

Detecting fire in Li-ion battery



Tillsammans räddar vi liv.

Ulf Allvar

Presto Brandsäkerhet AB
Sales Manager Gas & Detection

Demands and requirements for a test space:

- Detection solution
- Extinguishing solution



DIFFERENT TYPE OF FIRE DETECTION METHODS



Very early
Gas detection



Gas

Very early
Smoke Detection



Aspiration

Early detection



CO

Optical
Detector



Smoke

Flame
Detector



Flame

Heat
Detector



High
Temp

Sprinkler



Time

Type of detectors:

- Point detector
- Laser aspiration detector
- Gas detector

- Gas detector



- Laser aspiration detector



- Point detector



KFA = **K**ontrollenhet och **F**ördröjnings **A**nordning (Control and Delay Equipment)

Type of KFA (extinguishing panel):

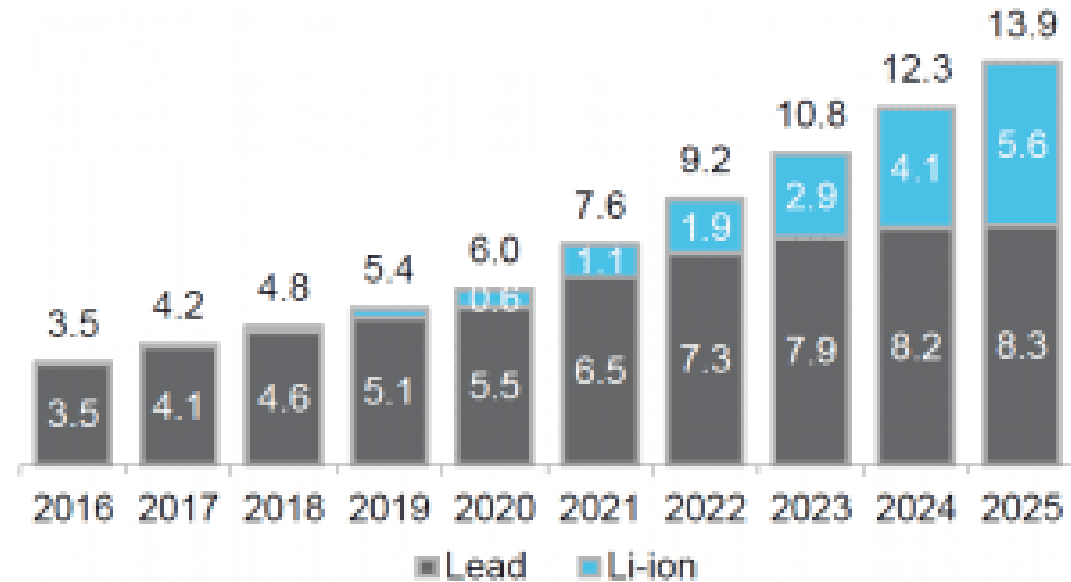
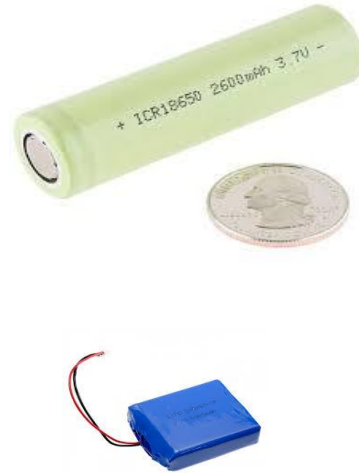
- Addressable extinguishing panel
- Conventional extinguishing panel

Requirements for a KFA (extinguishing panel):

- EN 54-2
- EN 54-4
- EN 12094
- SBSC



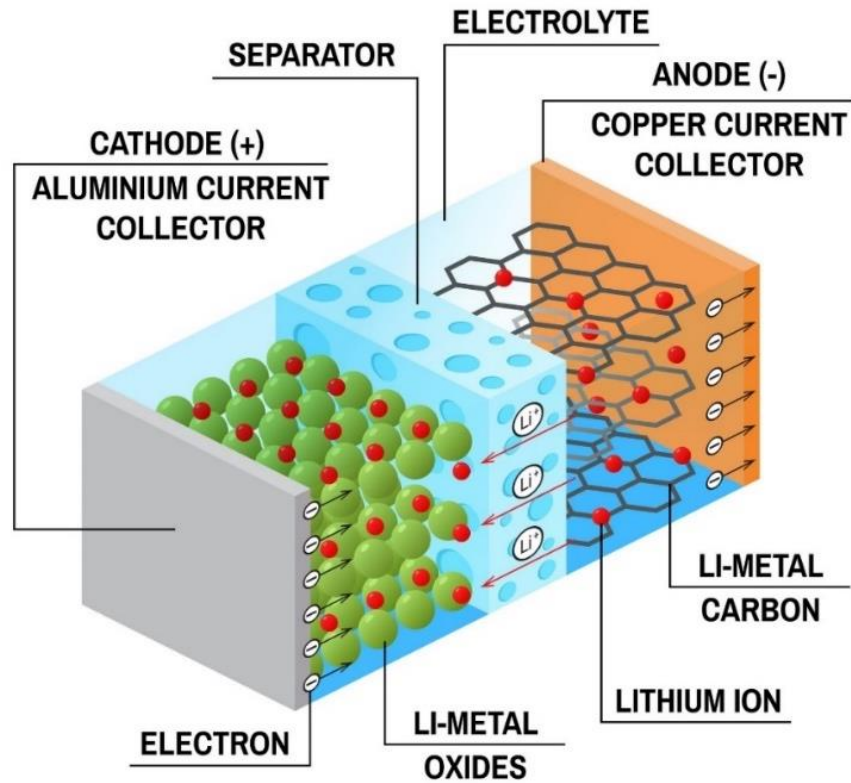
Li-Ion battery



Source: Bloomberg New Energy Finance

Figure 1: North America and Europe data center annual battery back-up demand, 2016-25 (GWh)

Lithium-Ion battery discharge



Lithium-Ion battery fires

- Separator failure
- Battery cell temperature and pressure increases
- Decomposition of electrolyte
- Venting of flammable gases



Lithium-Ion battery limitations

Requires protection circuit to maintain voltage and current within safe limits.

Complex battery management systems need to continuously adapt to battery cell aging.

If things go wrong, the fires are extremely challenging.

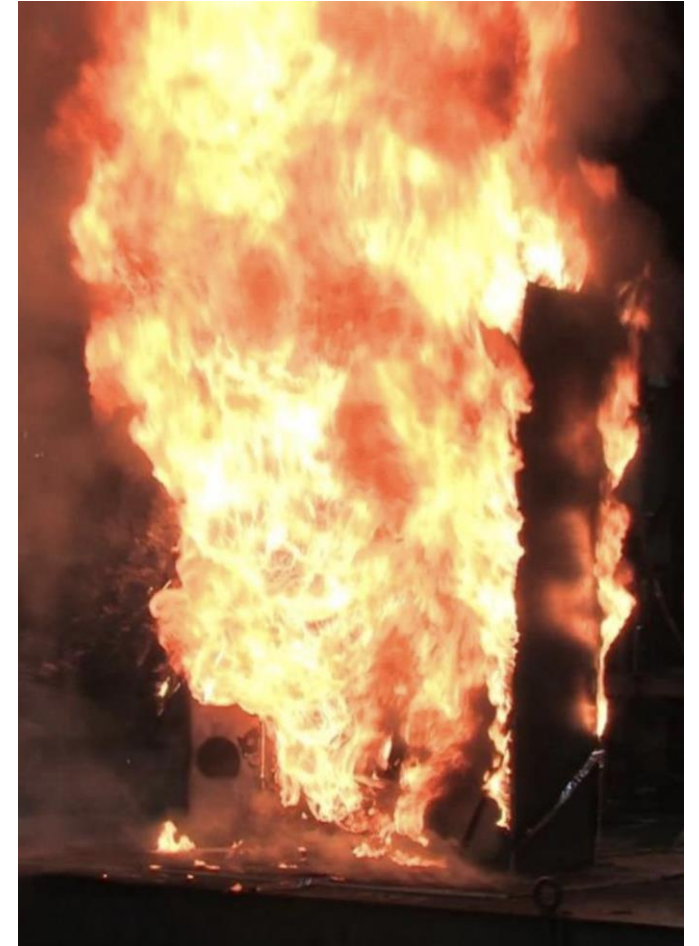
1:00:20



1:10:10



1:28:50



Li-ion Battery Failure

- Overcharging
- Battery misuse or abuse
- Exposed to high temperatures
- Manufacturing defects
- Short circuits caused by dendrites whiskers

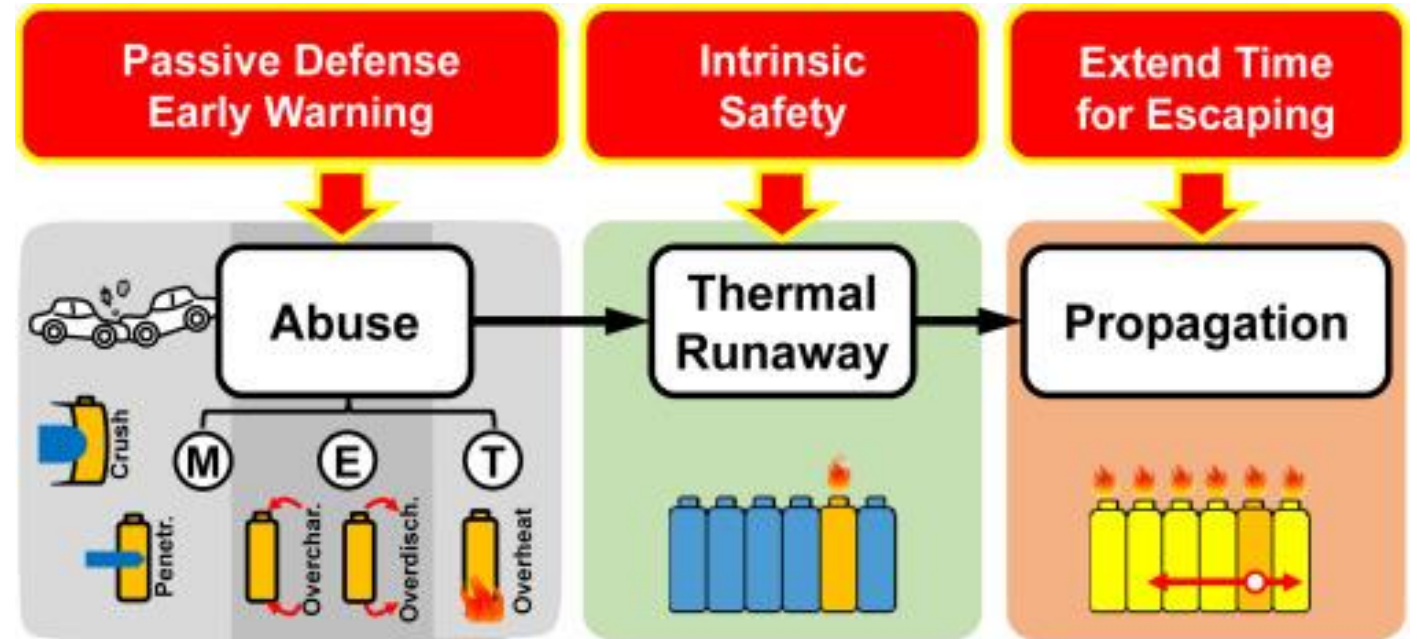


Image Source: <https://www.powerelectronicstips.com/thermal-propagation-triggering-and-mitigation-in-medium-and-large-format-battery-modules/>

Battery Failure Stages

Stage 1: Abuse Factor

- Thermal, Electrical or Mechanical abuse

Stage 2: Electrolyte Vapour Release

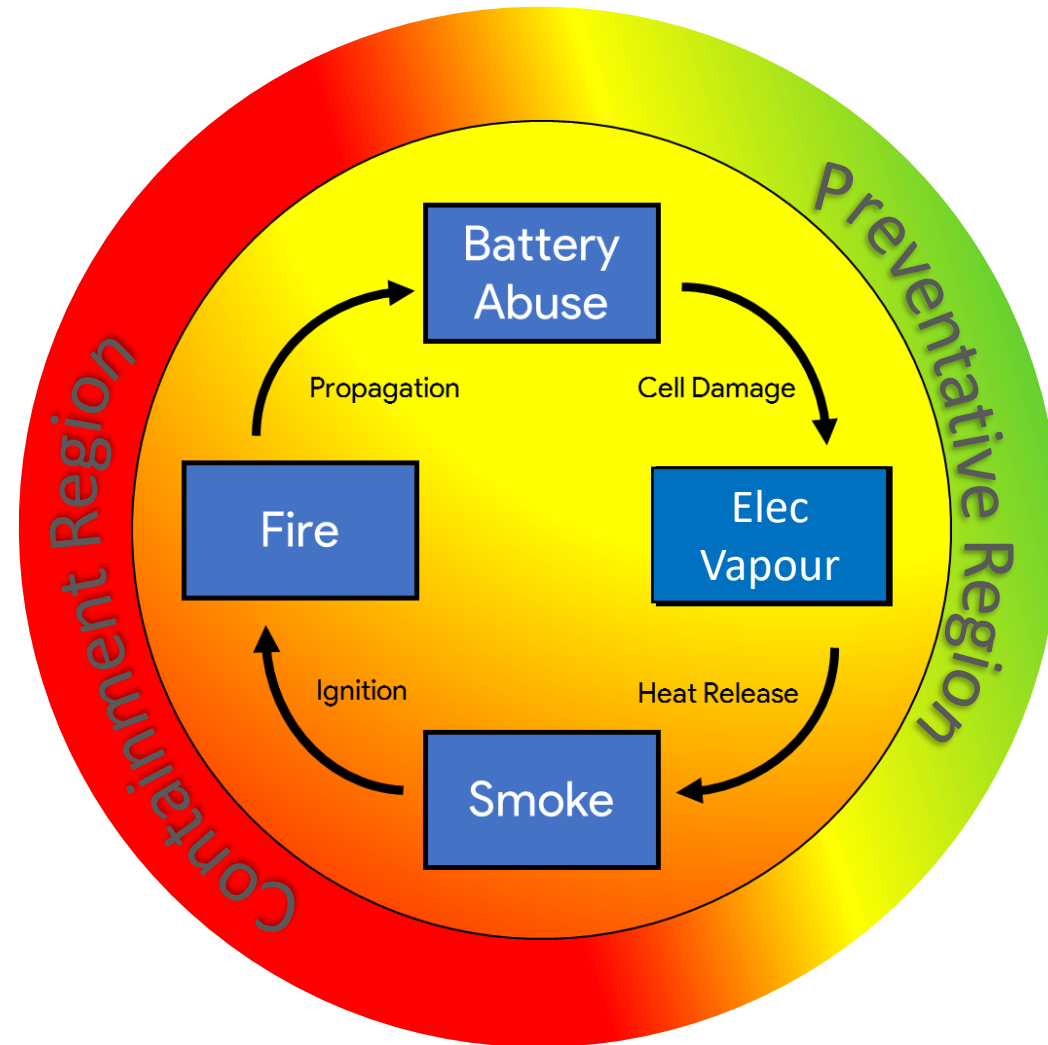
- Golden Time

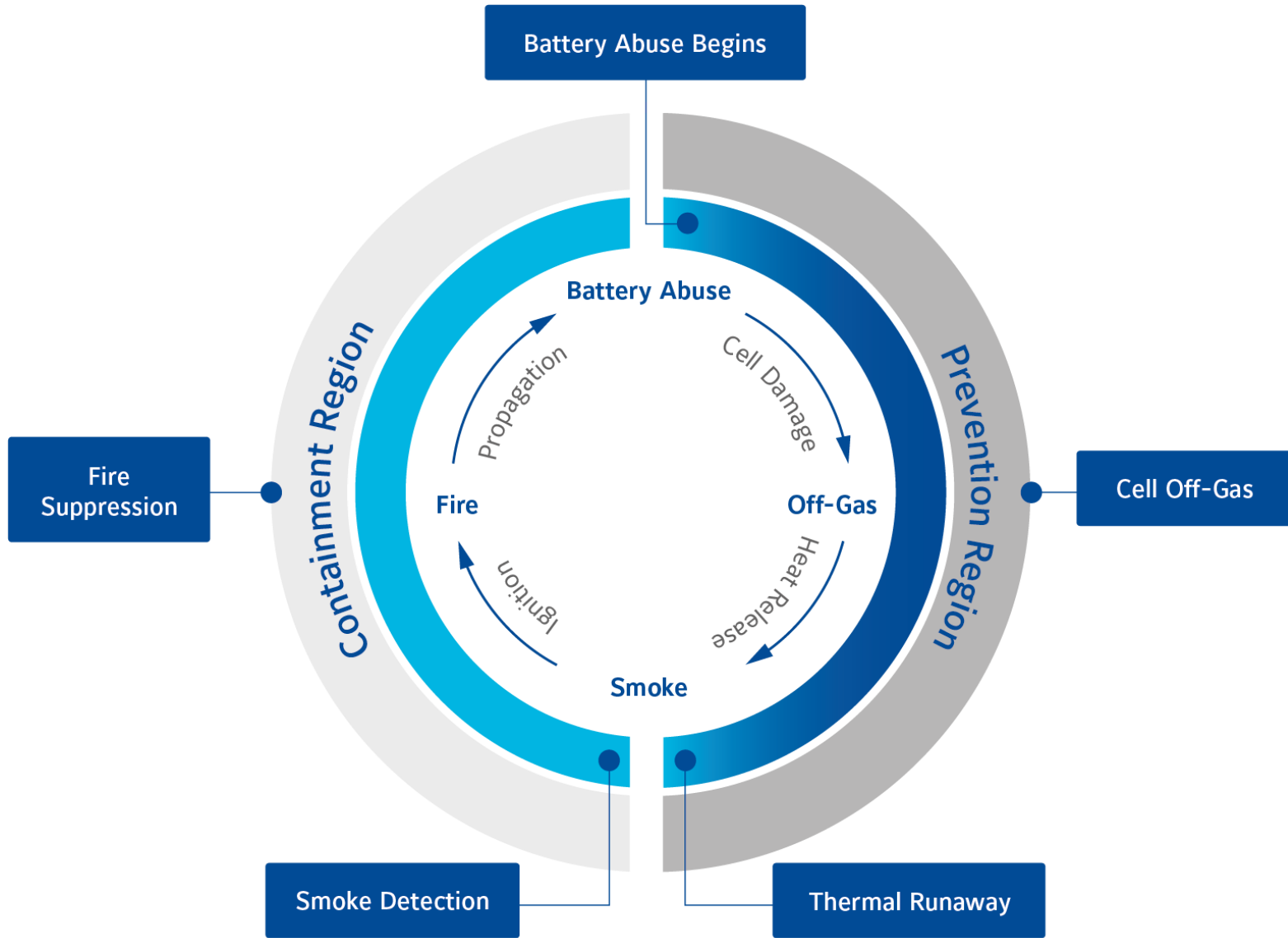
Stage 3: Smoke Generation

- Catastrophic failure is imminent

Stage 4: Fire Generation

- Propagation occurrence





Lithium-Ion Risk Prevention

offers advanced early failure monitoring of Lithium-Ion batteries by detecting Off-Gases.

1

Stage 1: Battery Abuse

Thermal, electrical or mechanical abuse

2

Stage 2: Off-Gas Generation

Time to take ACTION

3

Stage 3: Smoke Generation

Catastrophic failure is imminent

4

Stage 4: Fire Generation

Propagation occurrence

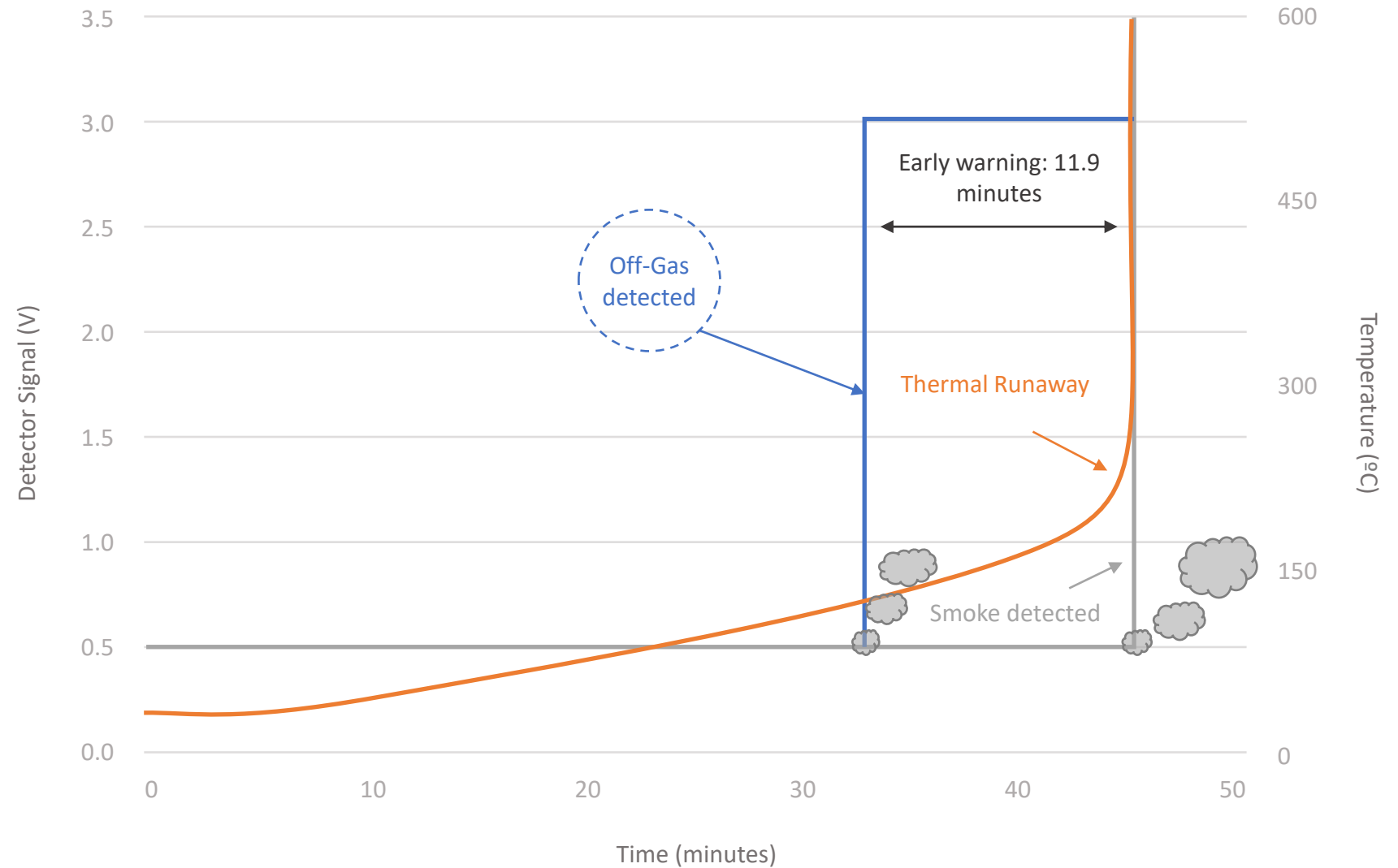
Prevent Thermal Runaway by detecting for Lithium-Ion 'Off-Gases'

Dictionary

off-gas
/'ɒfgas/
noun

1. a gas which is given off, especially one emitted as the by-product of a chemical process.

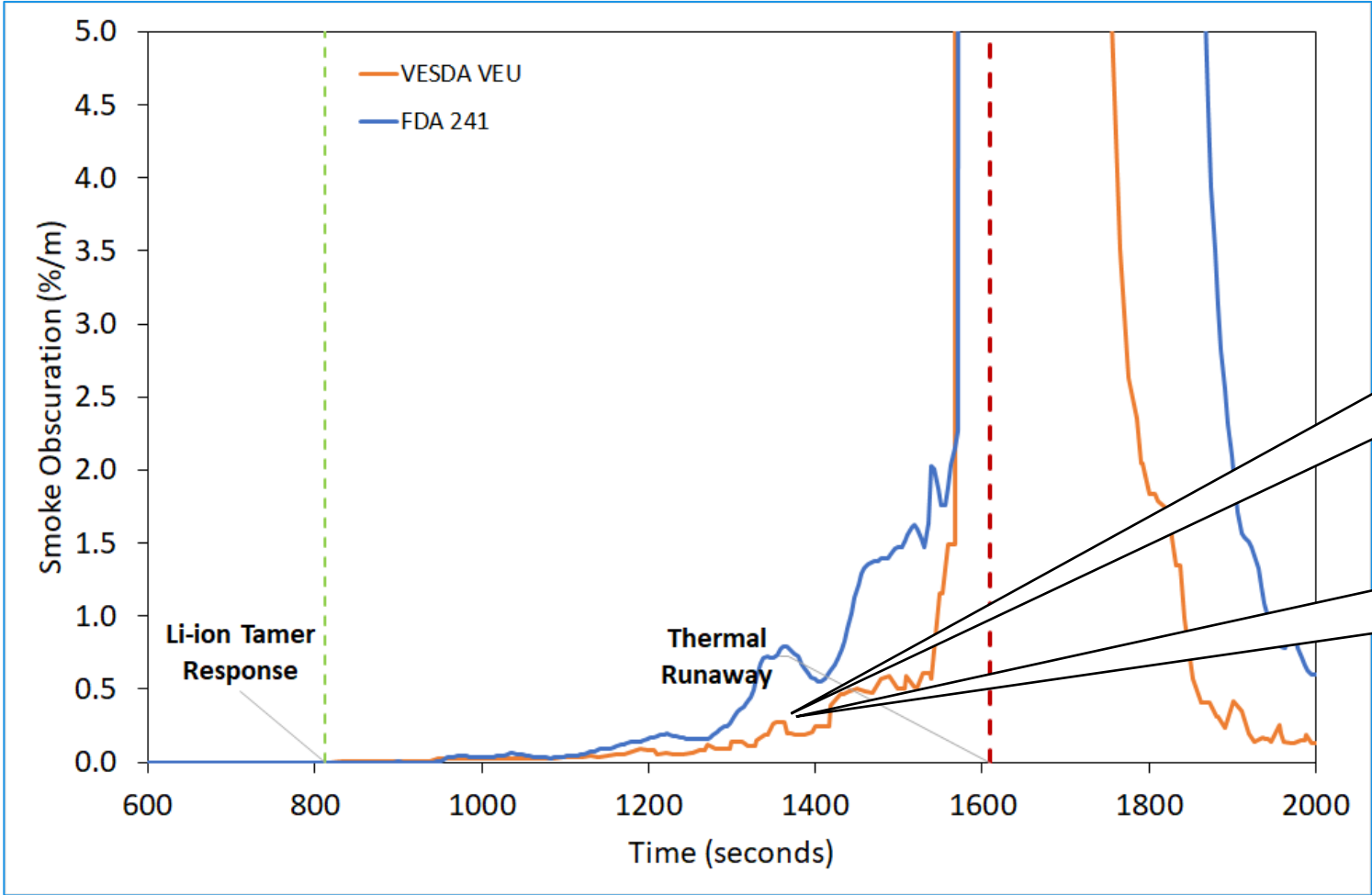
In the case of Lithium-Ion Batteries when the battery starts to fail, the chemical process produces electrolyte vapor from the battery cells.



— Off-Gas monitoring — Air sampling detector signal — Surface temp of cell (°C)

Detection Performance: Li-ion Tamer vs ASD

- Setup B: Open Space**
- Chemistry: LFP
 - Form: Prismatic
 - Abuse: Over-Charge



High ASD smoke readings achieved due to single hole sampling (no dilution) and FDA241 "Ultra Sense" setting

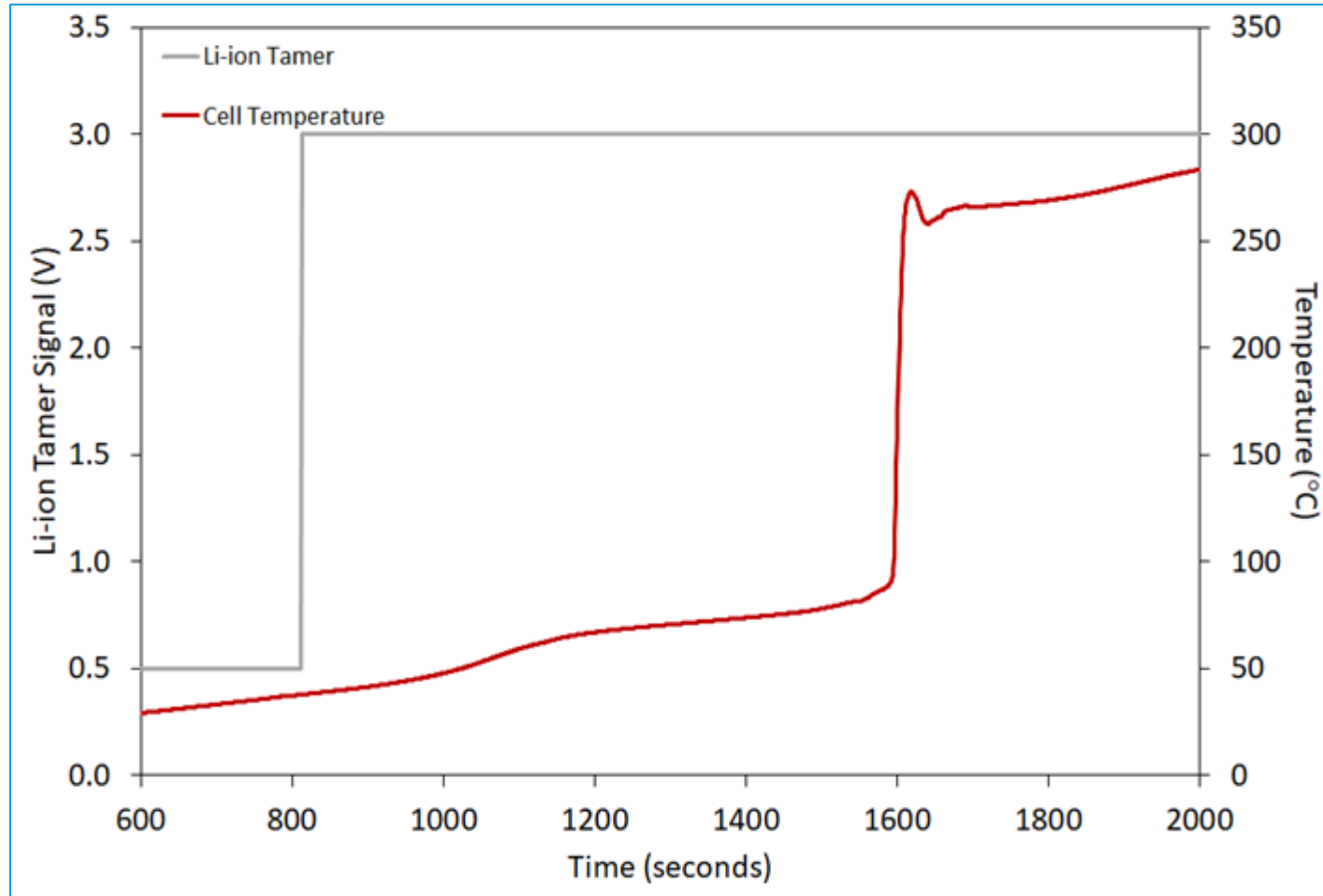
Previous FDA241 calibration testing demonstrates higher signal output for controlled smoke concentration.

Both Li-ion Tamer and ASDs responded before Thermal Runaway with Li-ion Tamer providing earlier notification.

Runaway

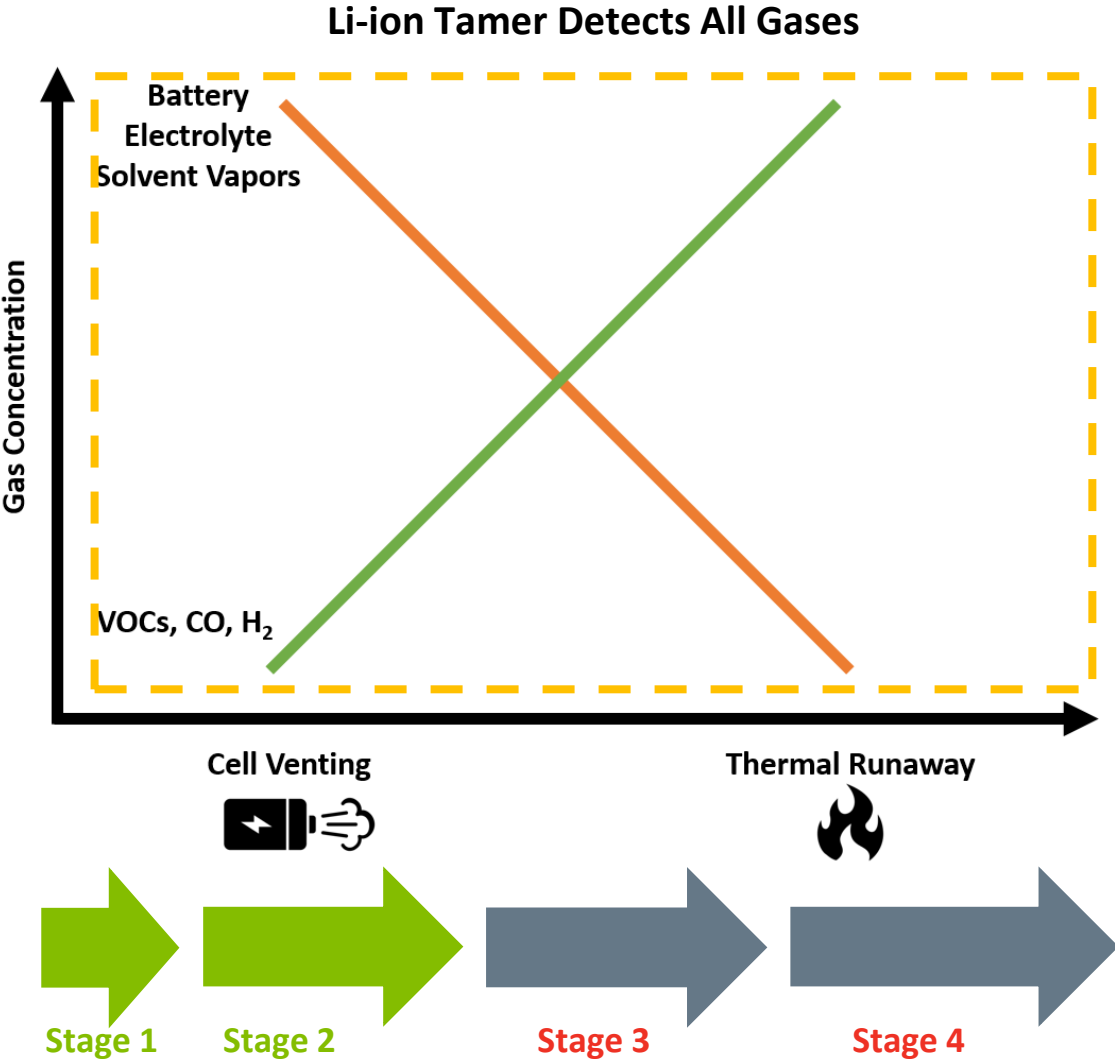
Setup B: Open Space

- Chemistry: LFP
- Form: Prismatic
- Abuse: Over-Charge



Li-ion Tamer alarmed to the initial venting (“electrolyte vapour”) of the li-ion battery 794s (13.2 min) before Thermal Runaway.

Cell Venting vs Thermal Runaway



3rd party testing data with GC-MS, FTIR

Stage 2

Cell venting gas composition:
 45% Battery Electrolyte Solvent Vapors (DEC, DMC)
 <0.1% H₂
 0% CO
 55% Rest (water vapor, CO₂, etc.)

Stage 3 & 4

Thermal runaway gas composition:
 5% Battery Electrolyte Solvent Vapors (DEC, DMC)
 15% H₂
 32% CO
 15% tVOC (Propane, Butane, Ethane, Methane, etc.)
 33% Rest (water vapor, CO₂, etc.)

Preventative Actions

Non-propagation Design

Separation Distance Specification

Cooling/Heat Transfer Plates

PCM/Intumescent Materials

Exhaust and Deflagration Venting

LFL Gas Detection

Conventional Smoke Detection

Cell Quality

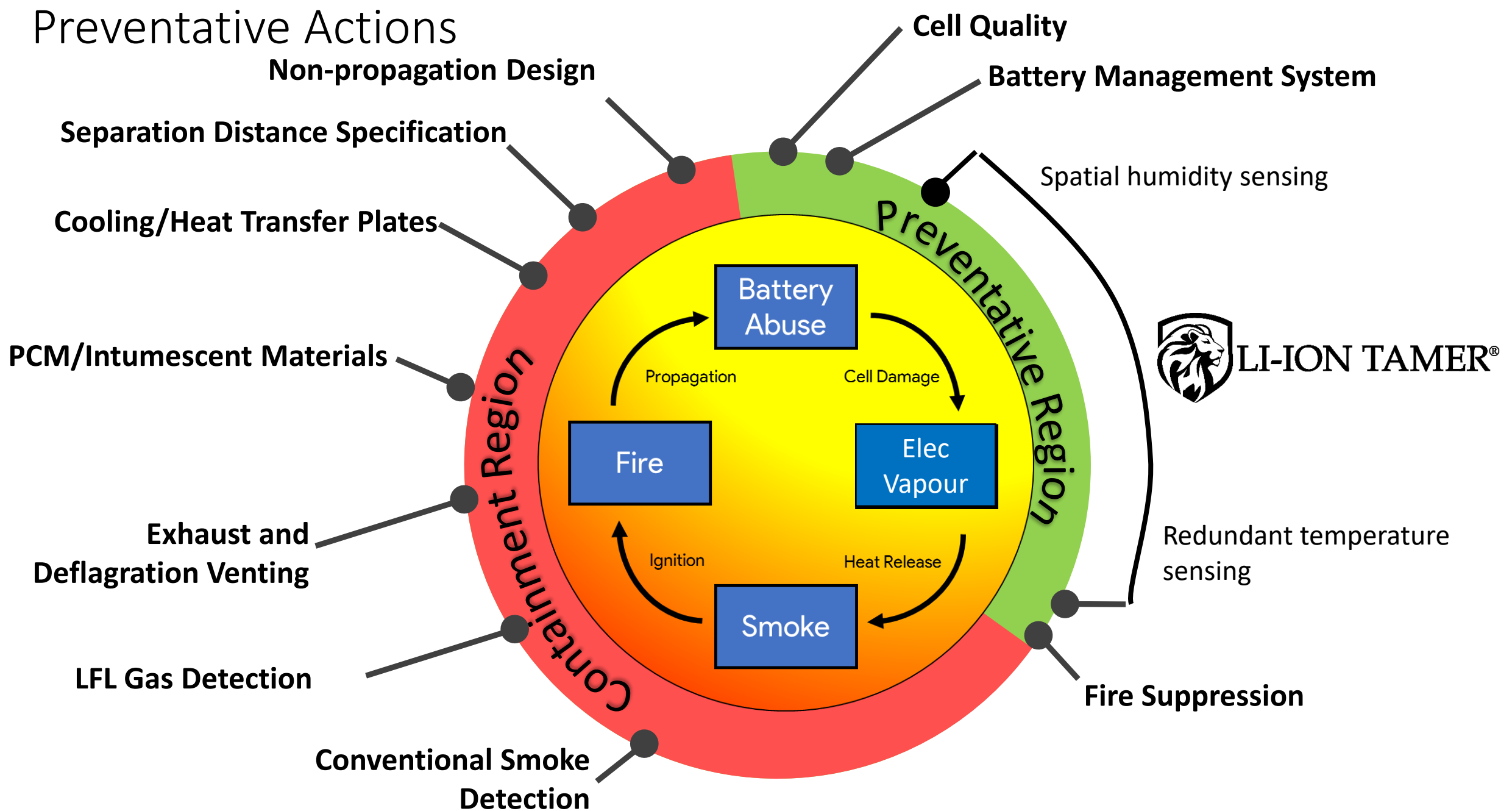
Battery Management System

Spatial humidity sensing

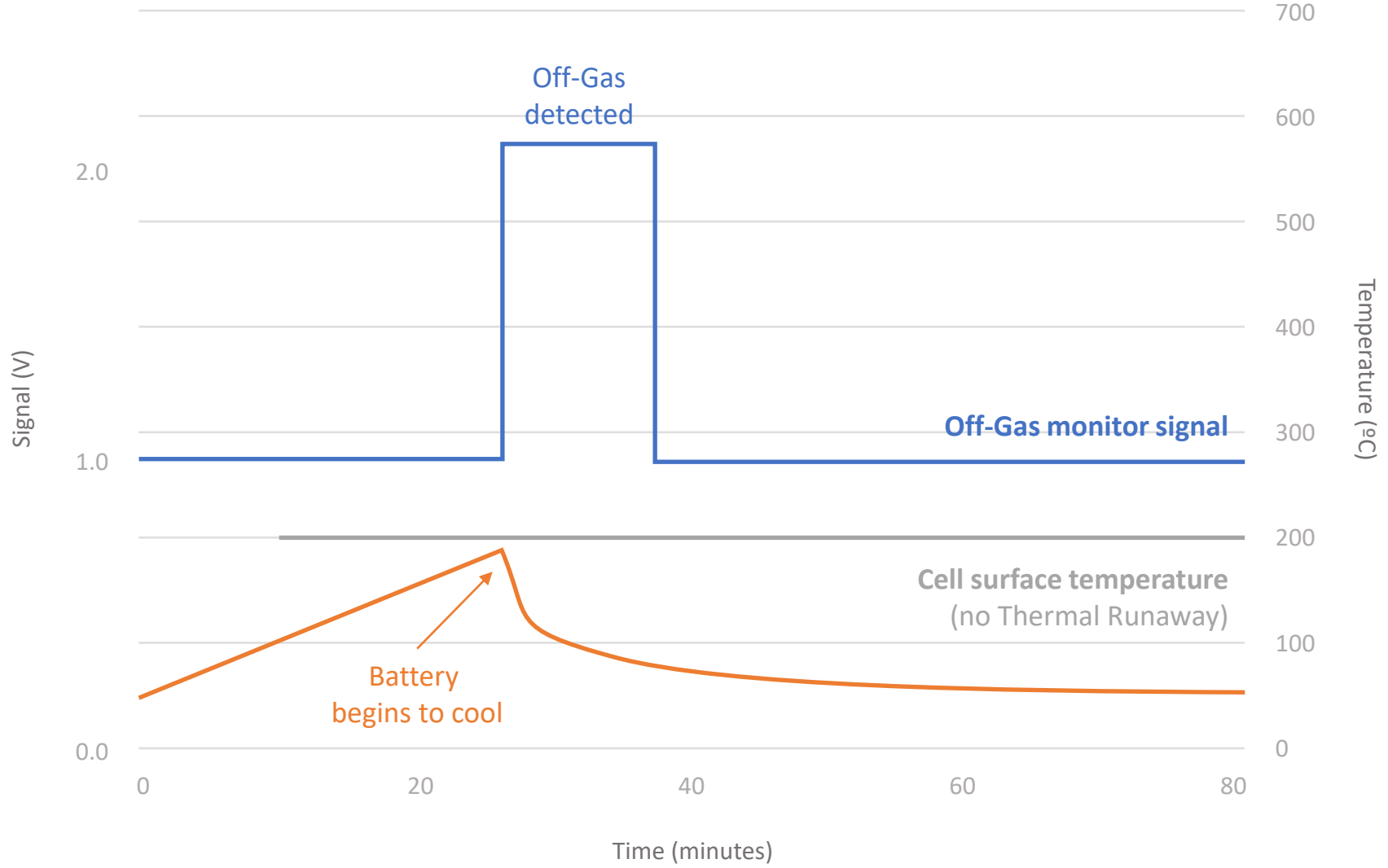


Redundant temperature sensing

Fire Suppression

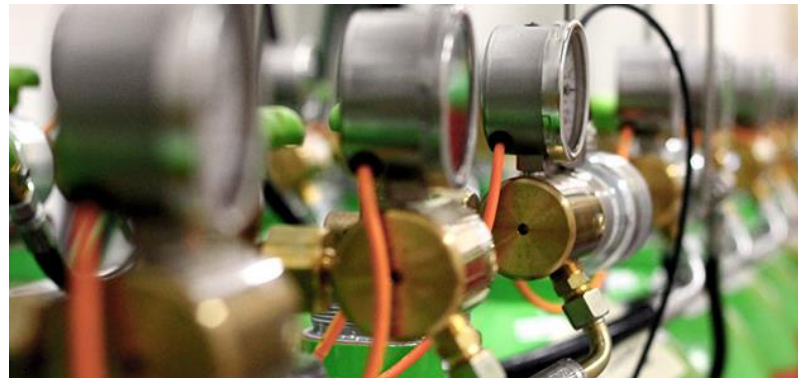


The Lithium-Ion risk prevention solution



DIFFERENT EXTINGUISHING METHODS

- Inergen
- Novec
- CO2



EXTINGUISHING WITH INERGEN

- Reduce oxygen level from 21% to under 15% (11%)
- Still safe to be inside the space



EXTINGUISHING WITH NOVEC

- Reduce the temperature fast (10 sek)
- "Dry water" don't harm any electronics
- Still harmless to be inside the test space
- Lower pressure, 25bar or 42bar,



EXTINGUISHING WITH CO2

- Reduce the temperature fast
- Reduce the oxygen
- Don't harm any electronics
- Good in small and leakly spaces
- Dangerous to inhale!, stop breathing!





Thank You!