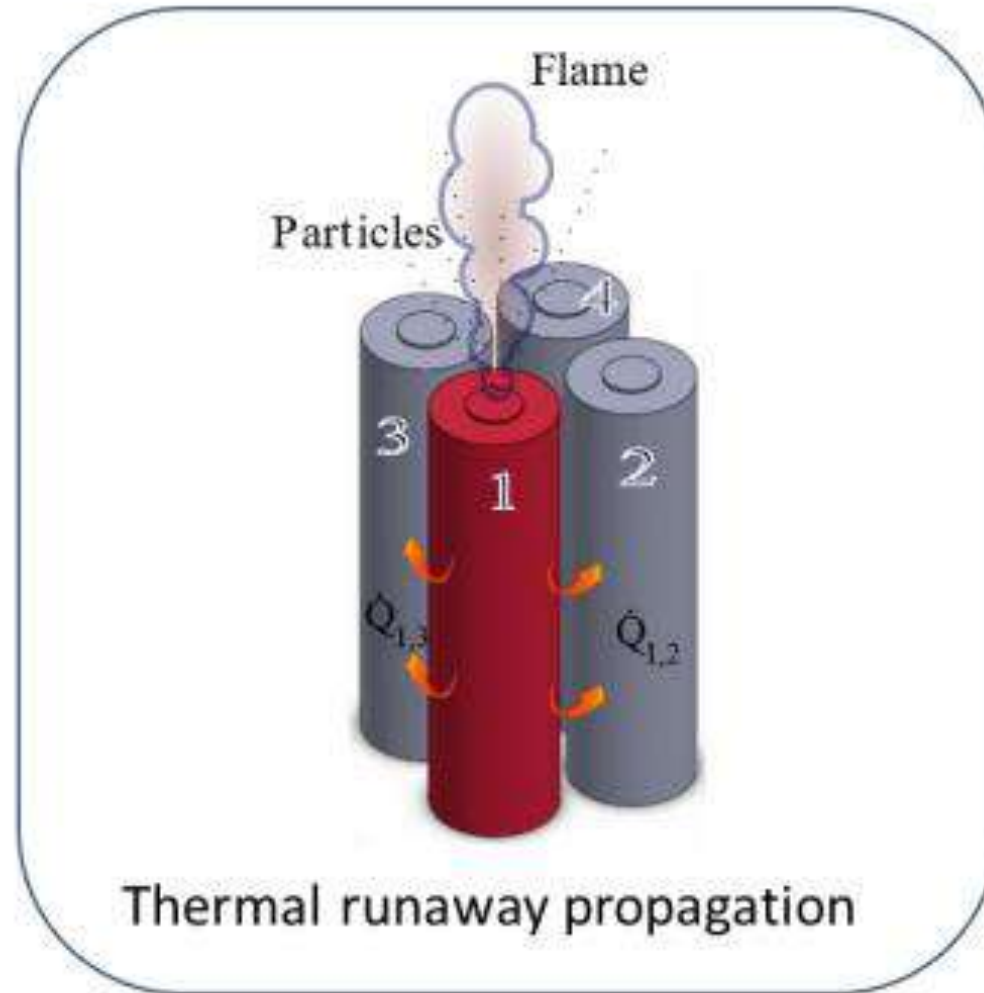
$10^{-1} - 10^0$ (m)
~ 10 MJ



$10^0 - 10^1$ (m)
~10 GJ

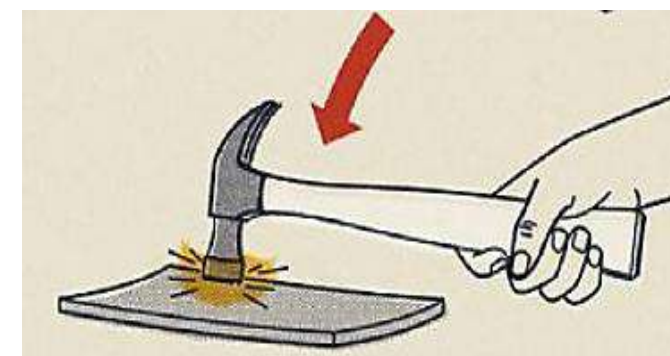


$10^0 - 10^2$ (m)



Fuga Térmica (Runaway) o incendio en celdas de iones de litio.

- **Eléctrico:**
Inapropiada carga o descarga
- **Termal:**
Exposición a altas temperaturas
- **Mecánico:**
Impacto físico

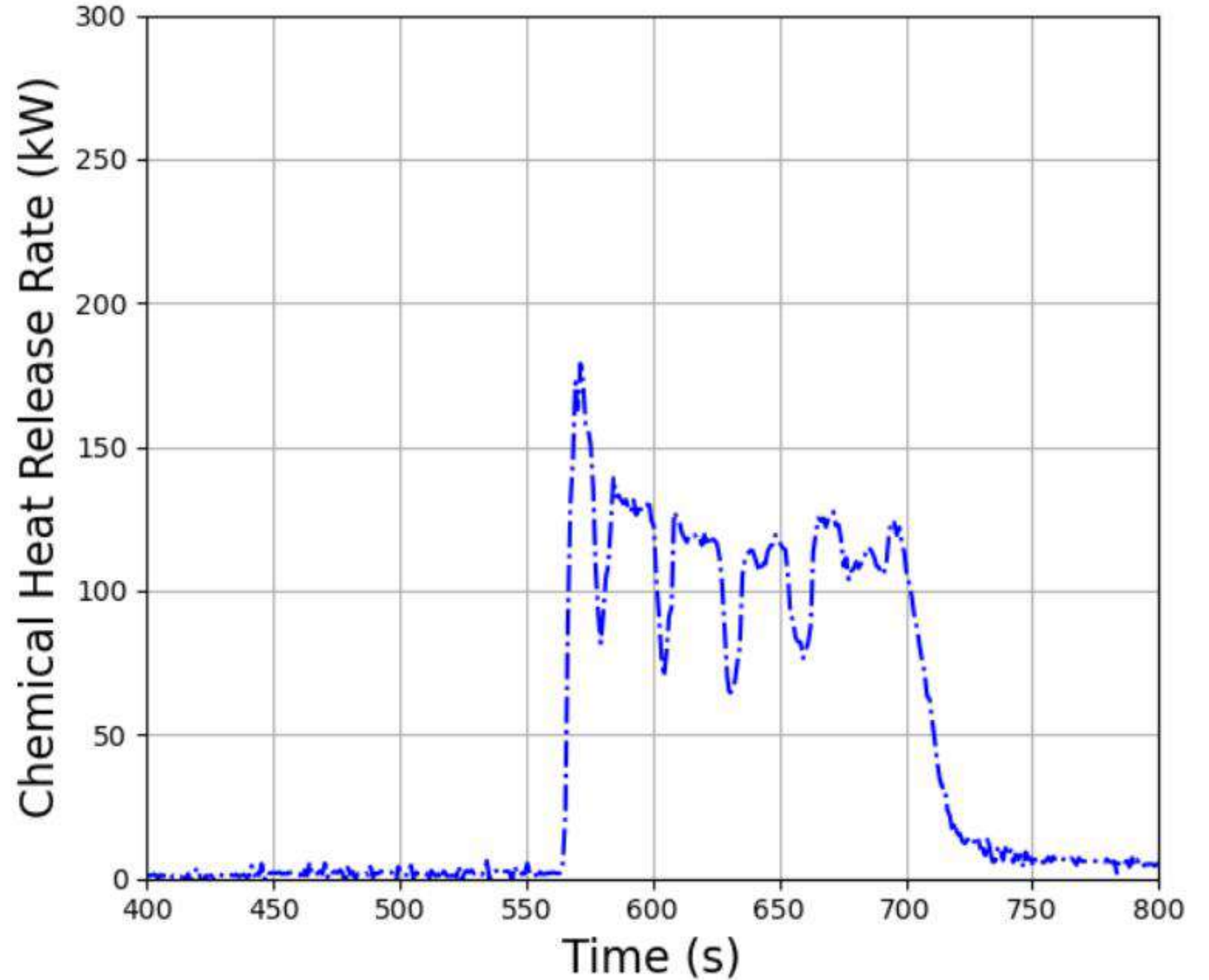


Thermal Runaway – Module Gas Generation

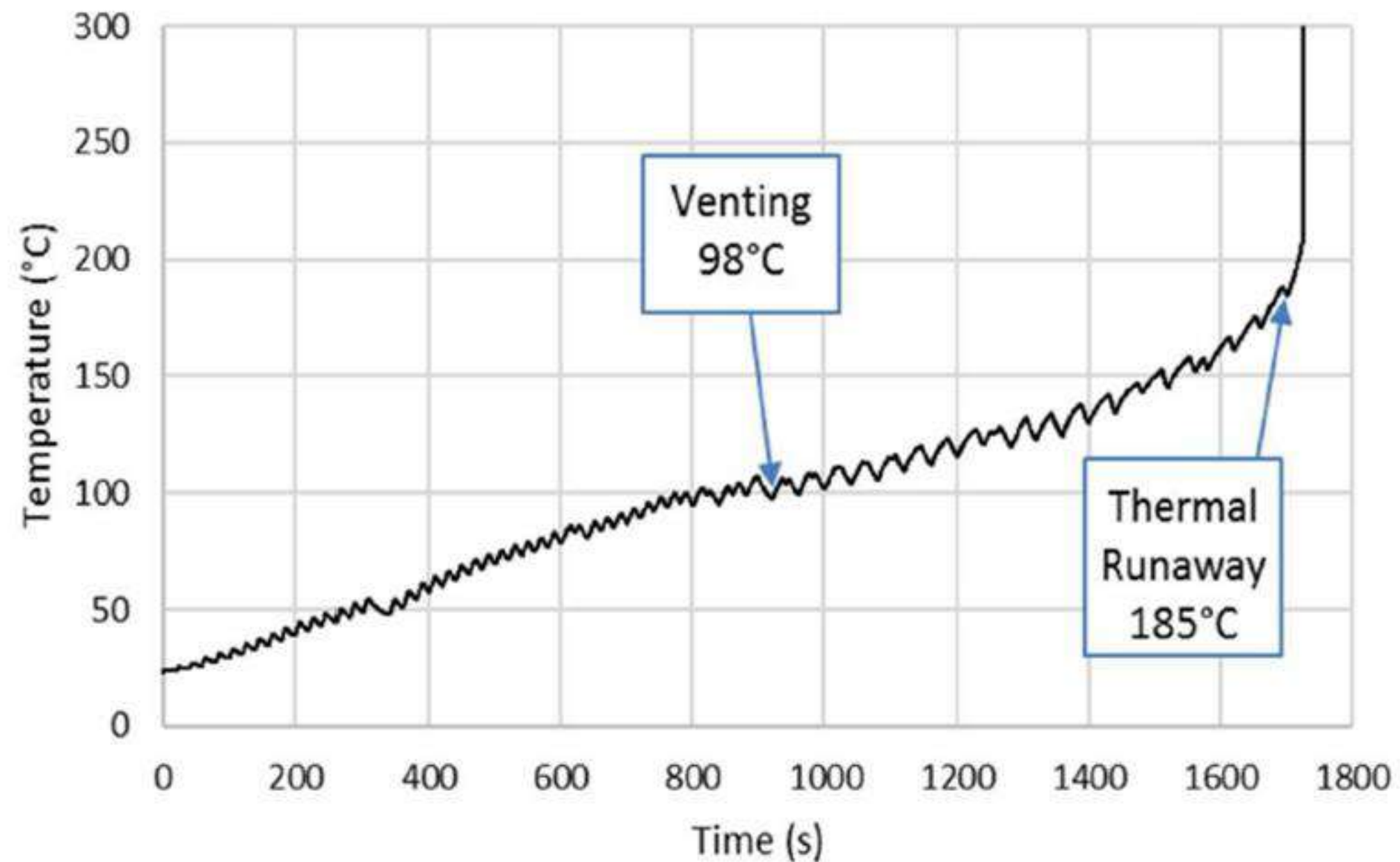


- Research Campus FM Global
- Lithium Iron Phosphate Module 5.2 kWh
- Set up 3 heaters to replicate a thermal abuse condition

Six Cell Propagation Test



Venting occurs before thermal runaway identified by BMS



Flammable Gas Composition

Gas	LFP	NMC	NCA
Hydrogen	50.73%	31.8%	31.7%
Carbon Monoxide	11.17	19.40	36.20
Carbon Dioxide	24.86	28.60	22.10
Methane	6.60	9.20	7.40
Ethylene	3.06	5.50	0.92
Ethane	1.19	0.52	0.61
Propene	1.01	-	-
Propane	0.40	2.10	0.04
Propylene	-	2.10	0.22
Other Hydrocarbons	0.98	0.78	0.81

Video

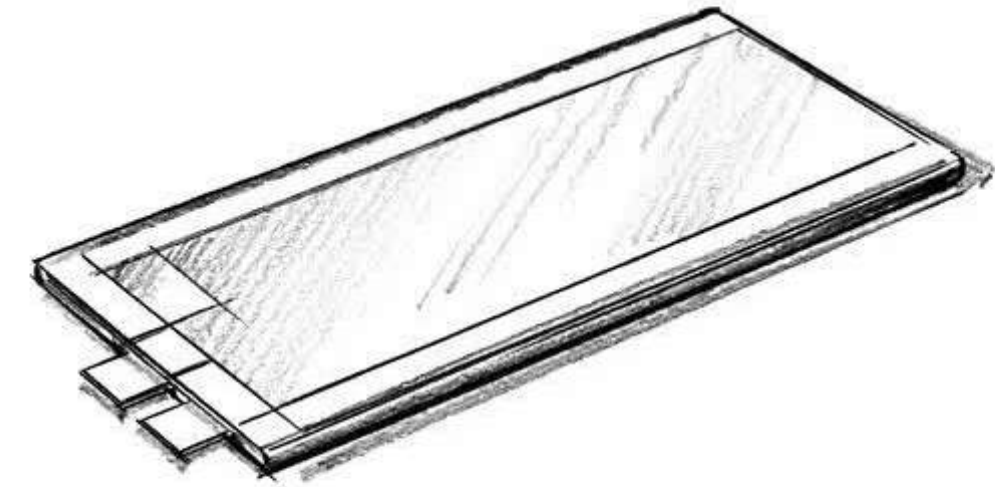
- **Evalúa el riesgo de incendio que plantea un almacenamiento a granel de baterías de iones de litio en un entorno de racks**
- **Contiene 15,552 células poliméricas**
- **Representa el almacenamiento en rack de hasta 15 pies (4.6 m)**
- **Prueba a escala real en centro de investigación de FM Global**



Fire Hazard of Lithium-ion Batteries in Warehouse Storage

Lithium-ion Polymer Cells

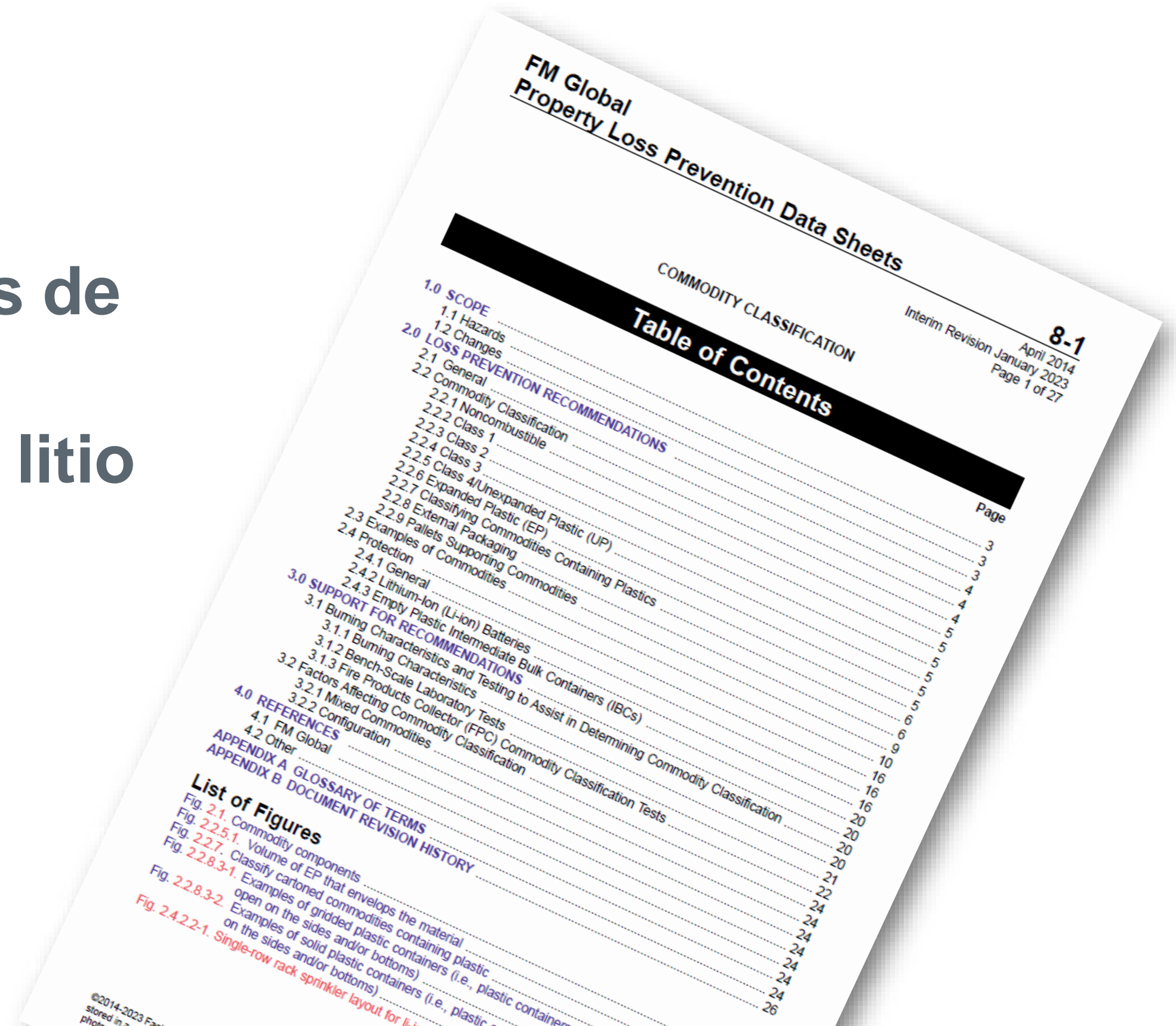
Full test report available at:
fmglobal.com/researchreports



THE
FIRE PROTECTION
RESEARCH FOUNDATION

DS 8-1 Commodity Classification:

- Última Revisión Enero - 2023
- Paquetes de baterías de iones de litio dentro de los productos
- Grandes baterías de iones de litio



FM Global
Property Loss Prevention Data Sheets
COMMODITY CLASSIFICATION
Interim Revision January 2023
Page 1 of 27
8-1
April 2014

	Page
1.0 SCOPE	3
1.1 Hazards	3
1.2 Changes	3
2.0 LOSS PREVENTION RECOMMENDATIONS	4
2.1 General	4
2.2 Commodity Classification	4
2.2.1 Noncombustible	4
2.2.2 Class 1	4
2.2.3 Class 2	4
2.2.4 Class 3	4
2.2.5 Class 4/Unexpanded Plastic (UP)	4
2.2.6 Expanded Plastic (EP)	4
2.2.7 Classifying Commodities Containing Plastics	4
2.2.8 External Packaging	4
2.2.9 Pallets Supporting Commodities	4
2.3 Examples of Commodities	4
2.4 Protection	4
2.4.1 General	4
2.4.2 Lithium-Ion (Li-ion) Batteries	4
2.4.3 Empty Plastic Intermediate Bulk Containers (IBCs)	4
3.0 SUPPORT FOR RECOMMENDATIONS	5
3.1 Burning Characteristics and Testing to Assist in Determining Commodity Classification	5
3.1.1 Burning Characteristics	5
3.1.2 Bench-Scale Laboratory Tests	5
3.1.3 Fire Products Collector (FPC) Commodity Classification Tests	5
3.2 Factors Affecting Commodity Classification	5
3.2.1 Mixed Commodities	5
3.2.2 Configuration	5
4.0 REFERENCES	6
4.1 FM Global	6
4.2 Other	6
APPENDIX A GLOSSARY OF TERMS	16
APPENDIX B DOCUMENT REVISION HISTORY	16
List of Figures	16
Fig. 2.1. Commodity components	16
Fig. 2.2.5.1. Volume of EP that envelops the material	16
Fig. 2.2.7. Classify cartoned commodities containing plastic	16
Fig. 2.2.7.1. Examples of gridded plastic containers (i.e., plastic containers open on the sides and/or bottoms)	16
Fig. 2.2.7.2. Examples of solid plastic containers (i.e., plastic containers on the sides and/or bottoms)	16
Fig. 2.2.8.3-1. Single-row rack sprinkler layout for lithium-ion batteries	16



FM Global Property Loss Prevention Data Sheets

8-1

April 2014

Interim Revision January 2023

Page 1 of 27

2.4.2 Lithium-Ion (Li-ion) Batteries

2.4.2.1 Protect new li-ion cells and modules stored in open-frame rack, solid-pile or palletized storage arrangements per the guidance in Table 2.4.2.1. Protection guidance is not differentiated based on battery chemistry.

2.4.2.1.1 Protect finished products that contain li-ion cells or modules per the products commodity classification provided the following conditions are met:

- A. Ceiling height is no greater than 40 ft (12 m)
- B. Li-ion battery state of charge is $\leq 60\%$

2.4.2.1.1.1 When the ceiling is greater than 40 ft (12 m) or battery state of charge is greater than 60%, store finished products that contain li-ion cells or modules in open-frame racks; and protect with in-rack sprinklers per Section 2.4.2.2.

2.4.2.1.2 Protect used or refurbished li-ion cells or modules with in-rack sprinkler protection per Section 2.4.2.2.

FM Data Sheet 8-1 (Table 2.4.2.1.)



Table 2.4.2.1. Protection of Lithium-Ion Cells and Modules

<i>Li-ion Cell/Module State of Charge</i>	<i>Ceiling Height</i>	<i>Storage Height</i>	<i>Storage Arrangement</i>	<i>Packaging</i>	<i>Ceiling Protection (QR sprinklers only)</i>	<i>In-Rack Protection</i>
≤ 60%	≤ 40 ft (12 m)	Maximum 3 levels of storage up to a total height of 15 ft (4.5 m)	Open-frame rack, solid-pile or palletized	Wood crate, metal encased or corrugated carton with cellulosic and/or unexpanded plastic internal packaging only	K22.4 or K25.2 (K320 or K360) 12 @ 35 psi (2.4 bar)	NA
				Corrugated carton with expanded plastic internal packaging	CEP per 8-9*	NA
				Plastic external packaging	UUP per 8-9*	NA
	> 40 ft (12 m)	NA	Open-frame rack	Uncartoned	Per surrounding occupancy.	See Section 2.4.2.2
				Cartoned or uncartoned	Per surrounding occupancy.	See Section 2.4.2.2
> 60%	NA					

* Use the Data Sheet 8-9 protection table based upon the storage configuration (open-frame rack, solid-pile or palletized) and the protection option based on the ceiling height.

FM Data Sheet 8-1 (Table 2.4.2.1.)



Table 2.4.2.1. Protection of Lithium-Ion Cells and Modules

Li-ion Cell/Module State of Charge	Ceiling Height	Storage Height	Storage Arrangement	Packaging	Ceiling Protection (QR sprinklers only)	In-Rack Protection		
≤ 60%	≤ 40 ft (12 m)	Maximum 3 levels of storage up to a total height of 15 ft (4.5 m)	Open-frame rack, solid-pile or palletized	Wood crate, metal encased or corrugated carton with cellulosic and/or unexpanded plastic internal packaging only	K22.4 or K25.2 (K320 or K360) 12 @ 35 psi (2.4 bar)	NA		
				Corrugated carton with expanded plastic internal packaging	CEP per 8-9*	NA		
				Plastic external packaging	UUP per 8-9*	NA		
				NA	Open-frame rack	Uncartoned	Per surrounding occupancy.	See Section 2.4.2.2
				> 40 ft (12 m)	Cartoned or uncartoned	Per surrounding occupancy.	See Section 2.4.2.2	
> 60%	NA							



* Use the Data Sheet 8-9 protection table based upon the storage configuration (open-frame rack, solid-pile or palletized) and the protection option based on the ceiling height.

FM Data Sheet 8-1 (In-Racks)



2.4.2.1.3 Do not allow storage above the batteries for ceiling only protection options.

2.4.2.1.4 Provide a minimum of 10 ft (3.0 m) space separation between li-ion cell or module storage areas and other combustibles when stored in solid-pile or palletized storage arrangements.

2.4.2.1.5 Store defective or damaged cells and modules outside of the building with space separation per Data Sheet 1-42, *Maximum Foreseeable Loss Limiting Factors*.

2.4.2.2. When in-rack sprinklers are required, provide plywood (minimum 3/8 in. [10 mm]) or sheet metal (minimum 22 ga. [0.7 mm]) horizontal barriers and in-rack sprinklers installed in accordance with Figures 2.4.2.2-1 and 2.4.2.2-2, depending on the rack type for storage.

1. Use a maximum vertical spacing of 12 ft (3.7 m) between barriers.
2. Do not store li-ion cells or modules above the top barrier level.
3. Design barriers without gaps in longitudinal flue spaces. A maximum gap of 3 in. (75 mm) between each barrier is permitted at the rack uprights (transverse flue) for single and double row racks.

2.4.2.2.1 Install K8.0 (K115) or K11.2 (K160), 165°F (74°C) rated, quick-response in-rack sprinklers below each barrier.

1. Design the in-rack sprinklers to provide a minimum flow of 60 gpm (227 L/min.) out of the hydraulically most remote six (6) sprinklers (e.g., three face sprinklers and three flue sprinklers in a double-row rack) if one barrier is provided, or the most remote eight (8) sprinklers (e.g., two face sprinklers and two flue sprinklers on two levels in a double-row rack) if two or more barrier levels are provided.
2. Locate face sprinklers within 6 in. (150 mm) of the rack face.

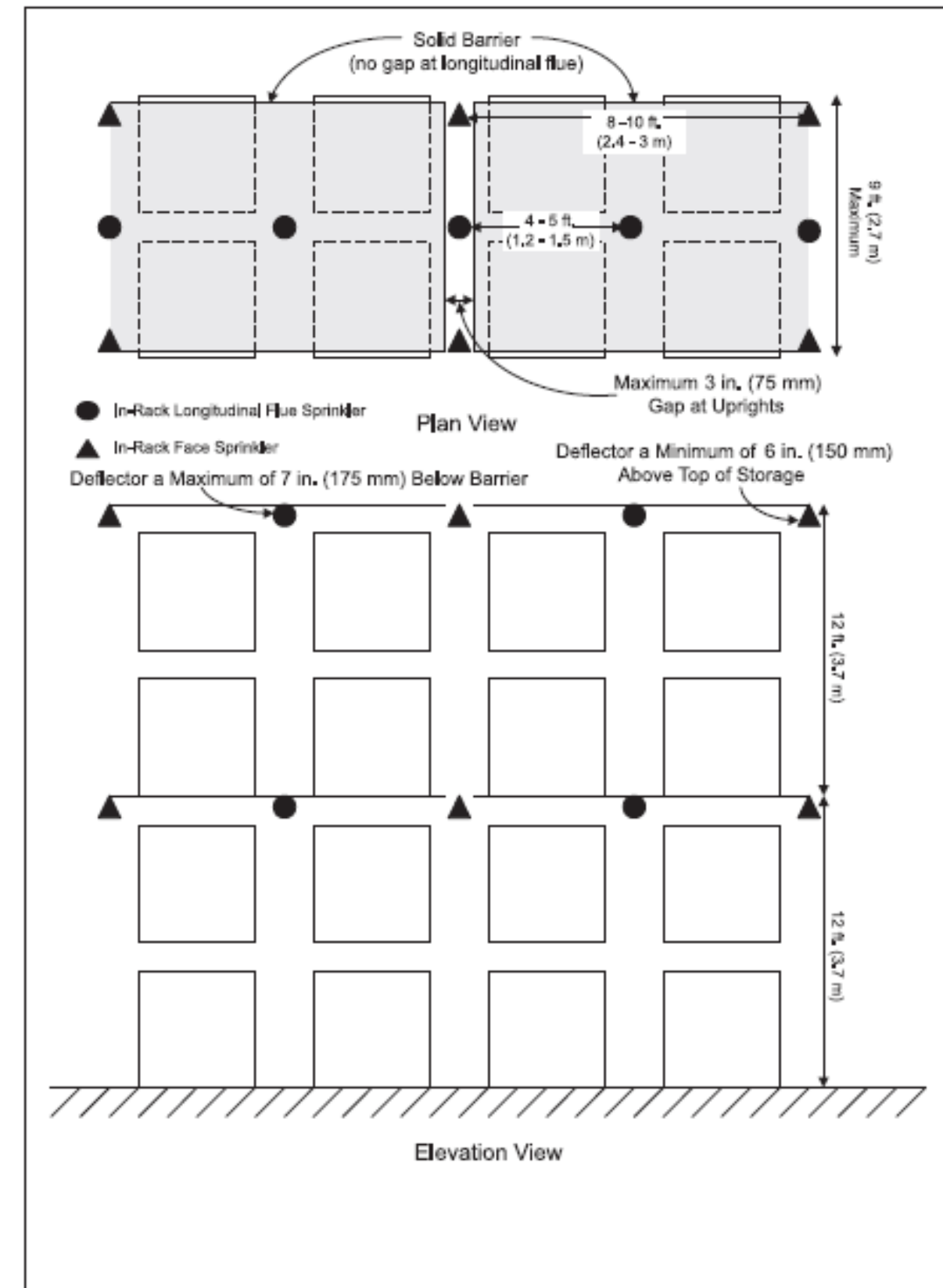


Fig. D.2.2.1.3. Double-row rack sprinkler layout: fire protection scheme A

Sprinklered Fire Test of Lithium-ion Batteries in Warehouse Storage



Video

- Prueba de fuego con rociadores a gran escala
- Baterías de polímero de iones de litio de 20 Ah
- Evaluar el rendimiento de la protección de rociadores a nivel de techo
- Representa almacenamiento de hasta 15 pies (4.6 m) bajo una altura de techo de hasta 40 pies (12.2 m)



Sprinklered Fire Test of Lithium-ion Batteries in Warehouse Storage



Video

Protección con rociadores a nivel de techo

- Respuesta rápida
- Temperatura estándar
- K22.4 gpm/psi (K320L/min/bar)
- 35 psi (2.1 bar)

- 24 Pallets cargados con Baterías (~27,000 baterías)



This video is the property of
Factory Mutual Insurance Company and its affiliates.
It may contain confidential information or information
subject to legal privilege. It is intended strictly for the
use of the person(s) or entity to which it is intended.
Disclosure, copying, distribution, or use of the contents
of this video by anyone other than the intended
recipient(s) is prohibited.

© 2016 FM Global. All rights reserved.

Sprinklered Fire Test of Lithium-ion Batteries in Warehouse Storage

Table 2.4.2.1. Protection of Lithium-Ion Cells and Modules

Li-ion Cell/Module State of Charge	Ceiling Height	Storage Height	Storage Arrangement	Packaging	Ceiling Protection (QR sprinklers only)	In-Rack Protection
≤ 60%	≤ 40 ft (12 m)	Maximum 3 levels of storage up to a total height of 15 ft (4.5 m)	Open-frame rack, solid-pile or palletized	Wood crate, metal encased or corrugated carton with cellulosic and/or unexpanded plastic internal packaging only	K22.4 or K25.2 (K320 or K360) 12 @ 35 psi (2.4 bar)	NA

- El objetivo de la protección es minimizar la participación de las baterías en el incendio.
- Operación de un solo Rociador Automático
- El incendio no se propagó más allá del área de ignición.





0 min 30 s (30 s)



1 min 0 s (60 s)



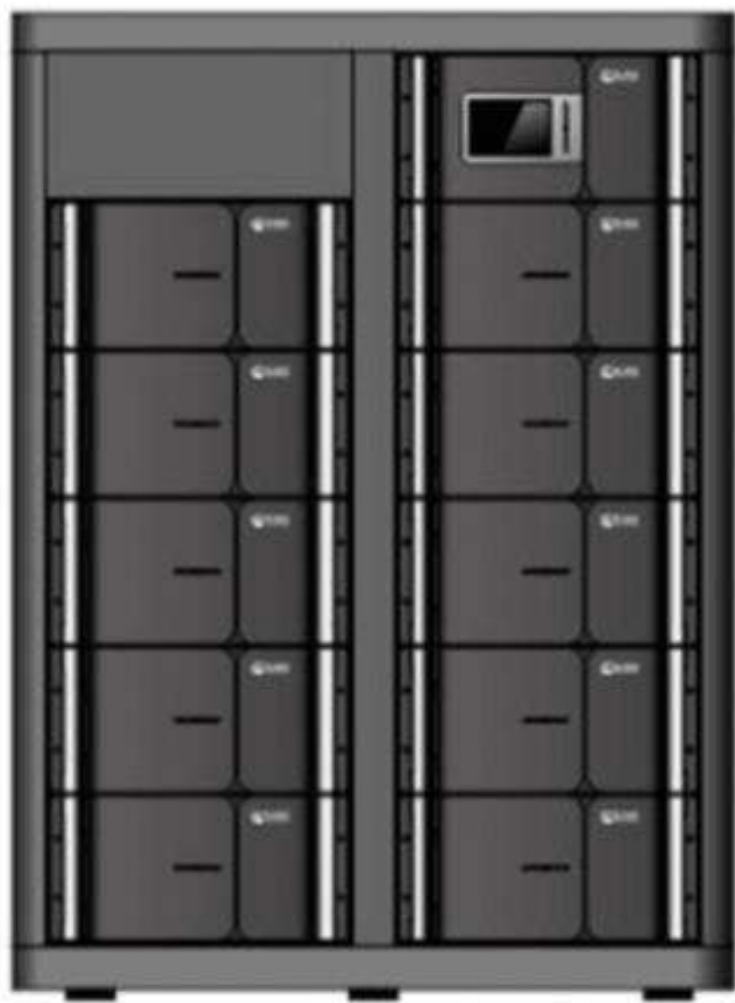
DONDE ESTA EL RIESGO?

➤ Tipo de Empaque

➤ Arreglo de almacenamiento

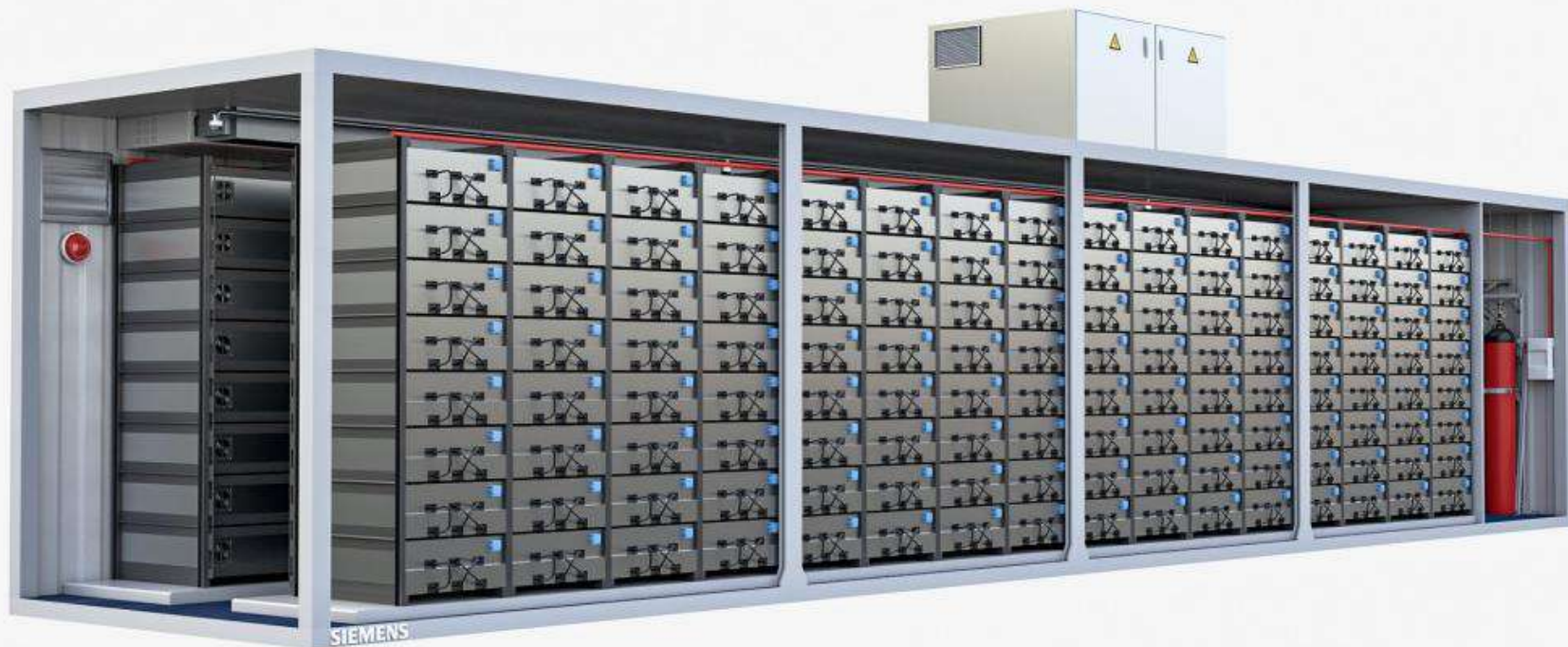
➤ Activación tardía de los rociadores

Sistemas de Almacenamiento de Energia (ESS) Energy Storage Systems



RETOS IMPORTANTES

- **Sistemas de almacenamiento de energía.**
- **Vehículos eléctricos.**
- **Racks de baterías para centros de datos.**



Example: Li-ion Battery in ESS



**63 Ah, 4.15V
(940 kJ)**



Fire Hazard of a Lithium-ion Based Energy Storage System (ESS)



Video

Prueba de fuego con rociadores a gran escala de un sistema de almacenamiento de energía (ESS) compuesto por baterías de óxido de litio y níquel / óxido de litio y manganeso



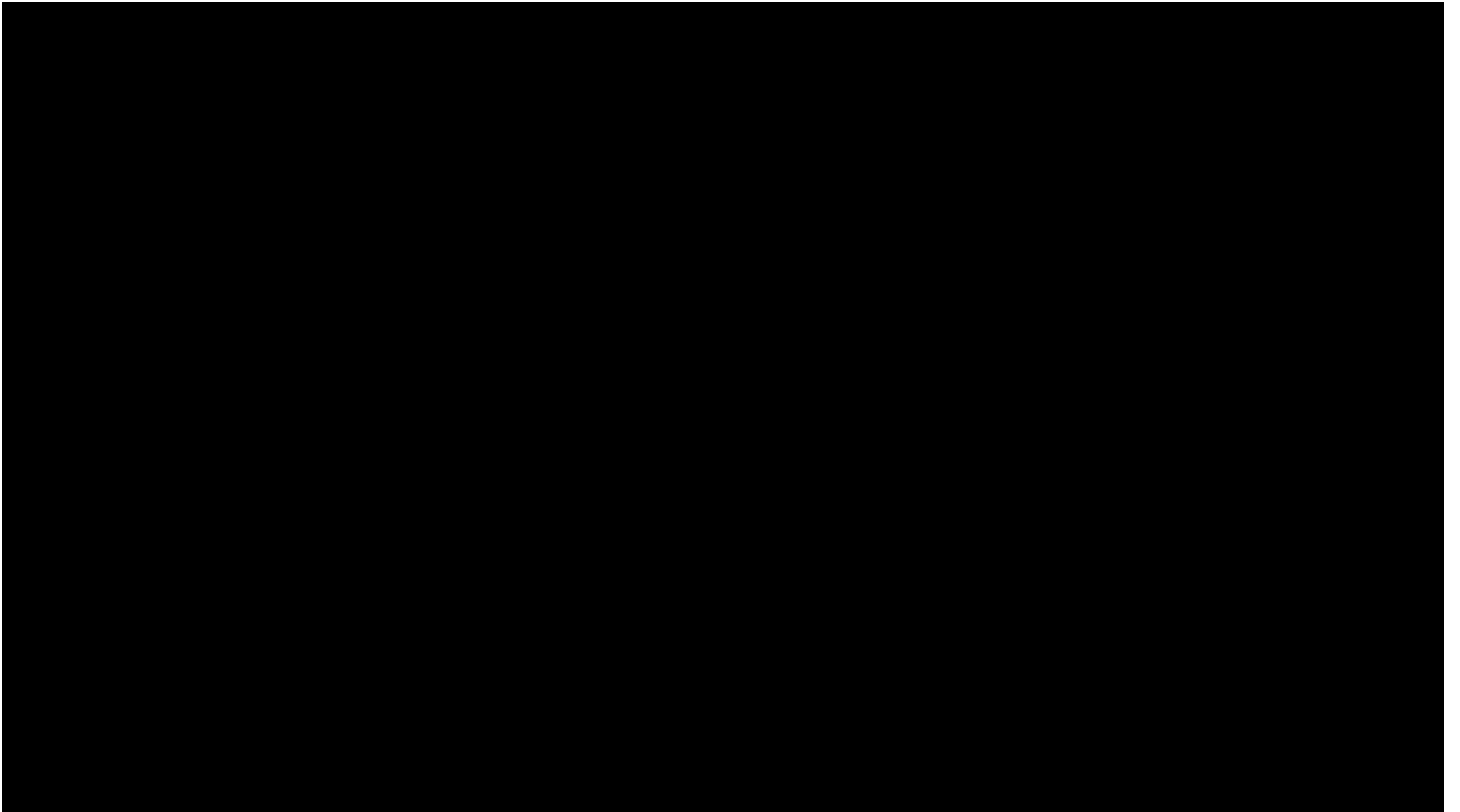
Fire Hazard of a Lithium-ion Based Energy Storage System (ESS)



Video

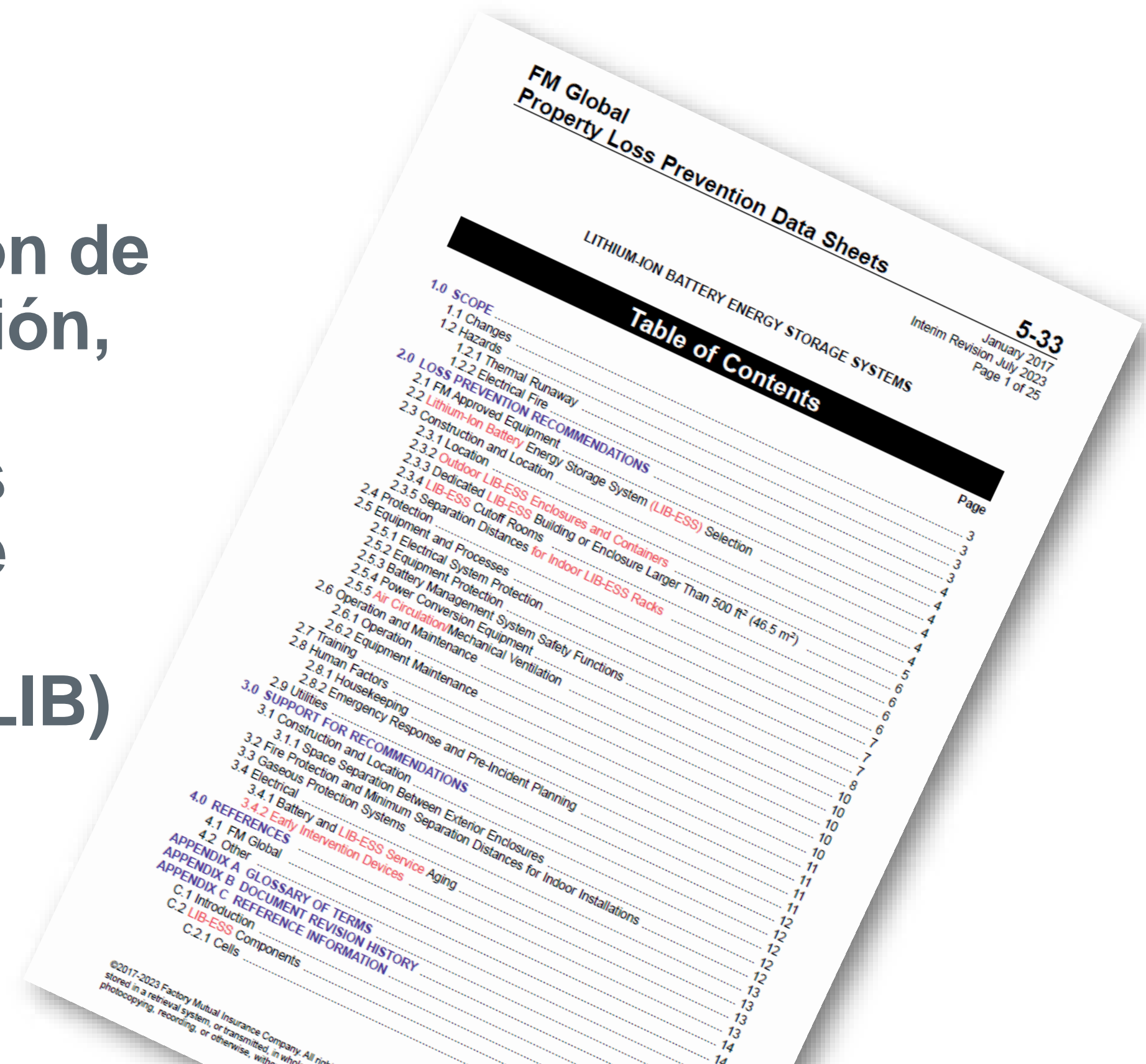
- Evaluar el rendimiento de la protección de rociadores a nivel de techo.
- Dos racks eléctricos colocados uno al lado del otro.
- Todos los módulos > 95% de estado de carga.
- Sin protección eléctrica activa.





DS 5-33 Lithium Battery Energy Storage Systems (ESS)

- Ultima Revisión Julio - 2023
- Recomendaciones de prevención de pérdidas para el diseño, operación, protección, inspección, mantenimiento y pruebas de los sistemas de almacenamiento de energía (ESS) de baterías estacionarias de iones de litio (LIB) superiores a 20 kWh.



FM Global Property Loss Prevention Data Sheets		5-33
LITHIUM-ION BATTERY ENERGY STORAGE SYSTEMS		Interim Revision July 2023 January 2017 Page 1 of 25
Table of Contents		Page
1.0 SCOPE		3
1.1 Changes		3
1.2 Hazards		3
1.2.1 Thermal Runaway		3
1.2.2 Electrical Fire		3
2.0 LOSS PREVENTION RECOMMENDATIONS		4
2.1 FM Approved Equipment		4
2.2 Lithium-Ion Battery Energy Storage System (LIB-ESS) Selection		4
2.3 Construction and Location		4
2.3.1 Location		4
2.3.2 Outdoor LIB-ESS Enclosures and Containers		4
2.3.3 Dedicated LIB-ESS Building or Enclosure Larger Than 500 ft ² (46.5 m ²)		4
2.3.4 LIB-ESS Cutoff Rooms		4
2.3.5 Separation Distances for Indoor LIB-ESS Racks		4
2.4 Protection		5
2.4.1 Electrical System Protection		5
2.4.2 Equipment Protection		5
2.4.3 Battery Management		5
2.4.4 Power Conversion System Safety Functions		5
2.4.5 Air Circulation/Mechanical Ventilation		5
2.5 Operation and Maintenance		6
2.5.1 Equipment Maintenance		6
2.5.2 Human Factors		6
2.5.3 Housekeeping		6
2.5.4 Emergency Response and Pre-Incident Planning		6
2.5.5 Utilities		7
2.6 SUPPORT FOR RECOMMENDATIONS		7
2.6.1 Construction and Location		7
2.6.2 Fire Protection and Minimum Separation Distances for Indoor Installations		7
2.6.3 Gaseous Protection Systems		7
2.6.4 Electrical		7
2.6.5 Battery and LIB-ESS Service Aging		7
2.6.6 Early Intervention Devices		7
2.7 REFERENCES		10
2.7.1 FM Global		10
2.7.2 Other		10
APPENDIX A GLOSSARY OF TERMS		11
APPENDIX B DOCUMENT REVISION HISTORY		11
APPENDIX C REFERENCE INFORMATION		11
C.1 Introduction		12
C.2 LIB-ESS Components		12
C.2.1 Cells		12

FM Global Property Loss Prevention Data Sheets

5-33

January 2017

Interim Revision July 2023

Page 1 of 25

LITHIUM-ION BATTERY ENERGY STORAGE SYSTEMS

2.4 Protection

2.4.1 Provide automatic sprinkler protection designed to a 0.3 gpm/ft² (12 mm/min) **over** the room area, with an additional allowance of 250 gal/min (946 L/min) for hose streams.

2.4.2 Ensure the water supply is capable of providing sprinkler water and hose stream requirements for the duration of the fire event (see Section 3.2). The expected duration will depend on the number of racks in a single fire area. The fire area is comprised of a row or rows of racks where minimum separation is not provided in accordance with 2.3.5. The duration should be estimated as 45 minutes times the number of adjacent LIB-ESS racks.

DS 5-33

- Evite la transferencia de calor a los sistemas de almacenamiento de energía (ESS) adyacentes.
- Proteja los combustibles cercanos.
- Proteger la construcción.

DS 5-33

- **Proporcionar construcción que limite los daños.**
- **Separar edificios/contenedores de otros recintos con ESS.**
- **Ventilación constante, detección de gases inflamables.**



PROTECCION CONTRA
INCENDIO EN EL MODULO



INTERVENCION TEMPRANA
(BMS / DETECCION DE GASES)

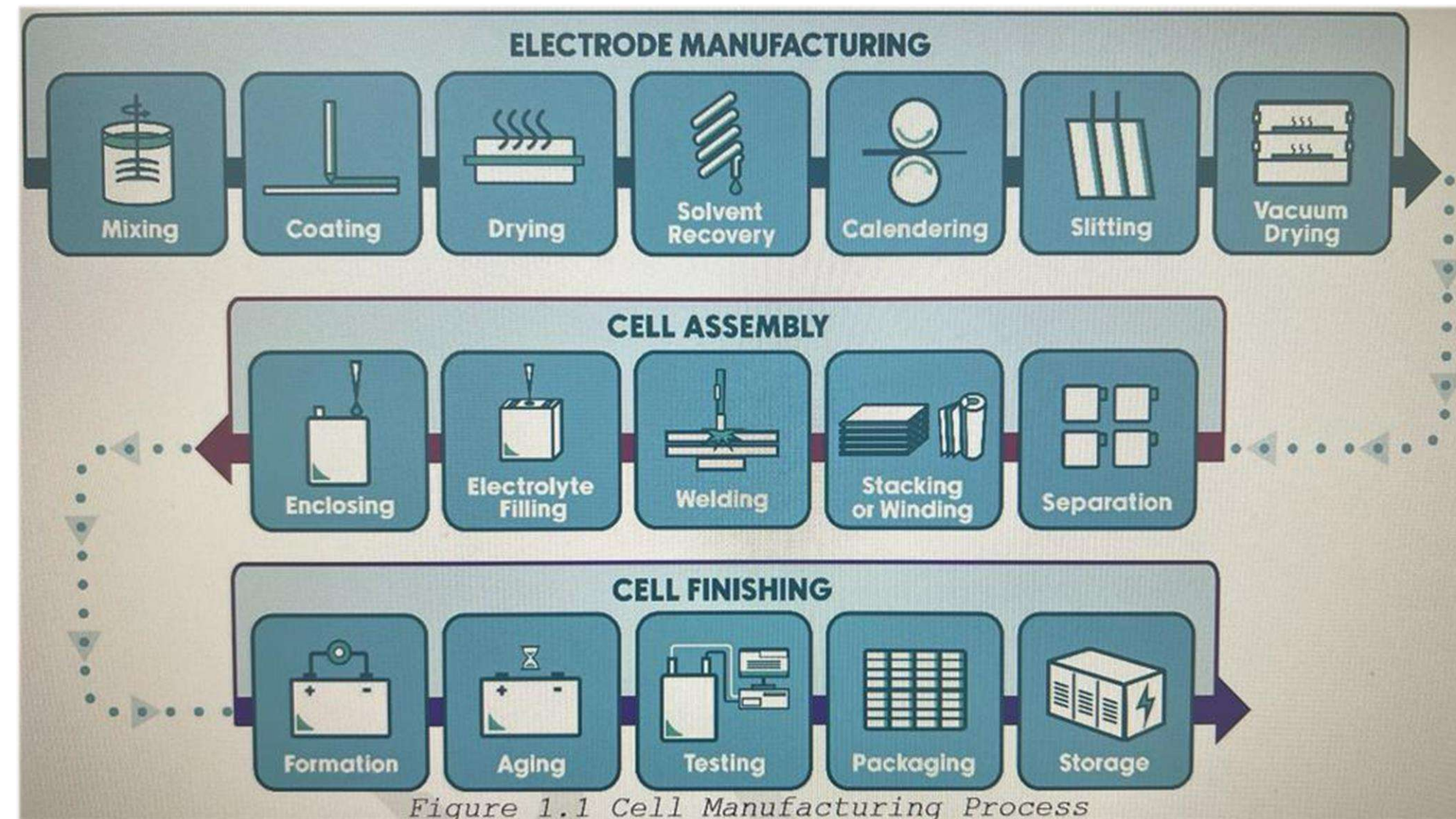


PROTECCION PASIVA

- **Próximamente DS 7-112**
Enero – 2024
- **Fabricación de baterías de iones de litio, ensamblaje de módulos, instalaciones de almacenamiento y ensamblaje de productos de uso final**
- **Hace referencia a todas las hojas de datos existentes.**



- **Proceso de fabricación de células.**
- **Proceso de envejecimiento / formación de células.**
- **Almacenamiento de células**
- **Ensamblaje / Almacenamiento de Módulos**
- **Ensamblaje de productos**



- La tecnología sigue cambiando cada día y tenemos más retos de protección contra incendio.

- La tecnología sigue cambiando cada día y tenemos más retos de protección contra incendio.
- La prevención es básica (Cargadores, BMS, ESS, etc.)

- La tecnología sigue cambiando cada día y tenemos más retos de protección contra incendio.
- La prevención es básica (Cargadores, BMS, ESS, etc.)
- **EL AGUA SIGUE SIENDO NUESTRA MEJOR ARMA DE CONTROL y COBATE AL FUEGO.**

- La tecnología sigue cambiando cada día y tenemos más retos de protección contra incendio.
- La prevención es básica (Cargadores, BMS, ESS, etc.)
- **EL AGUA SIGUE SIENDO NUESTRA MEJOR ARMA DE CONTROL Y COBATE AL FUEGO.**



[Reportar un siniestro](#)[Informar una puesta fuera de servicio](#)[MyRisk®](#)[Acerca de FM Global](#)[Productos y servicios](#)[Ideas y tendencias](#)[Investigación y recursos](#)[Noticias y eventos](#)

FM Global > Investigación y recursos > Fichas técnicas de FM Global

[IMPRIMIR](#)[SUSCRIBIRSE](#)[COMPARTIR](#)

FICHAS TÉCNICAS DE PREVENCIÓN DE SINIESTROS DE FM GLOBAL

[Contacto](#)[Suscribirse](#)

Preguntas?





ARE FM GLOBAL

Gracias.....

David Morales



david.morales@fmglobal.com



+52 (81) 8262-4741



www.fmglobal.mx



expo**fuego**

CHILE 2023

CONGRESO INTERNACIONAL
DE PROTECCIÓN CONTRA INCENDIO