FirePro.

Reinventing
Fire Suppression

Battery Tech Expo – Sweden 28th September 2023

Craig Nixon BDM
FirePro Systems

Company Profile

FirePro came to prominence in the fire fighting industry, following the Montreal Protocol finalized in 1987 and the Clean Air Act of 1990 on ozone depleting substances that banned the use of Halon 1301 fire extinguishing agent - the universally accepted and most widely used at the time.

- FirePro Systems Ltd established in 1996
- HQ & Manufacturing Facilities in Cyprus
- A Halma Company

- Distributors in 90 countries
- Installations in 110 countries

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Distribution Network

EUROPE

Albania
Austria
Belgium
Bulgaria
Croatia
Cyprus
Czech Rep.
Denmark
Estonia
Finland
France
Georgia
Germany
Greece
Hungary
Iceland
Ireland
Italy
Latvia
Lithuania
Luxembourg
Malta
Netherlands
Norway
Poland
Portugal
Romania
Serbia
Slovakia
Spain
Sweden
Switzerland
Turkey
United Kingdom

AMERICAS

Argentina
Brazil
Canada
Chile
Colombia
Mexico
Peru
Uruguay
U.S.A.

GULF & MIDDLE EAST

Bahrain
Iraq
Jordan
Kuwait
Saudi Arabia
Lebanon
Oman
Qatar
U.A.E.

ASIA & OCEANIA

Australia
Bangladesh
China
Hong Kong
India
Indonesia
Malaysia
Myanmar
New Zealand
Pakistan
Philippines
Singapore
South Korea
Sri Lanka
Taiwan
Thailand
Vietnam

AFRICA

Botswana
Congo
Egypt
Ghana
Kenya
Mauritius
Morocco
Nigeria
South Africa
Sudan
Tanzania
Tunisia

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SWEDEN – Channel Partners

HEAD OFFICE

Industrigatan 14A 511 62 Skene

https://x-fire.se/

info@x-fire.se

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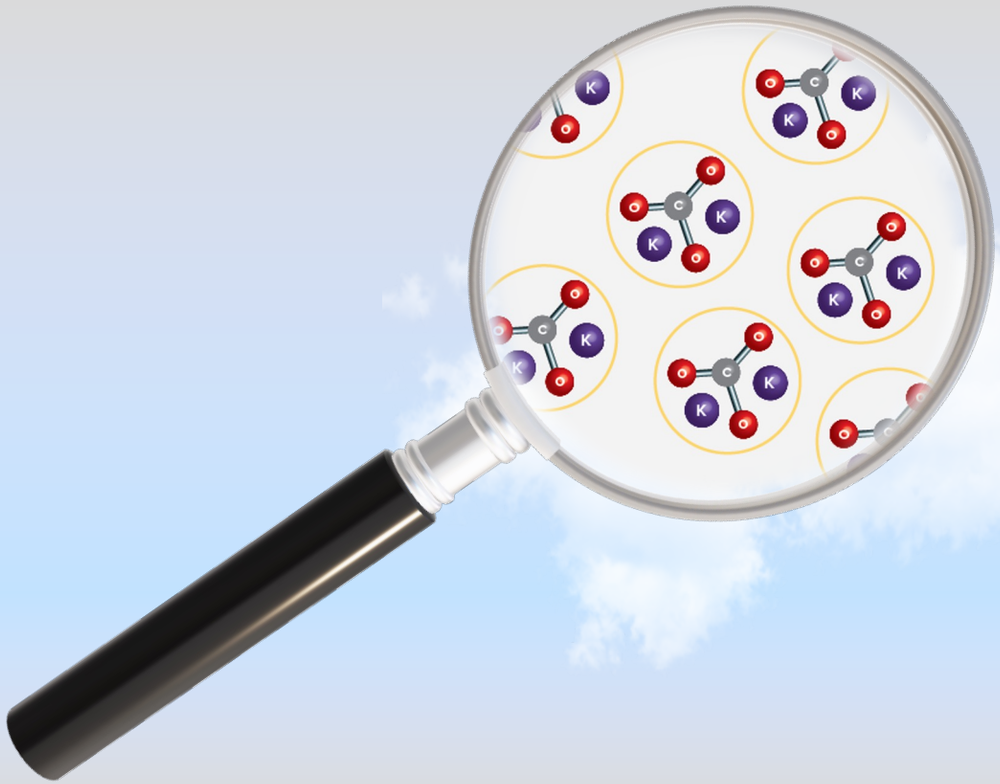
What is Aerosol?

Definition:

- Aerosol: A colloidal suspension of particles dispersed in air or gas(es)
- Colloids: Particles with diameter of a few microns – nanometers



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Solid Aerosol Forming Compound (FPC)

- Compact - strong solid
- Certified Lifetime – 15 years
- Transformed into Aerosol upon activation (electrical or thermal)
- Exothermic transformation process
- Self-activation Temperature + 300 °C

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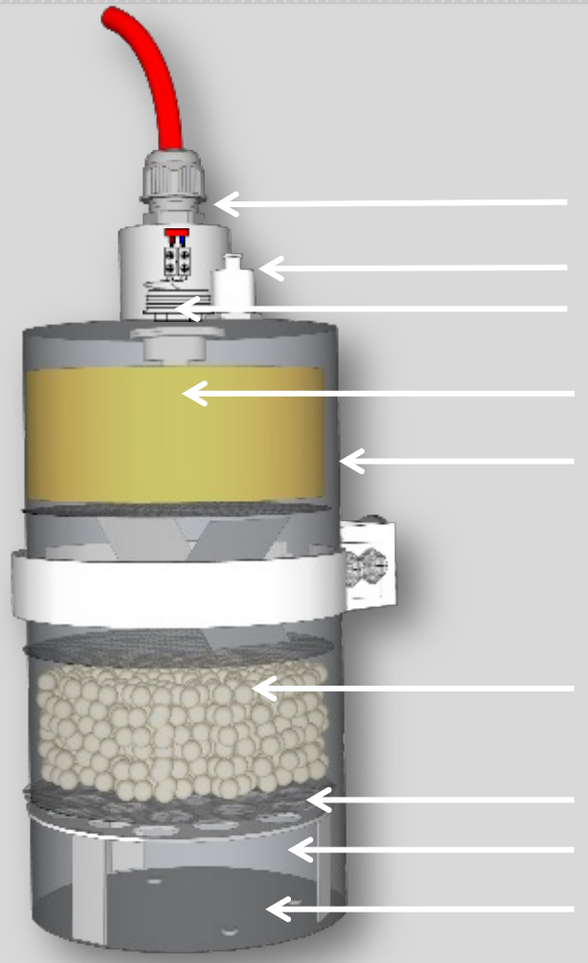
FirePro Condensed Aerosol Generator



Cable Connection Port

Thermal Actuator Port
Electrical Actuator

Solid Aerosol Forming Compound

Stainless Steel Casing

Heat Absorbing Medium & Filter

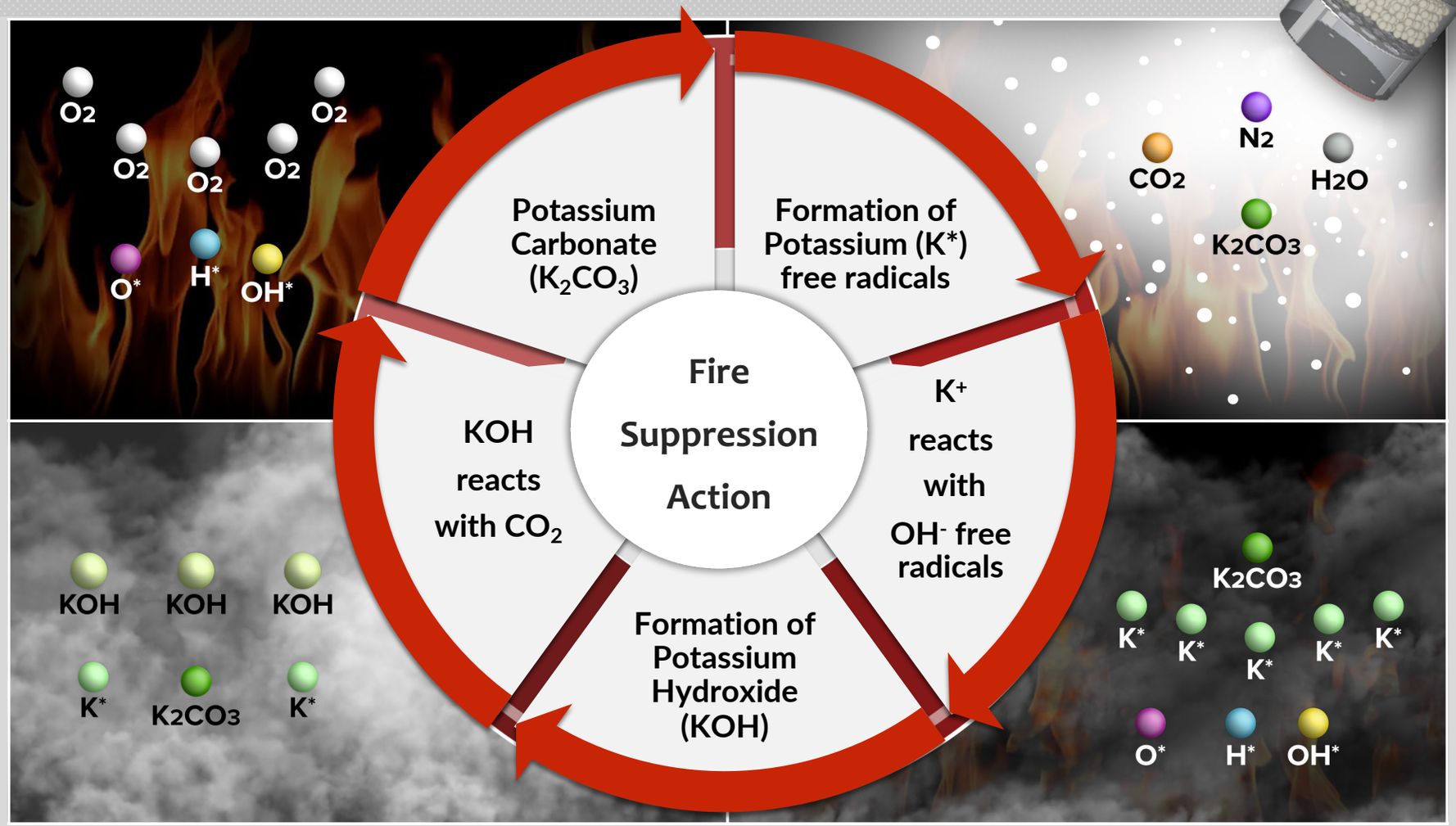
Sealant

Egress Chamber

Discharge Outlet

FirePro.

FirePro Fire Suppression Action



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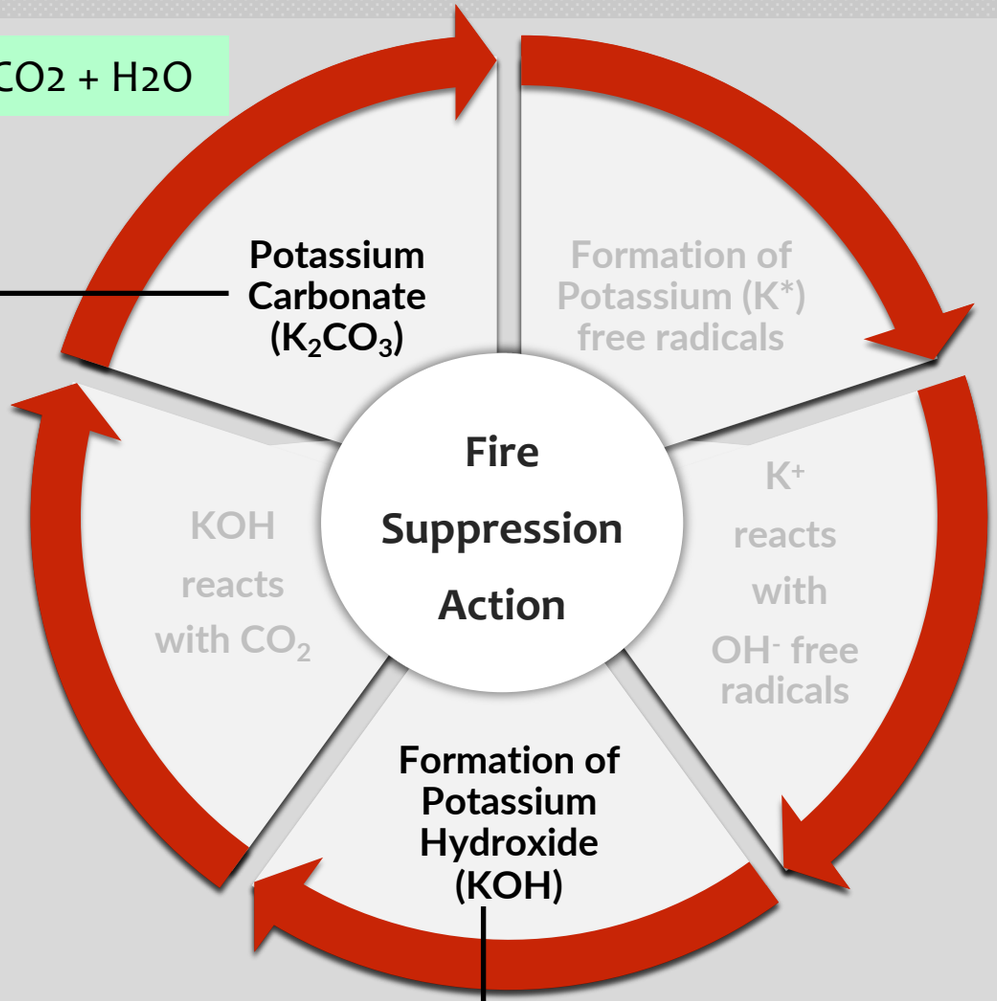
FirePro neutralizes electrolyte decomposition gases

$K_2CO_3 + 4HF \rightarrow 2KHF_2(s) + CO_2 + H_2O$



$KOH + HF \rightarrow KF(s) + H_2O$

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Range of Products

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FirePro technology Listings & Approvals

FOR LAND APPLICATIONS (1/2):

Organization
UL - Underwriters Laboratories
Certification Protocol
ANSI/CAN/UL/ ULC 2775 – Fixed Condensed Aerosol Extinguishing Units
Reference
FWSA.EX6960

Organization
ULC - Underwriters Laboratories of Canada
Certification Protocol
ANSI/CAN/UL/ ULC 2775 – Fixed Condensed Aerosol Extinguishing Units
Reference
FWSA7.EX6960

Organization
BSI - British Standards Institution
Certification Protocol
BS EN 15276 Condensed aerosol extinguishing systems
Reference
Kitemark License Number KM 738886

Organization
KIWA NV
Certification Protocol
BRL-K23001/06 Aerosol Generating Fire Extinguishing System Units
Reference
Product Certificate K21774

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FirePro technology Listings & Approvals

FOR LAND APPLICATIONS (2/2):

Organization
CSIRO - Commonwealth Scientific & Industrial Research
Certification Protocol
AS 4487-2013 & UL 2775 Fixed Condensed Aerosol Extinguishing Units
Reference
ActivFire Certificate of Conformity afp-2286

Organization
CNBOP PIB - Scientific & Research Center for Fire Protection
Certification Protocol
EN 15276-1:2019 Condensed Aerosol Fire Extinguishing Systems
Reference
Certificate of Constancy of Performance NR. 063-UWB-0098

Organization
KFI - Korea Fire Institute
Certification Protocol
Guideline for the Automatic Condensed Aerosol Fire Extinguisher
Reference
Sogong 15-23-1

Organization
VdS Schadenverhütung GmbH
Certification Protocol
VdS 2344:2014-07 &
VdS 2562:2013-03
Reference
G 622001

Organization
Global Mark
Certification Protocol
AS 4487-2013 Condensed aerosol fire extinguishing systems
Reference
FEF98B76945B5795CA258
82A0026592A

Organization
LPCB – Loss Prevention Certification Board
Certification Protocol
LPS 1656: Issue 1.0
Reference
1417a Issue:03
1417b Issue:02

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Health Safety and Environment

Ozone Depletion Potential (ODP):	Zero *(EPA-SNAP Listed for Occupied spaces)*
Global Warming Potential (GWP):	Zero
Atmospheric Lifetime (ALT):	Negligible
Oxygen Depletion:	None

MANAGEMENT SYSTEM CERTIFICATION
DNV
ISO 9001 = ISO 14001

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

SNAP
SIGNIFICANT · NEW · ALTERNATIVES · POLICY

GLOBAL ECOLABELLING NETWORK ™

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Applications

ELECTRICAL

- Electrical Switchgear & Panels
- Electrical and Control Rooms
- Transformer Rooms and Substations
- Diesel Generator Rooms and Gen-sets
- Batteries & Energy Storage Systems
- Cable Tunnels and Service Ways
- Wind Turbines

MECHANICAL

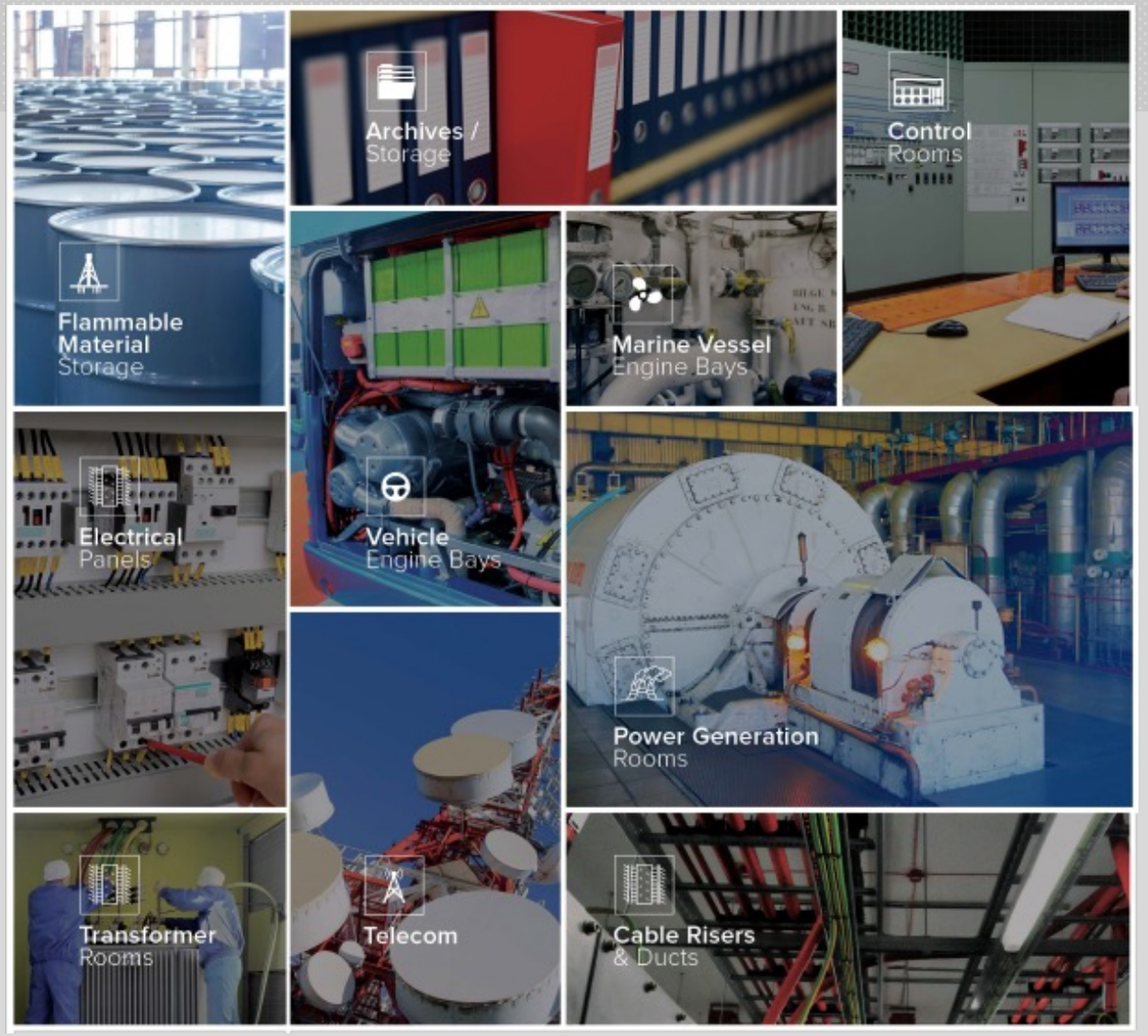
- Machinery Spaces / Plant Rooms
- Machine Tools (CNC and Lathing machines)
- Lifting Cranes
- Marine Engine Bays
- Electric Vehicle Engine Bays
- Railway (Rolling Stock and Infrastructures)

STORAGE

- Document Archives
- Bank Vaults
- Automated Storage Equipment
- Warehouses

INDUSTRIAL PROCESSING AREAS & EQUIPMENT

- Chemical Laboratories
- Paint Spray Booths
- Soldering Stations
- Medical Equipment
- Industrial Filters and Ducts



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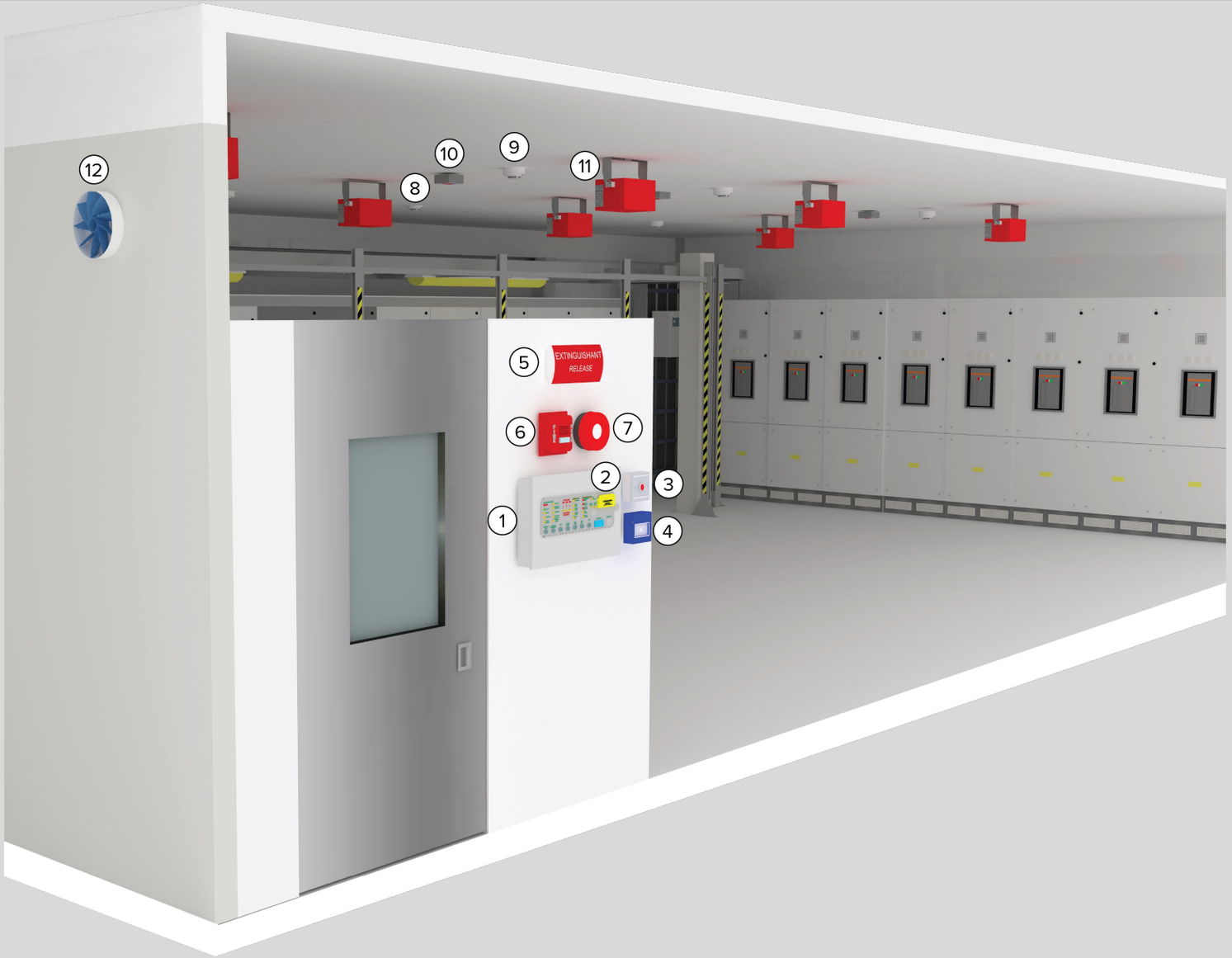
Room Flooding System



1. Extinguishing Control Panel
2. Manual Release Button
3. Emergency Hold Device
4. System Isolation Switch
5. Gas Release Sign
6. 2nd Stage Sounder (Horn Strobe)
7. 1st Stage Sounder (Bell)
8. Heat Detector (Zone 2)
9. Smoke Detector (Zone 1)
10. Sequential Activator
11. Aerosol Generator
12. Interlock with extractor fans or fire dampers

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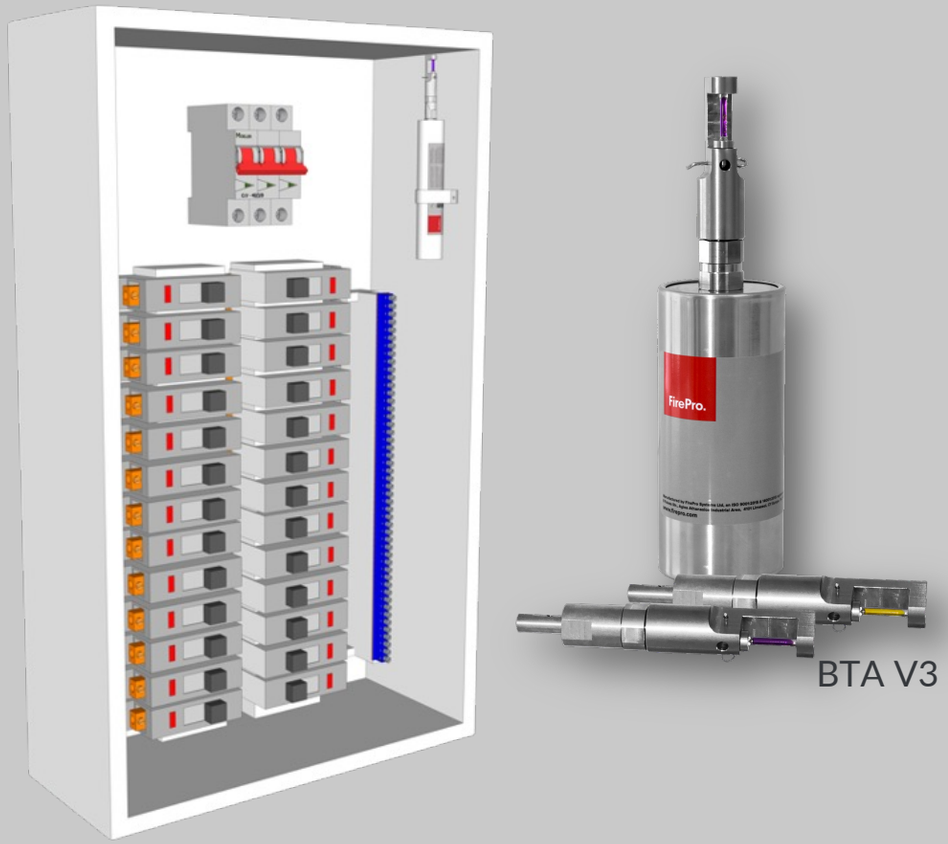
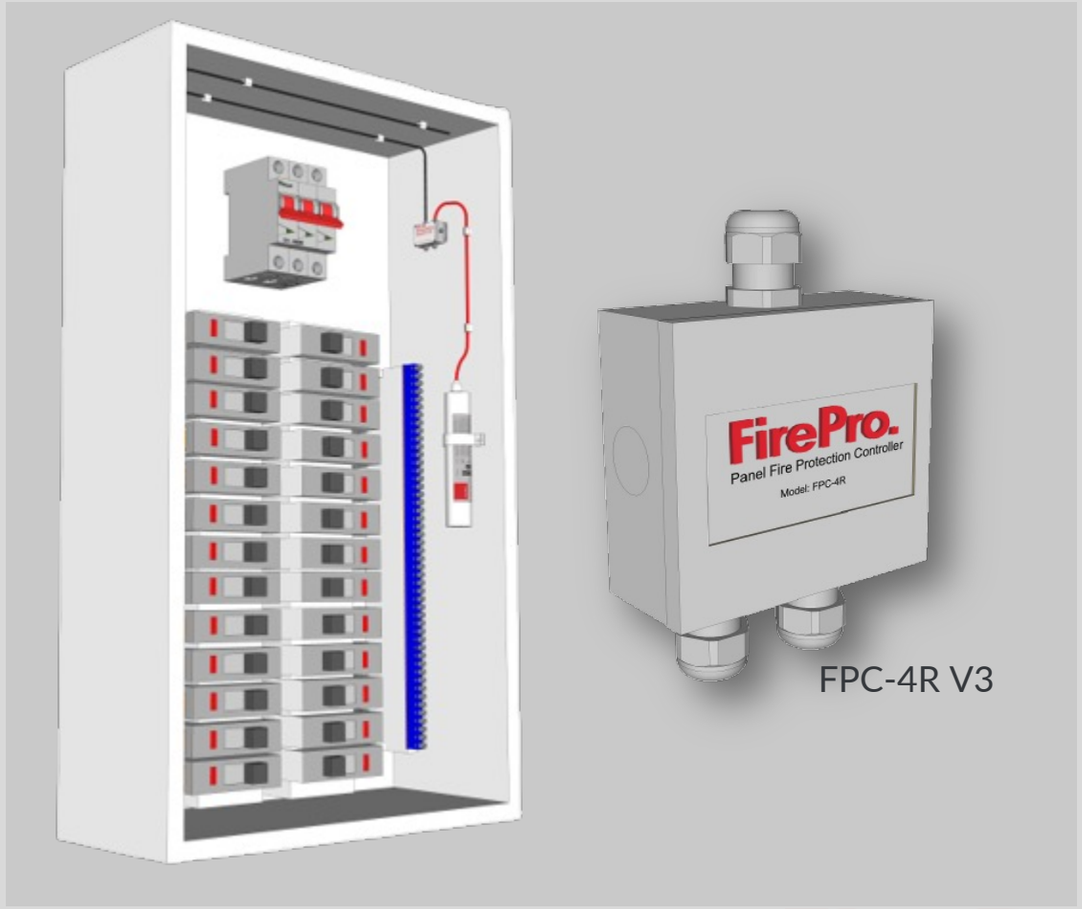
Protection of Small Enclosures

BTA – thermal-mechanical detection & activation



BTA V3

FPC-4R – thermal-electrical detection & activation



FPC-4R V3

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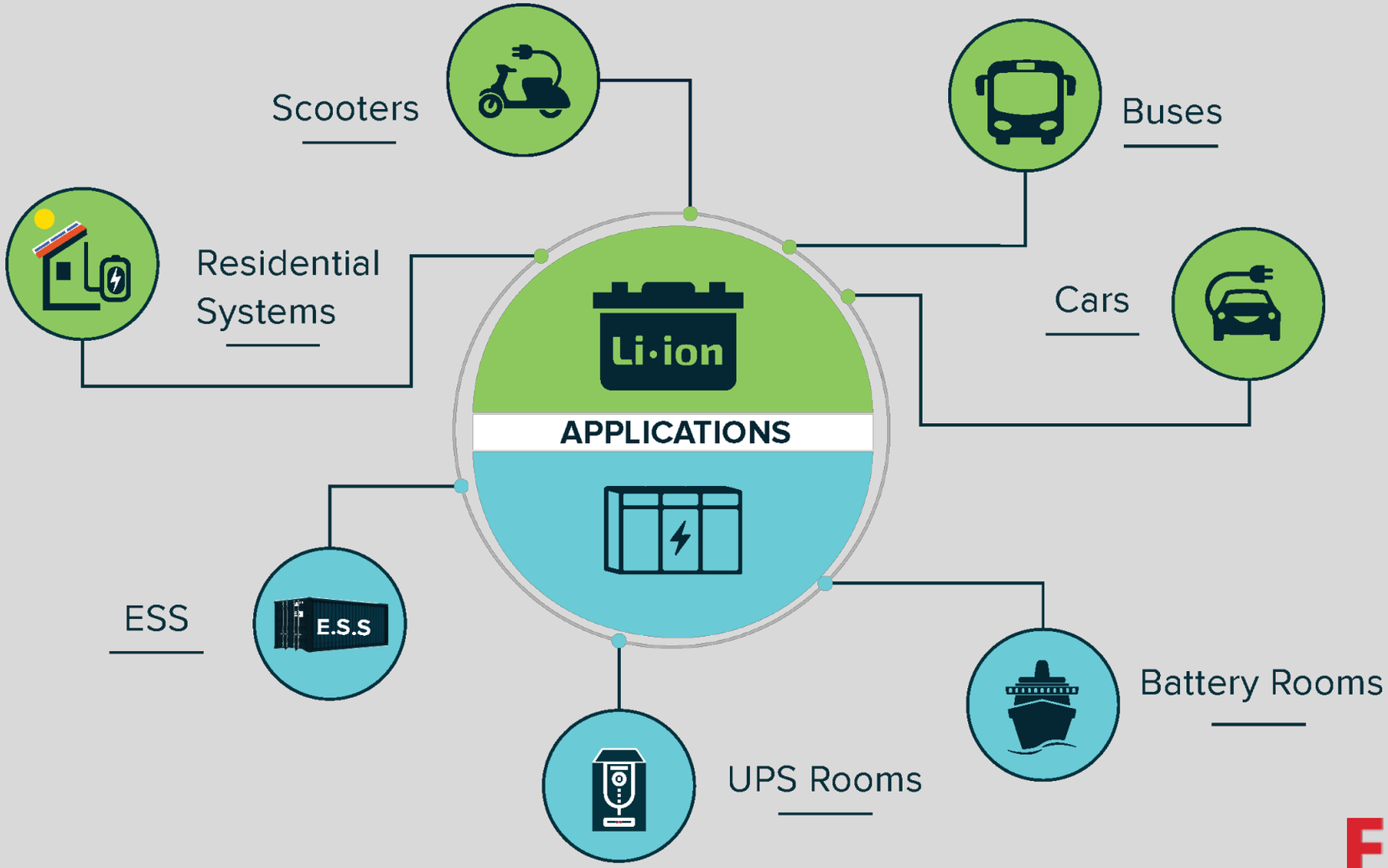
Common Lithium-Ion Applications



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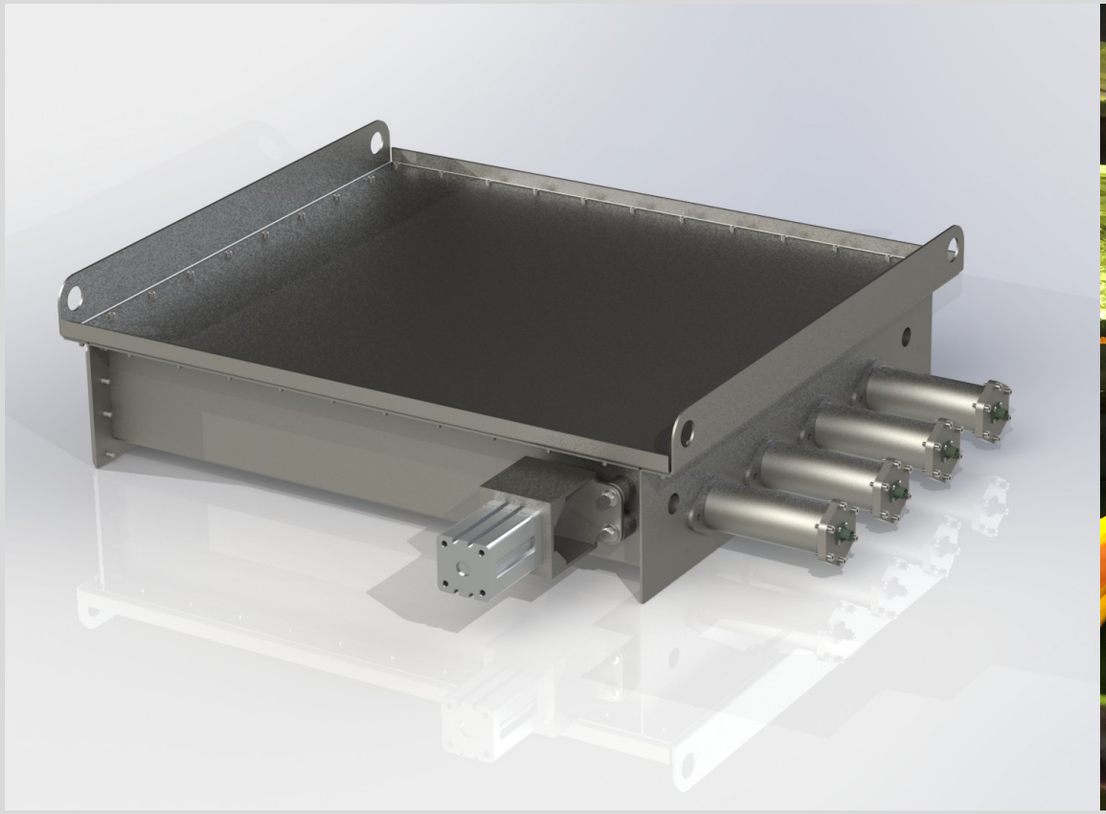
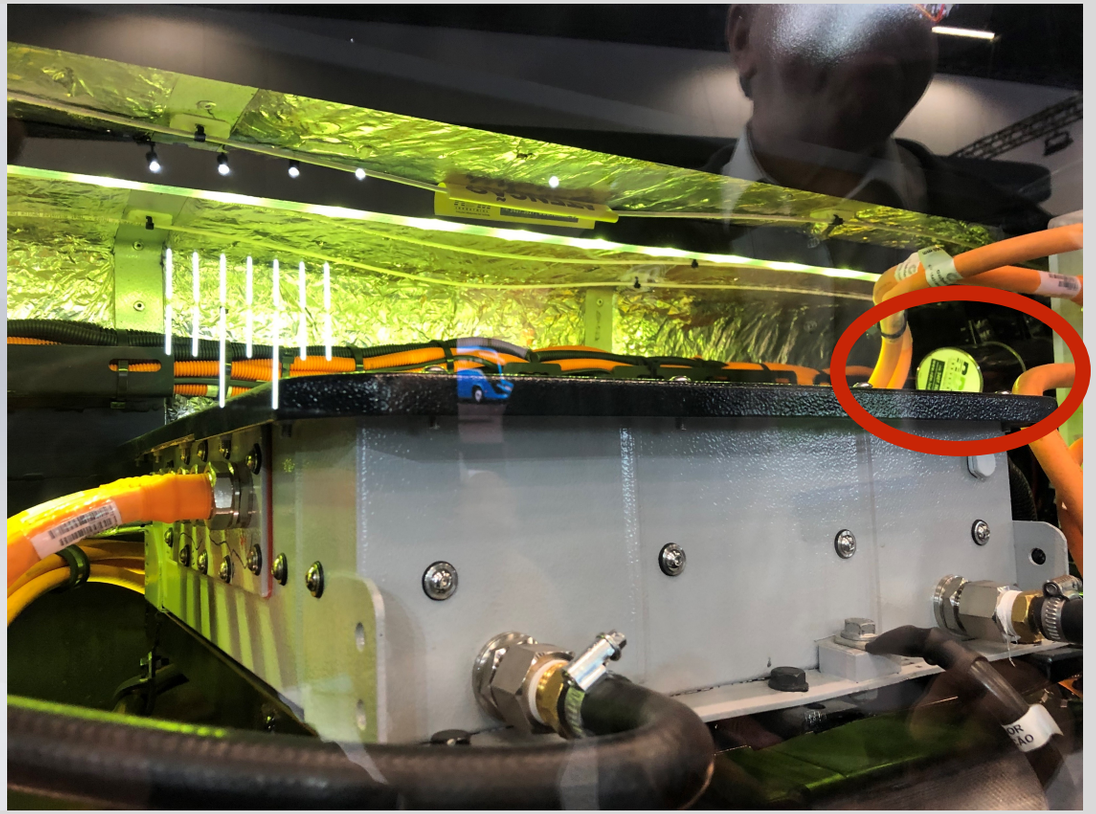
E-buses - Protection is Inside the Battery Pack





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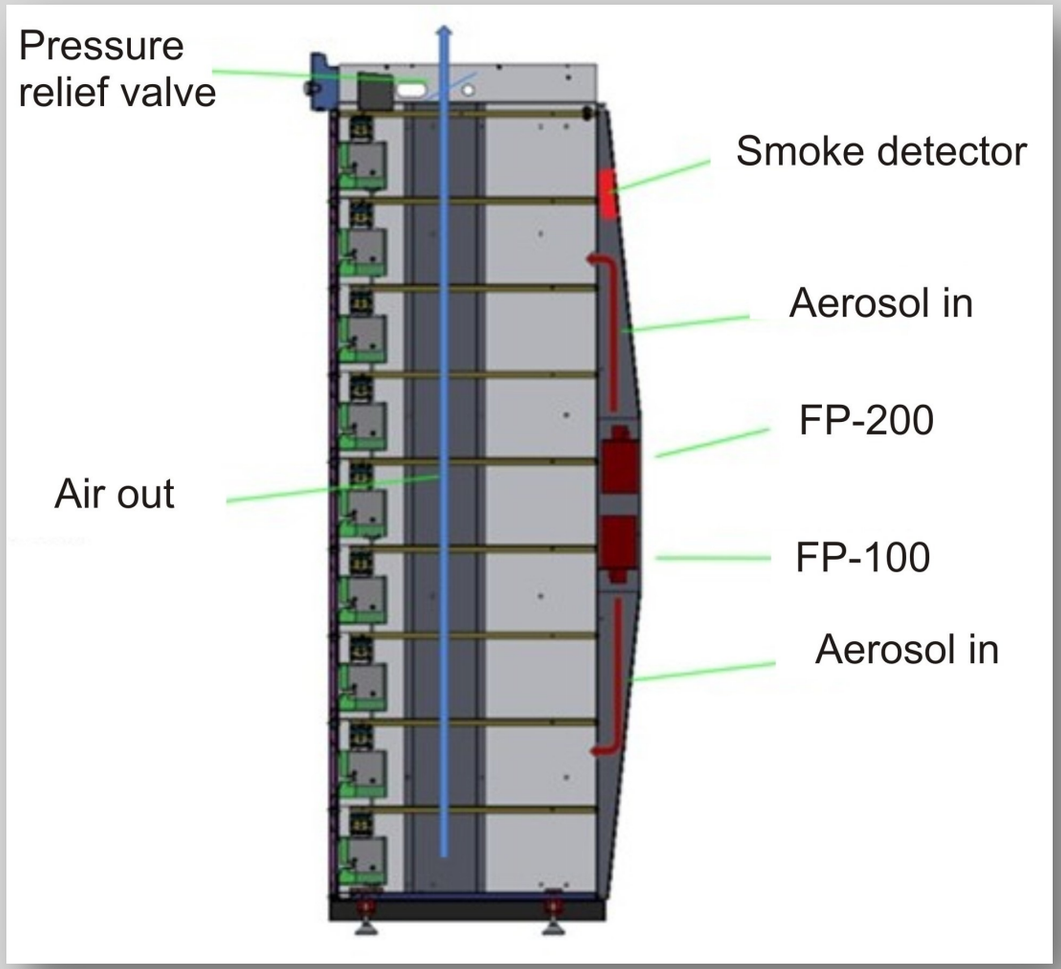
Li-Ion Battery Charging Cabinet / Station



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Research & Development

Currently no definite international standard or approval for Lithium-Ion risk. Therefore, actual testing needs to be done.

FirePro's Research & Development program on Lithium-Ion battery fires involves extensive testing since 2016 in several countries such as the Netherlands, Italy, S. Korea and Hungary.

The tests have been conducted in cooperation with battery manufacturers, accredited laboratories and certification bodies.

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Test 1 – Lithium-Ion Battery fire test (Netherlands - 2016)

- Tests performed at Twente Safety Campus, Oude Vliegveldweg, Deurmingen, Netherlands (2016)
- Witnessed by KIWA Netherland BV
- Test enclosure: 40ft container
- Several cradles, squire and round containers/bins/other objects were placed in order to create a realistic test and to be able to determine any adverse effect on surrounding materials.
- Battery manufacturer Cleantron, capacity: 1.9 kWh fully charged
- Lithium battery inside a synthetic barrel
- Thermal reaction was started with a glow plug

3.2.4 *Results*

The results of the tests are as follows:

Test-01_Lithium_40-feet-container_13-10-2016

kiwa
Partner for progress

Wednesday, December 7, 2016

Final report

Kiwa 161000995

Report of fire tests on Li-ion batteries based on condensed aerosol

Colofon

Title	Report of fire tests on Li-ion batteries based on condensed aerosol
Project Number	161000995
Date	Concept; Friday, November 11, 2016 Final; Wednesday, December 7, 2016
Pages	14, including this page
Project Manager	E.V. Teubler
Contractor	Fire Safety 4 You B.V.
Contact Person	R.G.C. Reijns
Quality Assurance	P.E. Voshol
Auteur(s)	E.V. Teubler

This report is not publicly available, but distributed only to the client(s) who commissioned this project. Distribution of the report is done only by and under responsibility of the client. This report is exclusively related to the tests as mentioned in this report and performed and/or witnessed by Kiwa.
Kiwa Nederland B.V. is not to blame for any incorrect interpretation or reproduction of data for the under this report delivered data.

Signature:

E.V. Teubler
Product Manager

Kiwa Nederland B.V.
PO box 510
3430 AM Nieuwegein
The Netherlands
www.kiwafss.nl

RESULTS: ***"A FirePro condensed aerosol system is able to achieve suppression and control mode over a period of at least 30 minutes, after ignition of a single 1.9KWh Cleantron battery, with an actual aerosol density of 61 grams per cubic meter."***

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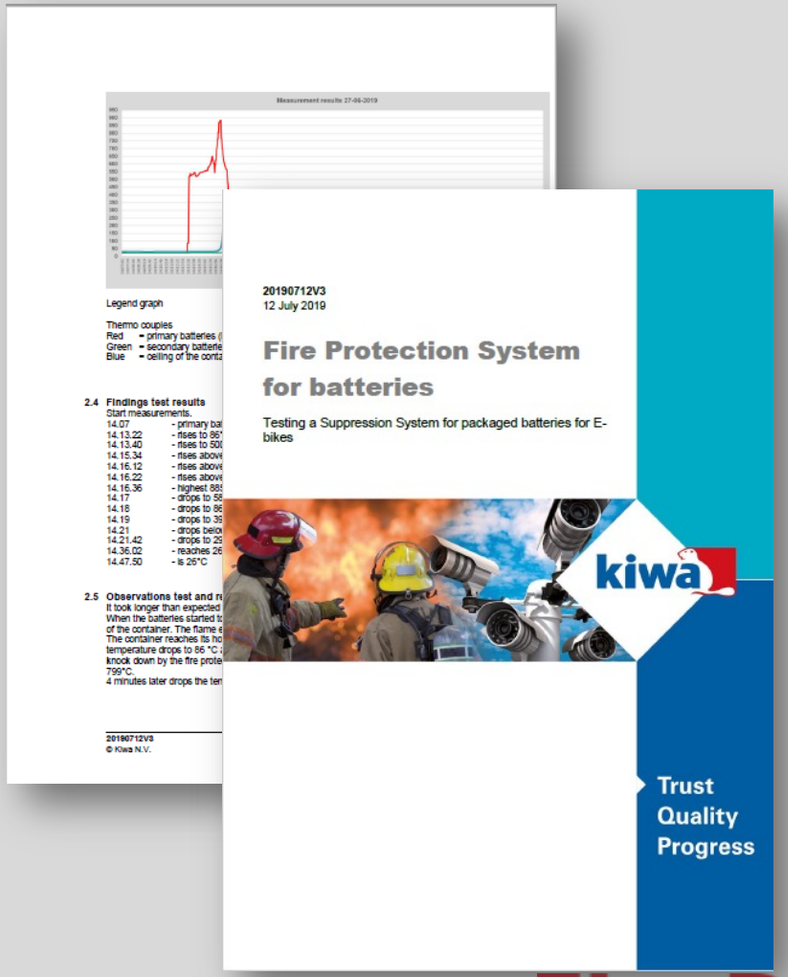
KIWA Report – Report of fire tests on Li-ion batteries based on condensed aerosol (2016)

Test 2 – Lithium-Ion Battery fire test (Netherlands - 2019)

- Tests performed at RelyOn Nutec Fire Academy test site, Rotterdam, Netherlands (2019)
- Witnessed by KIWA Fire Safety & Security
- Test enclosure: 40 ft metal container
- Lithium-Ion batteries on pallets: 144 x (36V/14.5Ah) – 2088 Ah
- Start battery burning process with heating plug

RESULTS: ***"…demonstrates the performance of the fire protection system to suppress and control this type of fire scenarios if the density of the medium is (kept) sufficient."***



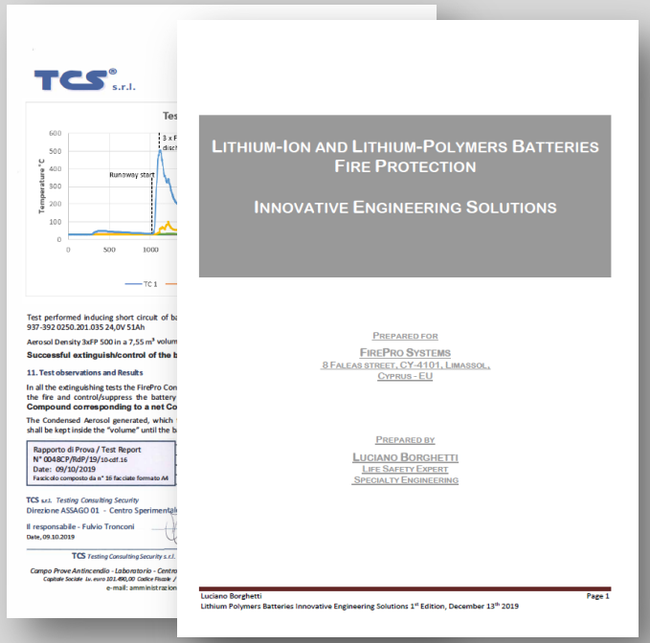
KIWA Report – Testing a Suppression System for packaged batteries for E-bikes (2019)

Test 2 – Lithium-Ion Battery fire test (Netherlands - 2019)

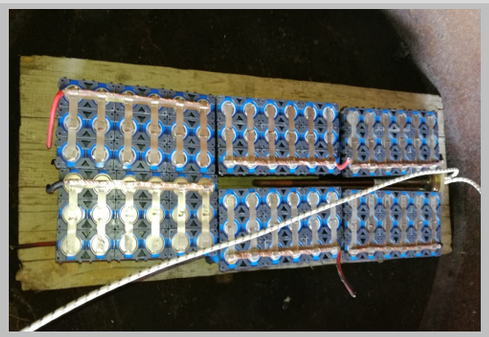
FirePro.

Test 3 – Lithium-Ion Battery fire tests (Italy - 2019)

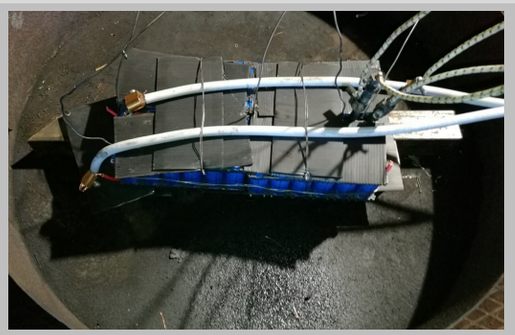
- Tests performed at TCS Testing Consulting Security SRL Test Facilities, Italy (2019)
- No of tests: around 50 tests
- Test enclosure: 7.55 m^3
- Battery type: Lithium Iron Phosphate battery $LiFePO_4$ 26650 – 3.2V 3.3Ah
- Thermal runaway induced by overcharging, forced discharge, heating devices (glow plugs, electric coils), short circuit



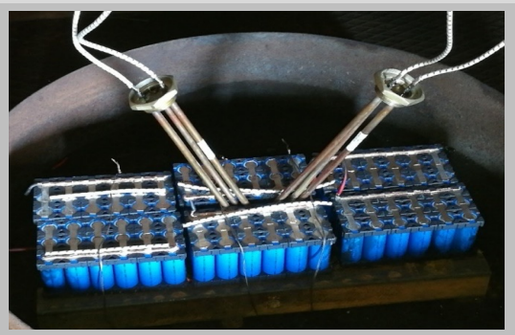
White Paper – Lithium-ion and Lithium-Polymers Batteries Fire Protection Innovative Engineering Solutions (2019)



Battery pack and power connecting wiring



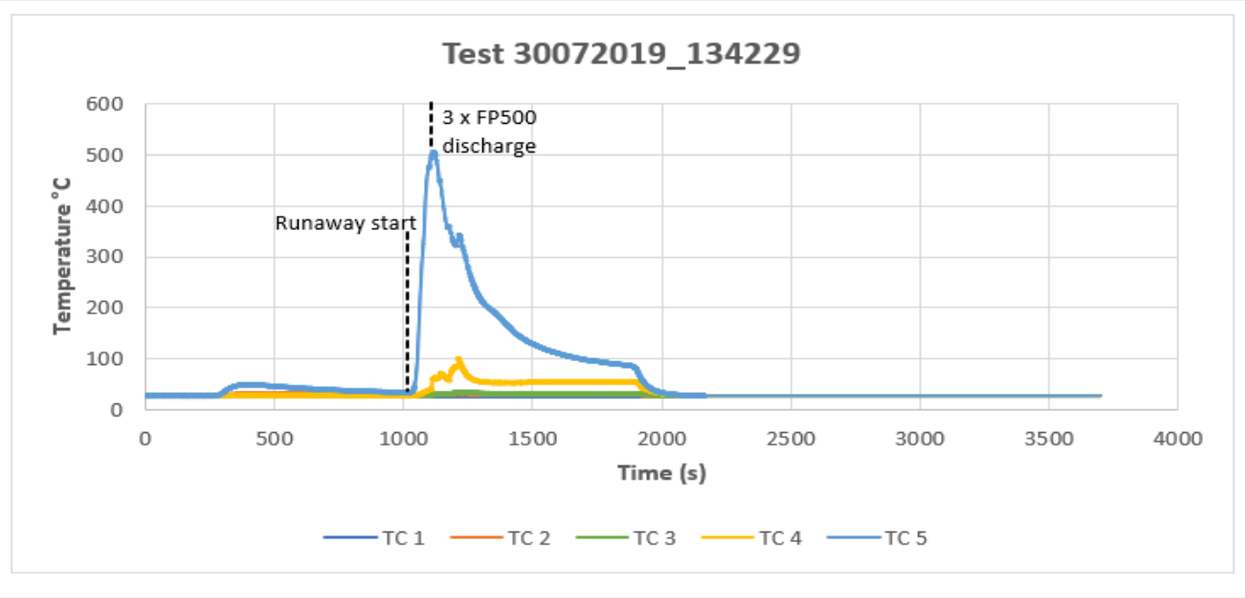
Battery pack power connecting wiring glow plugs



Electric heating coil TERMOWATT 3000W set-up

Battery cells aggregate after extinguishing/ controlling the runaway

Test 3 – Lithium-Ion Battery fire tests (Italy - 2019)



RESULTS: *"In all the extinguishing tests the FirePro Condensed Aerosol Technology demonstrated the capability to extinguish the fire and control/suppress the battery runaway utilizing an Aerosol Density of 200 g/m³ of Solid Compound corresponding to a net Condensed Aerosol 130 g/m³."*

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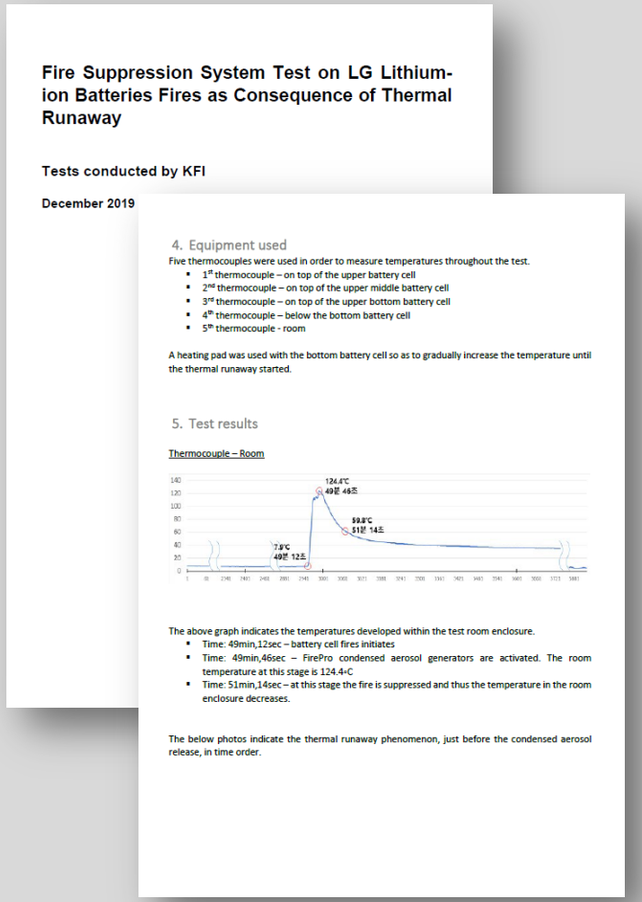
White Paper – Lithium-ion and Lithium-Polymers Batteries Fire Protection Innovative Engineering Solutions (2019)

Test 4 – Lithium-Ion Battery fire test (Korea - 2019)

- Tests conducted by the Korean Fire Institute (KFI) (2019)
- Test enclosure: 2.84m x 2.23m x 2.34m = 14.82 m^3
- LG-Chem Lithium-Ion battery cells (3 tightly packed cells)
- Cell type: pouch (310mm x 95mm x 15mm), Capacity 54Ah (normal) – for this test samples 64Ah, Energy: 0.2214 kWh, Nominal voltage: 4.1 V
- A heating pad was used with the bottom battery cell so as to gradually increase the temperature until the thermal runaway started



Fire Suppression System Test on LG Lithium-ion Batteries Fires as Consequence of Thermal Runaway

Tests conducted by KFI

December 2019

4. Equipment used

Five thermocouples were used in order to measure temperatures throughout the test.

- 1st thermocouple – on top of the upper battery cell
- 2nd thermocouple – on top of the upper middle battery cell
- 3rd thermocouple – on top of the upper bottom battery cell
- 4th thermocouple – below the bottom battery cell
- 5th thermocouple - room

A heating pad was used with the bottom battery cell so as to gradually increase the temperature until the thermal runaway started.

5. Test results

Thermocouple – Room

The above graph indicates the temperatures developed within the test room enclosure.

- Time: 49min,12sec – battery cell fires initiates
- Time: 49min,46sec – FirePro condensed aerosol generators are activated. The room temperature at this stage is 124.4◦C
- Time: 51min,14sec – at this stage the fire is suppressed and thus the temperature in the room enclosure decreases.

The below photos indicate the thermal runaway phenomenon, just before the condensed aerosol release, in time order.

RESULTS: ***"Based on the results, the fire was successfully suppressed, and no re-ignition occurred for the remaining 50 min of the test. FirePro condensed aerosol technology managed to suppress and control the li-ion battery fire successfully, with a gross extinguishing density of 200 g/m^3."***

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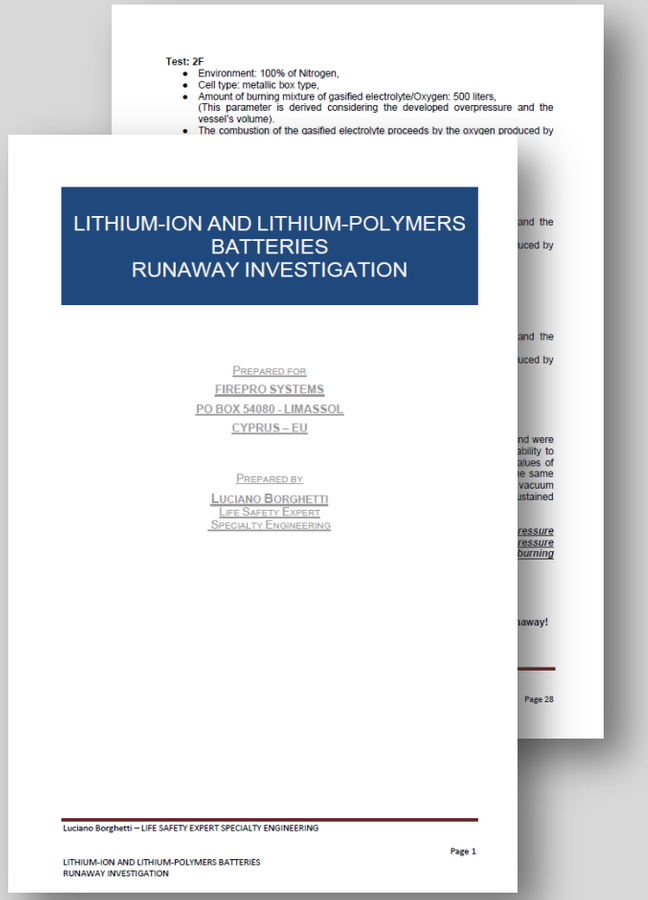
Test Report – Fire Suppression System Test on LG Lithium-ion Batteries Fires as Consequence of Thermal Runaway (2019)

Test 5 – Lithium-Ion / Li-Polymer Thermal Runaway tests (Italy - 2020)

- Test performed at AlbaRubens srl Test Facilities located in Scaparina Italy, 2020
- Test enclosures: steel reinforced concrete construction, high pressure safety test vessel, vertical steel mesh vessel cylindrical shape
- Battery types: Lithium-Ion and Lithium-Polymer Cells
- Cell types: pouch, metallic box type, cylindrical
- Thermal runaway induced by overcharging the cell



RESULTS: ***"In all extinguishing tests the FirePro Condensed Aerosol Technology demonstrated the capability to extinguish the fire and control/suppress the battery thermal runaway by utilizing an Aerosol Density of 200 g/m^3 of Solid Compound which corresponds to a net Condensed Aerosol of 130 g/m^3."***

White Paper – Lithium-Ion and Lithium-Polymers Batteries Runaway Investigation (2020)

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Summary

- Lithium-Ion batteries pose fire risks because of the high amount of energy stored in their cells.
- The intensity of the fire is significantly higher than the energy stored in the batteries.
- Mechanical damage, electric defects, abuse charging or high ambient temperature are some of the reasons causing battery thermal runaway.
- Thermal runaway causes the overheating of the battery, leading to the release of gases, vapours and smoke followed by potent fires and occasionally explosions.
- Lithium-Ion batteries vary in terms of construction materials, chemistry, and configuration. They also vary in terms of behaviour in a thermal-runaway scenario.
- The effectiveness of condensed aerosol technology in suppressing and controlling Lithium-Ion battery fires, has undergone numerous tests and is proven to be effective in suppressing the fire and controlling the propagation of thermal runaway.

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Application: Energy Storage Systems Industry: Energy

Kokam

LG
Life's Good

FLUENCE
A Siemens and AES Company

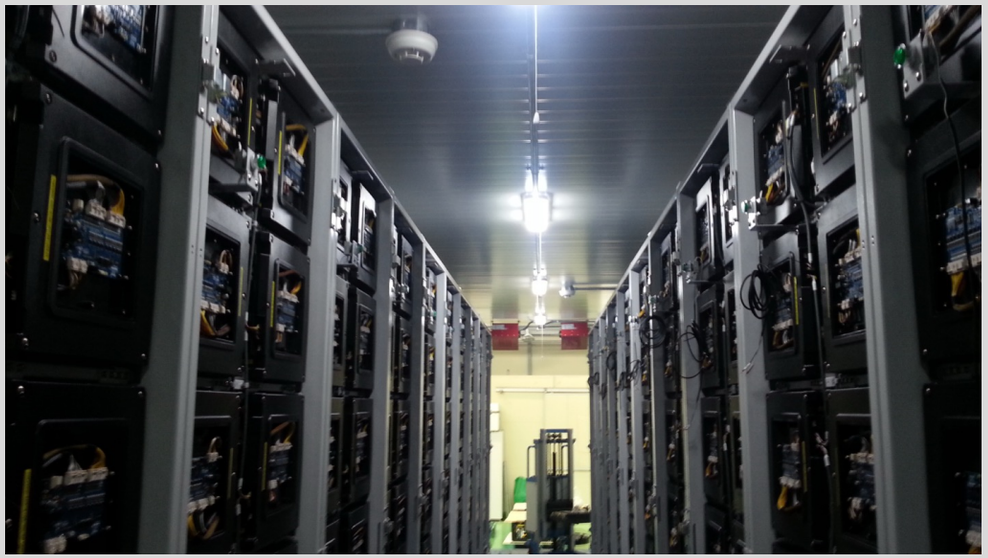
LARSEN & TOUBRO
It's all about Imagineering

Entech
smart energies

SAMSUNG
SAMSUNG SDI

AMPD
ENERGY

GE



Samsung SDI -Korea

Location: Asia

Application: Energy Storage System

Industry: Custom R&D

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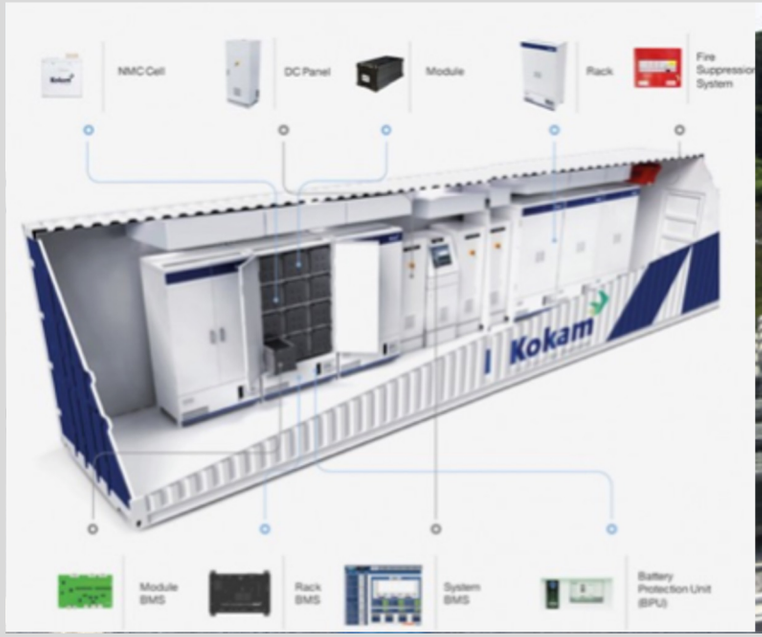
Kokam Co.

Location: Asia

Application: Energy Storage Systems, High Voltage Rooms

System Industry: Renewable Energy



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Mobility Scooter

Location: Europe

Application: Electric Vehicles

System Industry: Custom R&D

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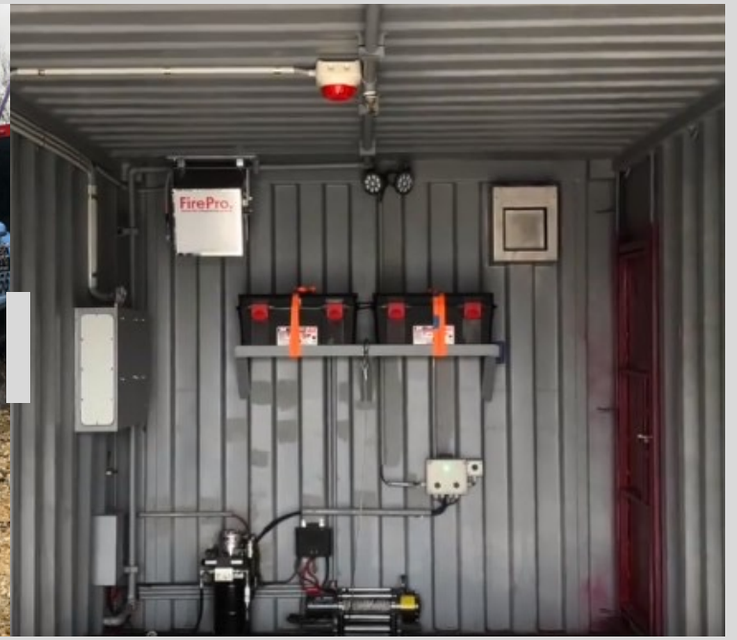
Salvage Containers Netherlands

Location: Europe

Application: Containers for transporting Electrical Vehicles

Industry: Recycling



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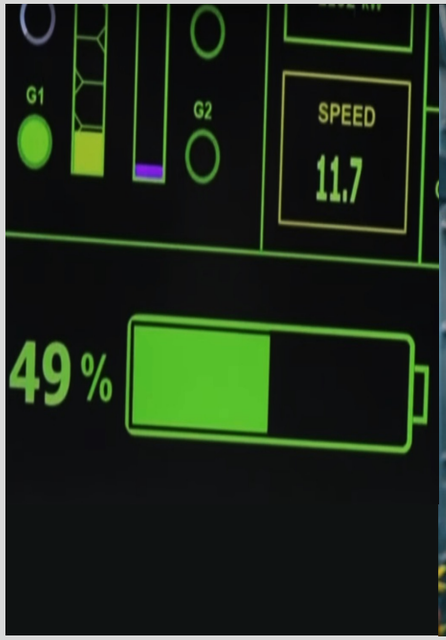
ForSea - Aurora

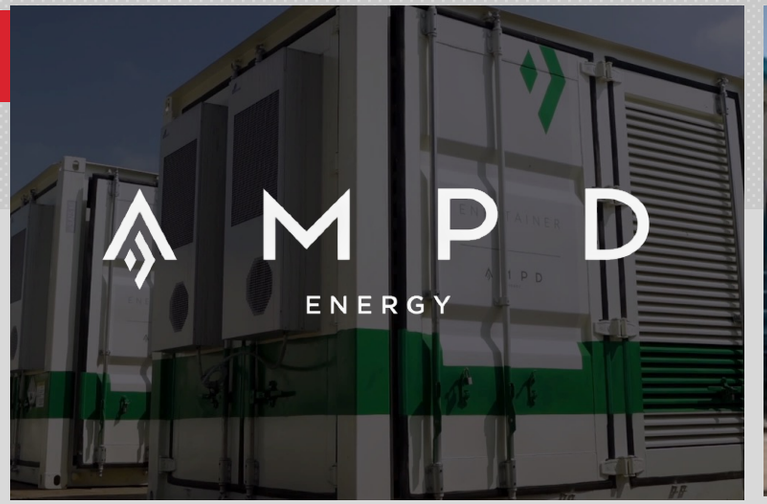
Location: Europe

Application: Energy Storage Systems (ESS)

System Industry: Marine



FirePro.



AMPD Energy

Location: Hong Kong

Application: Lithium Ion Battery Storage

System Industry: Custom R&D

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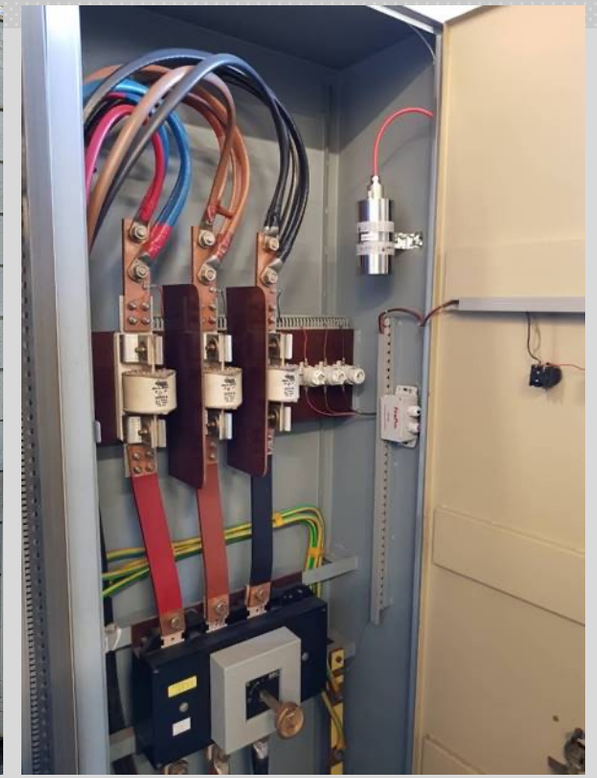
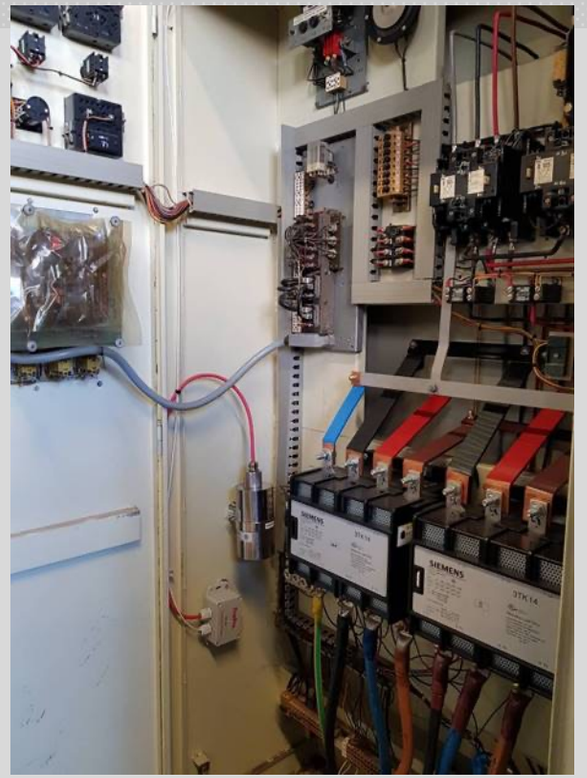
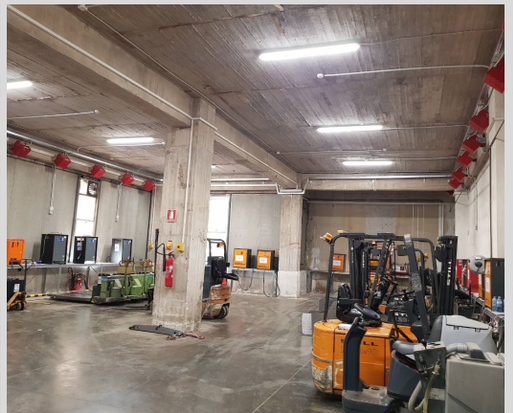
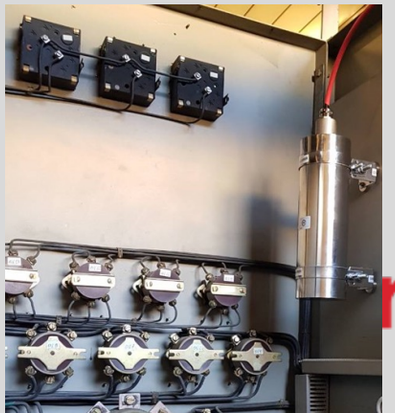
Application: Battery Charging Stations

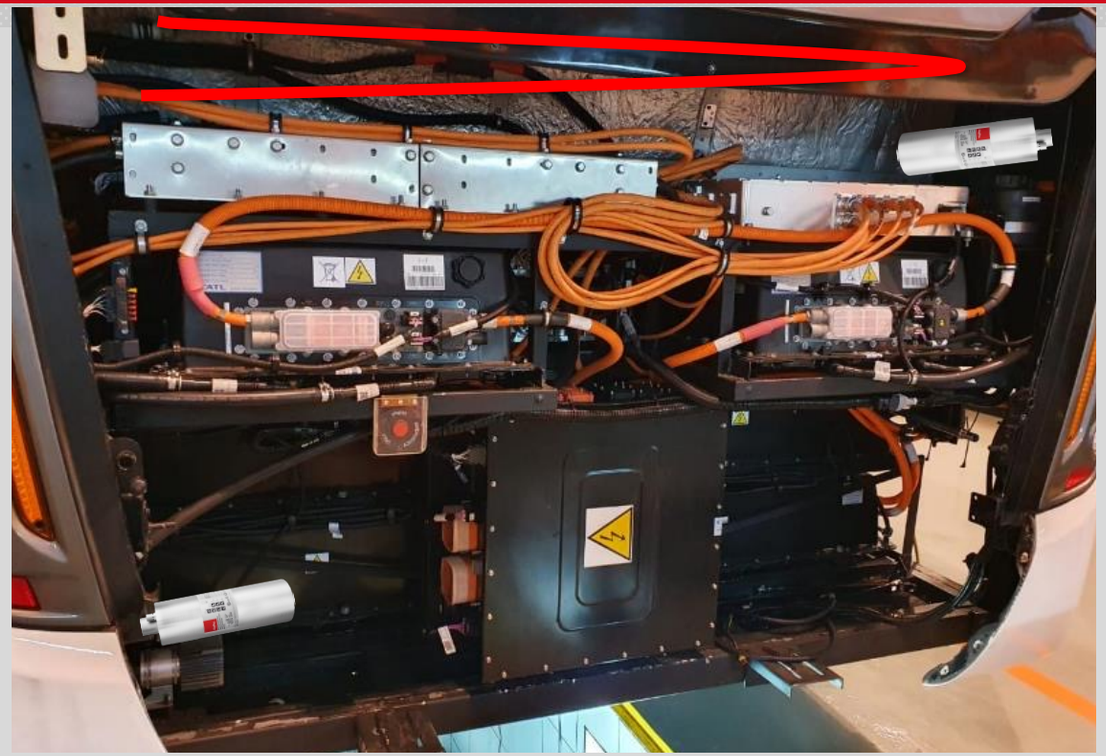


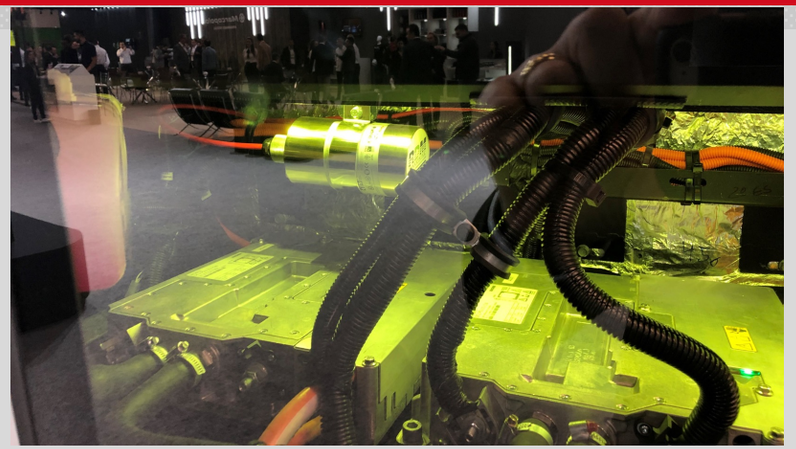


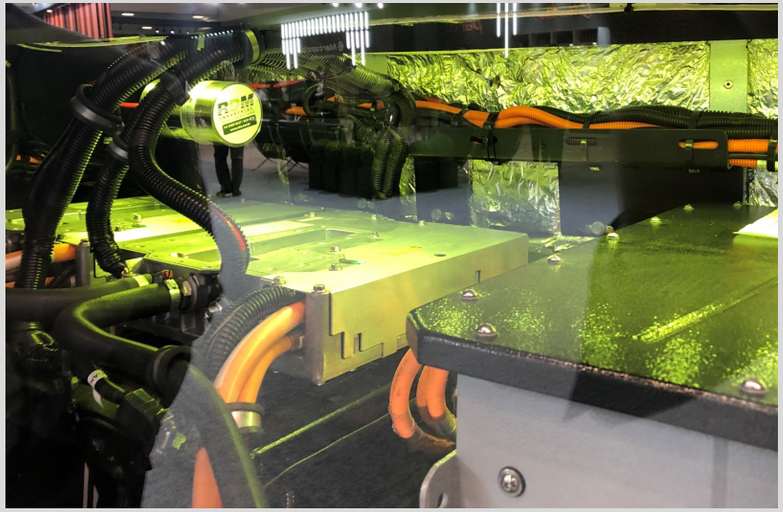




E-buses







FirePro.


Thank You
FirePro.