



Lithium Ion Battery Fire Risks and Precautions

JAMES INTRODUCTION

- Lithium-ion battery fire risks continue to be a growing safety concern for members
- Dynamic area and developing quickly (including controls)
- Share knowledge across our members



ISK MANAGER NOT SALES MANAGER

- Michael Fricker
- Chartered Safety Professional
- 20 years Risk Manager in Insurance
- 15 years in Industry

- Impart knowledge,
- Mitigate Mis-information
- CPD training



WELCOME TO AVD TRAINING SESSION

This seminar will cover lithium-ion battery fire risks and precautions.

Dupré Minerals and AVD have over 6 years in the Lithium Ion battery fire test sector

My colleagues and I have conducted hundreds of battery fire tests using many different battery technologies



TODAY'S OBJECTIVES

THREE MAIN OBJECTIVES:

- To illustrate the magnitude and types of fire risks.
- To provide an understanding of why battery fires occur.
- To provide information and recommendations regarding the prevention and control of these fires to aid with your Fire Risk Assessments.



Relevant???

New research paper out this month

Containing alarming statistics



53% of e-bike owners and 54% of e-scooter owners do not know that their device is powered by a lithium-ion battery.

FIRE RISK ASSESSMENT

- **NOT** going to lecture you on the law
- We do it because
- Don't want to injure our people or others
- Don't want to suffer a fire and loss of premises
- Don't want to suffer an interruption to the business
- Don't want to pollute the environment

**Produced in-house or by consultant BUT.....
are they competent and have they assessed all your risks**



WHAT ARE YOUR RISKS?

..... Or put another way



BATTERY DEVICES – Hand Tools



BATTERY DEVICES – Industrial Applications



BATTERY DEVICES – Transportation



BATTERY DEVICES - Other areas

RESEARCH ?????



BATTERY TECHNOLOGIES – Cylindrical

- 18650 & 21700 are the work-horse cells
- Typically 3.7 Volts 2.8 Ah = 10.36 Wh
- Battery modules are constructed from large numbers of cells
- Connected in series and parallel
- Series connections increases voltage
- Parallel connections increases capacity



BATTERY TECHNOLOGIES – Pouch (Li-Po)

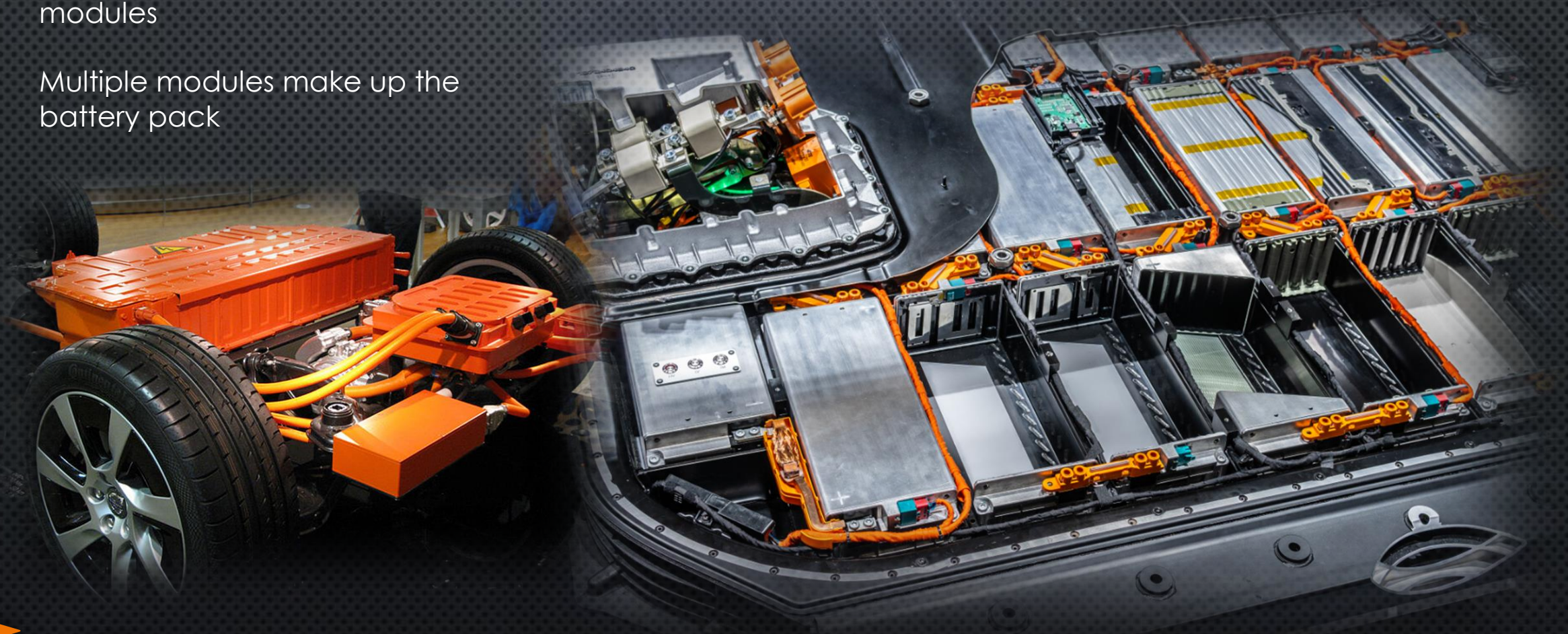


BATTERY TECHNOLOGIES – Prismatic



BATTERY MODULES

- Individual cells make up the modules
- Multiple modules make up the battery pack

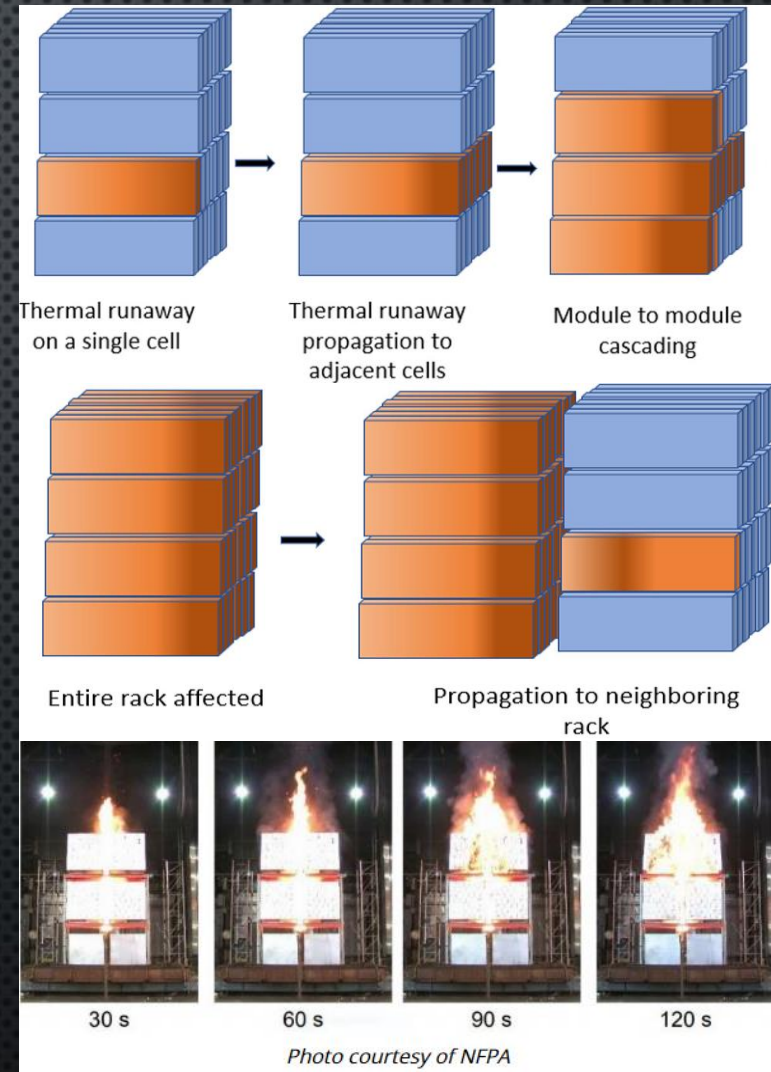
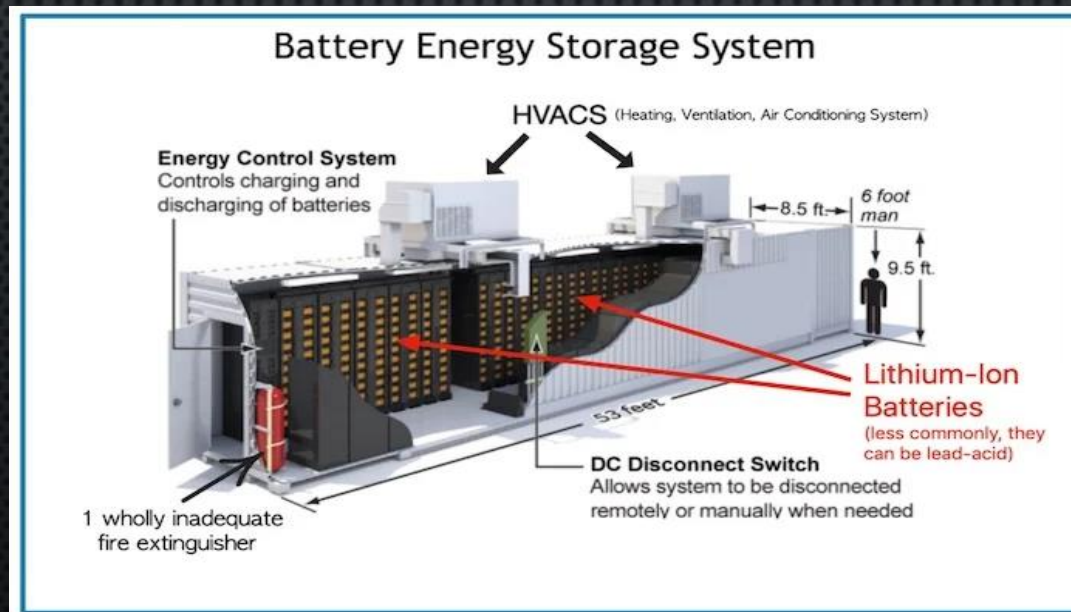
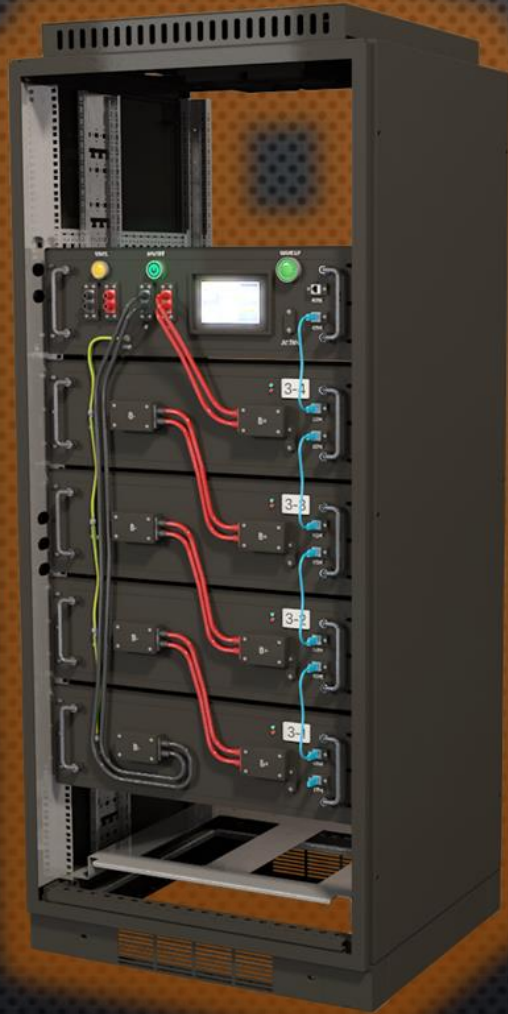


BATTERY PACKS

- The packs installed inside the vehicle



ENERGY STORAGE / UPS BATTERY FIRES



BATTERY FIRE INCIDENTS



OFFICE LAPTOP BATTERY FIRE



MOBILE PHONE BATTERY FIRE



E-SCOOTER BATTERY FIRE

Visible
vapor
cloud



E-SCOOTER BATTERY FIRE



E-BIKE BATTERY FIRE



E-BIKE BATTERY FIRE



ELECTRIC BUS BATTERY FIRE



WHAT CAUSES BATTERY FIRES?



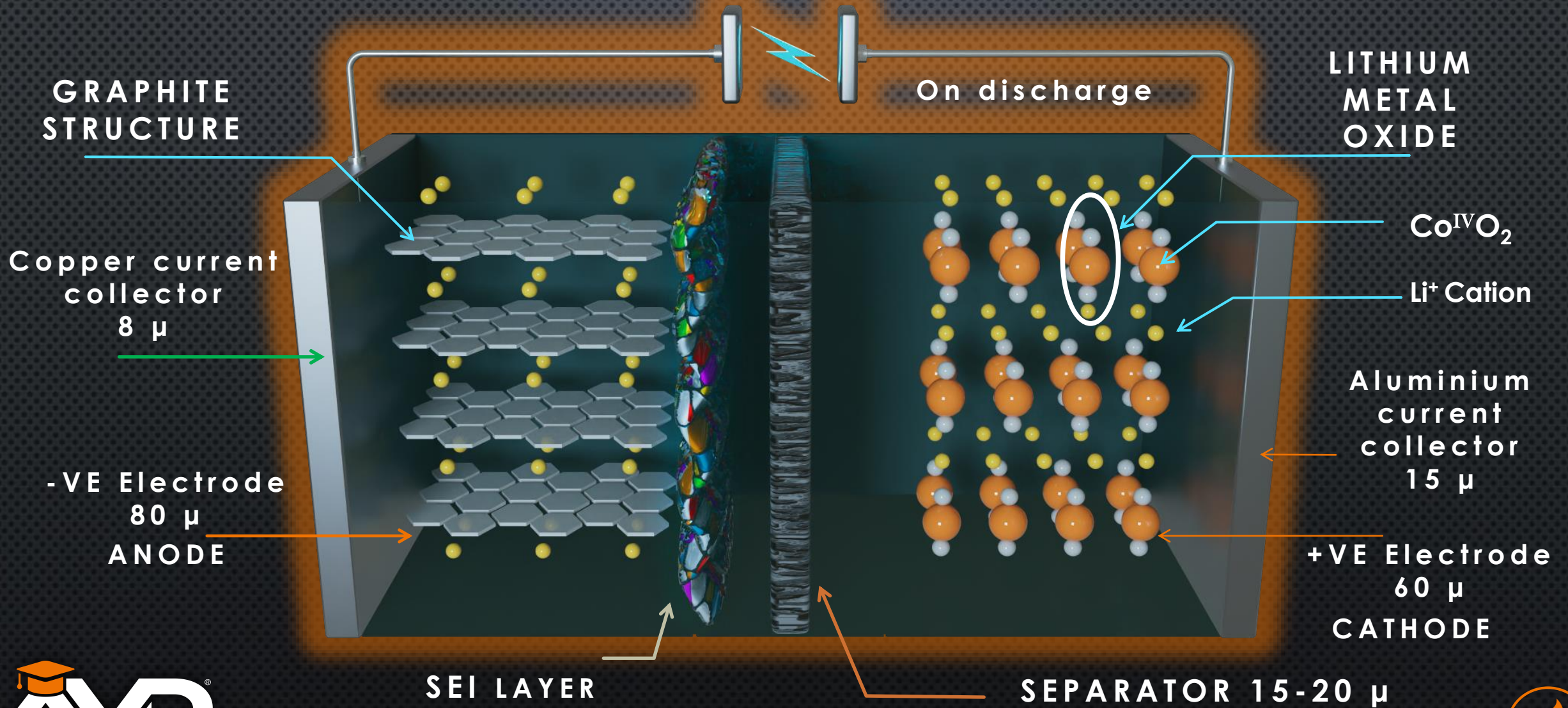
WHAT CAUSES BATTERY FIRES?

Three main causes:

- Electrical abuse / use
- Mechanical abuse
- Thermal abuse



LITHIUM-ION BATTERY CELL STRUCTURE

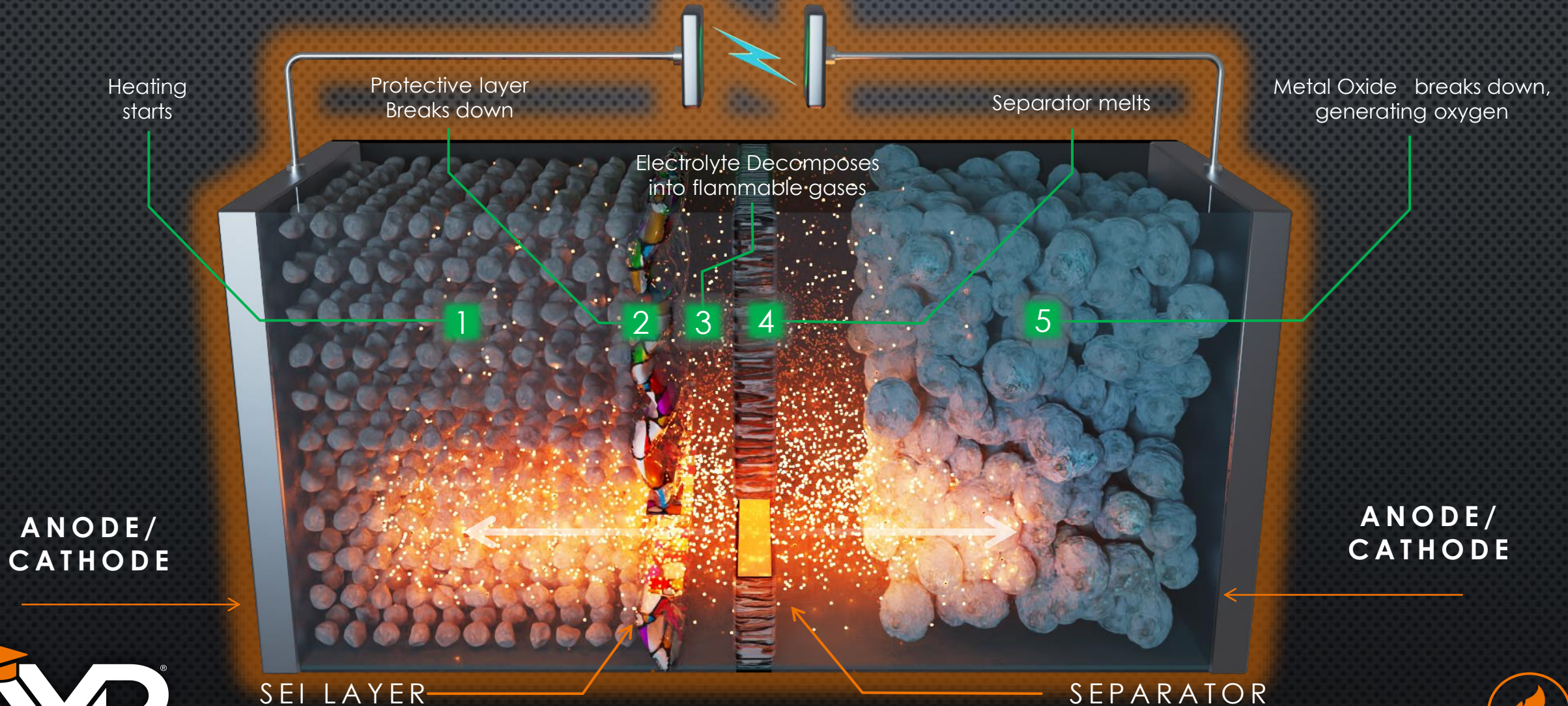


CELL FAILURE – BROKEN SEPARATOR

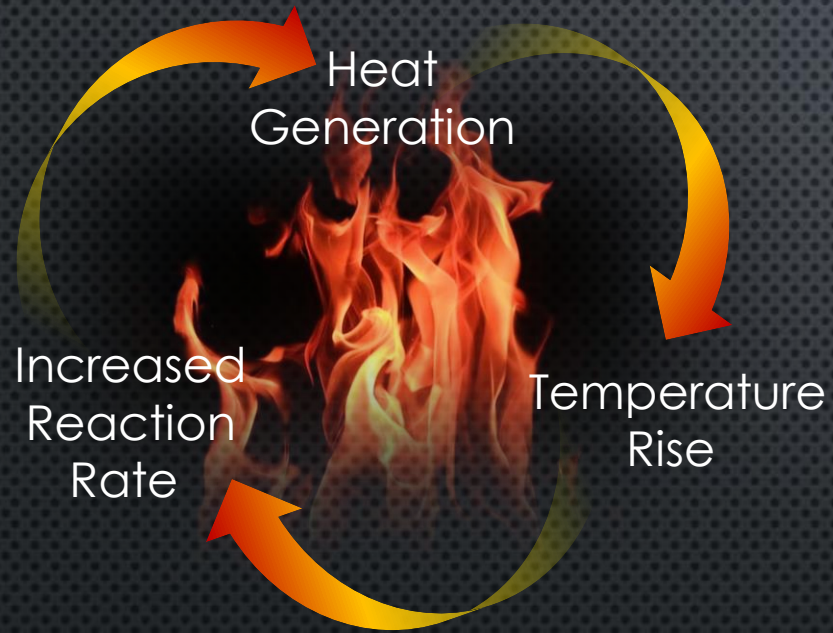
G R A P H I T E S T R U C T U R E

E L E C T R O L Y T E

L i M E T A L O X I D E

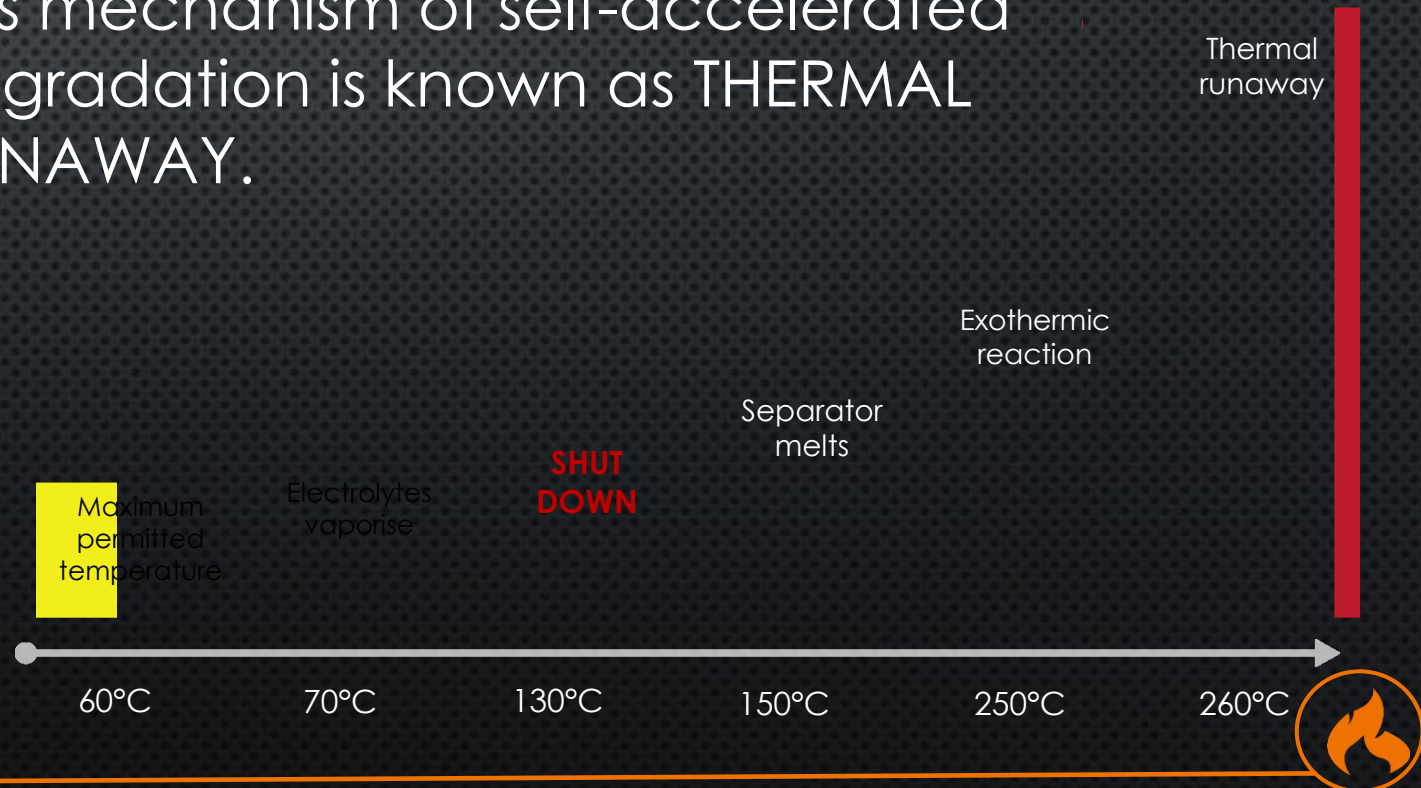


THERMAL RUNAWAY



If the electrolyte reaches a critical temperature, a chain of exothermic reactions can be triggered. This will further increase the temperature, which accelerates the reaction.

This mechanism of self-accelerated degradation is known as **THERMAL RUNAWAY**.



AVD ENCAPSULATION EFFECTIVELY TRAPS TOXINS

EXTRACT FROM THE JOURNAL OF ELECTROCHEMICAL CONVERSION & ENERGY

“The AVD fire extinguishing agent absorbed a large amount of **the toxic elements** within the smoke during the three-state conversion of gas-liquid-solid. Thus the AVD also demonstrates clear advantages in reducing harmful smoke components of battery fires”

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[< Previous Article](#) [Next Article >](#)

RESEARCH PAPERS

The Efficiency of Aqueous Vermiculite Dispersion Fire Extinguishing Agent on Suppressing Three Typical Power Batteries

Haibin Wang, Qiang Sun, Jun Guo, Song Xie, Yuanhua He, Xiantao Chen



+ Author and Article Information

J. Electrochem. En. Conv. Stor. May 2021, 18(2): 020901 (12 pages)

Paper No: JEES-20-1059 <https://doi.org/10.1115/1.4048368>

Published Online: October 5, 2020 [Article history](#) 

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Abstract

Fire extinguishing technology has become an important component for addressing battery safety issues. To accelerate the research of fire extinguishing technology for typical power batteries used in electric vehicles and electric aircraft, in this paper, an aqueous vermiculite dispersion (AVD) fire extinguishing agent is used to suppress the thermal runaway (TR) of batteries in various material systems. Two characteristic physical parameters, namely, temperature and flue gas composition, are analyzed and compared in two scenarios (with and without the fire extinguishing agent). Two typical clean fire extinguishing agents (Novec 1230 and 2-BTP) are also applied in the fire extinguishing experiment. The cooling effect of these two extinguishing agents is compared, demonstrating the advantages of the AVD extinguishing agent in terms of extinguishing and cooling.

Issue Section: Special Sections: Lithium-Ion Battery Safety



WHAT ARE YOUR CONTROLS?

- —Eliminate
- Use both Active and Passive Fire protection
- Segregate / Compartmentalisation
- Fire resistant floors / wall
- Fire Doors
- Fire Alarm
- Sprinklers / Suppression
- Extinguishers
- Blankets – (Not all fire blankets are the same).



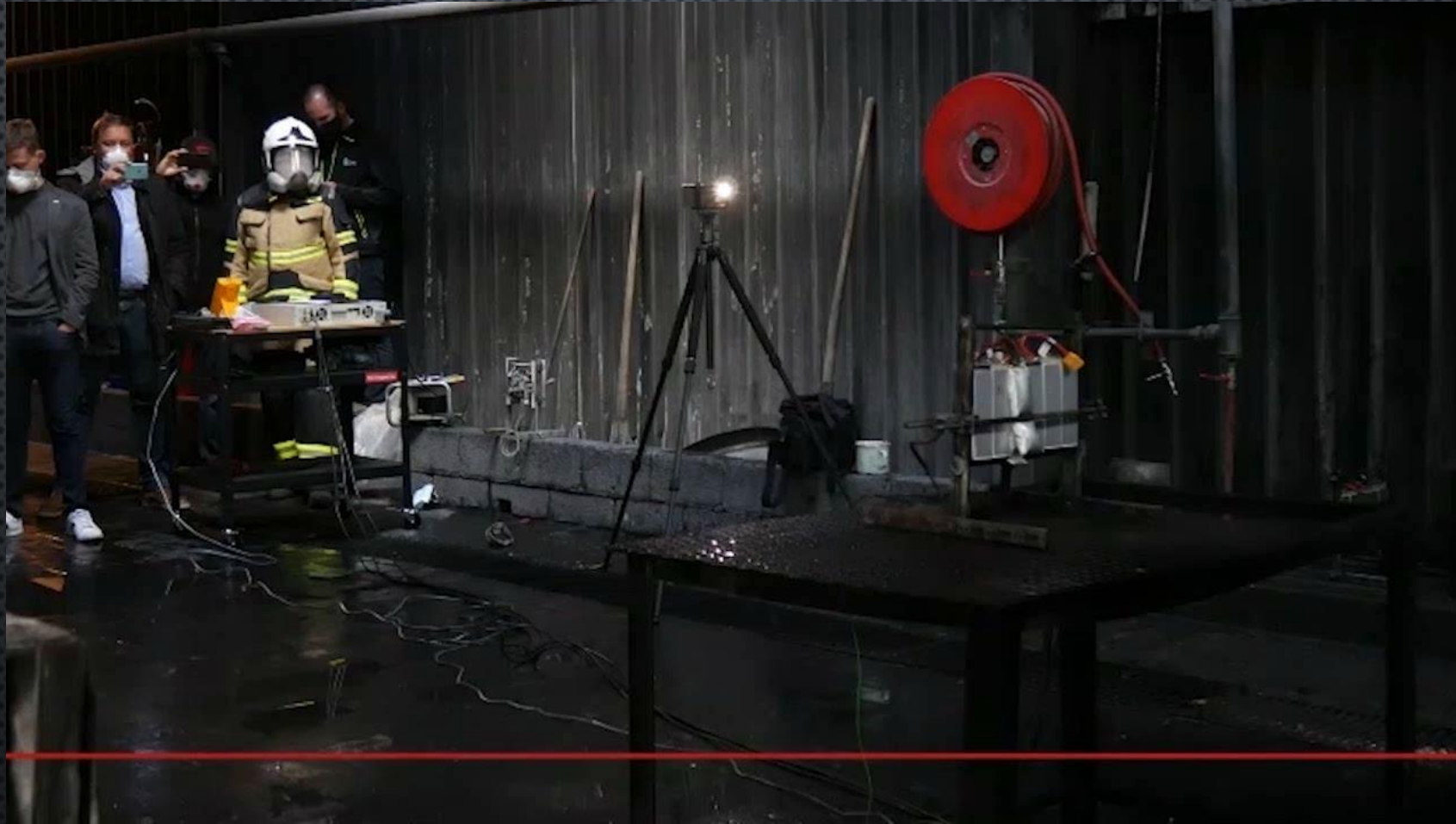
EFFECTIVENESS OF EXTINGUISHING AGENTS



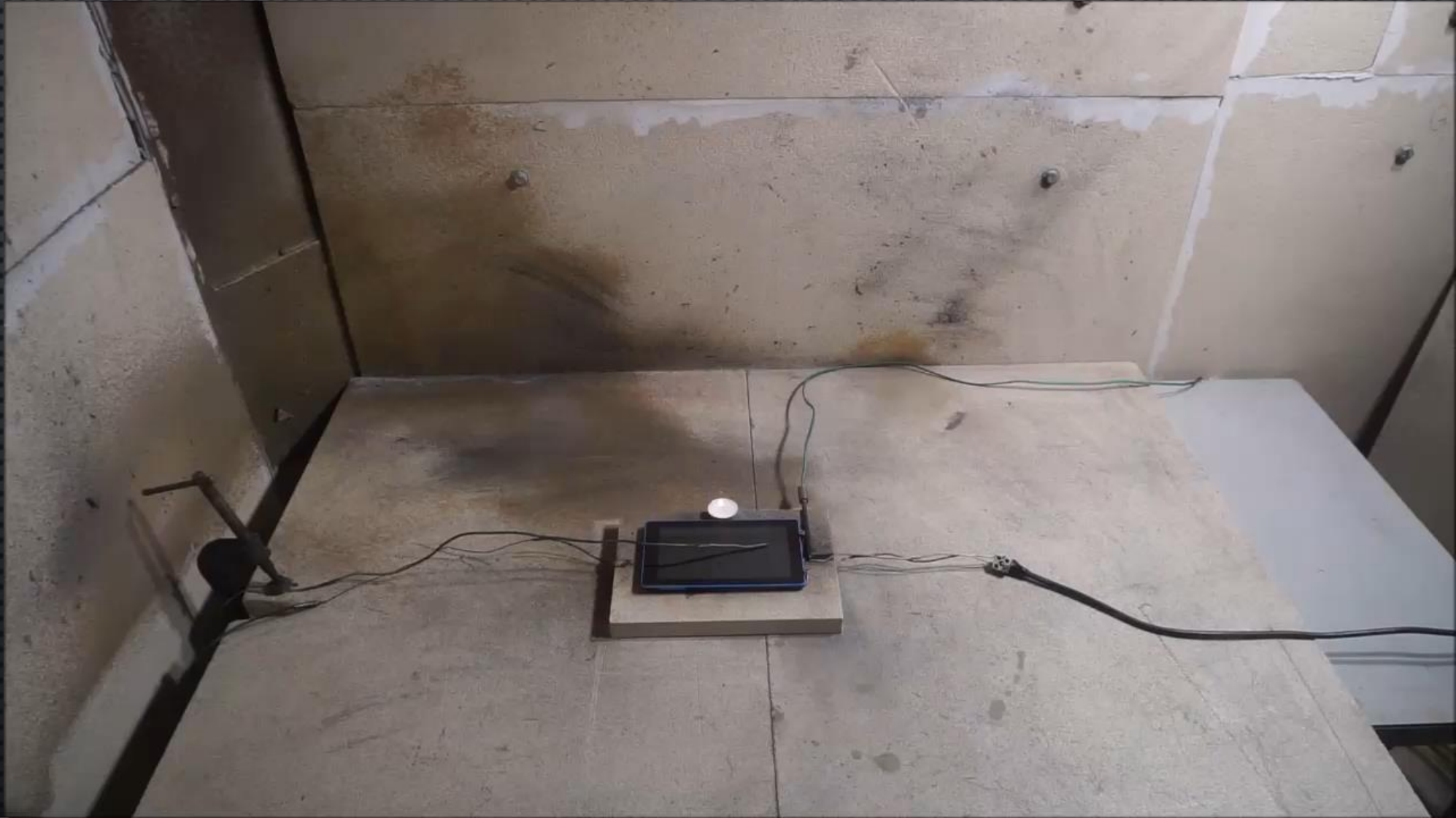
CONVENTIONAL AGENTS – NOT EFFECTIVE



INDEPENDENT TEST – Water plus Surfactant



AVD DEMONSTRATION



HOW DOES AVD WORK



WHAT IS VERMICULITE?

- VERMICULITE IS A NATURALLY OCCURRING MINERAL:

ALUMINIUM – IRON – MAGNESIUM – SILICATE

- IT IS MINED ALL OVER THE WORLD

- IT IS NON FLAMMABLE AND HAS EXCELLENT THERMAL INSULATION PROPERTIES

- IT IS CHEMICALLY AND PHYSICALLY INERT

- VERMICULITE MINERAL IS EXEMPT FROM REACH REGULATIONS AND ENVIRONMENTALLY FRIENDLY & NON_TOXIC

Naturally occurring mineral

Excellent thermal properties

Environmentally friendly



WHAT IS AVD & HOW IS IT EFFECTIVE?

AQUEOUS VERMICULITE DISPERSION

AVD is a pioneering fire extinguishing agent, specifically designed to tackle the threat posed by Lithium battery fires. It is the only agent that extinguishes, cools & contains Lithium battery fires.

- **AVD** is a stable suspension of vermiculite in water.
- **AVD** is water based, thus it extinguishes the fire and cools the cells.
- **AVD** is film forming and creates an oxygen barrier.
- **AVD** is nearly twice as effective as water on a class A fires.
- **AVD** creates a non-flammable oxygen barrier to prevent re-ignition.
- **AVD** can be applied as a fire break to prevent the propagation of fire.
- **AVD** reduces thermal propagation.
- **AVD** has passed the 35 kV dielectric test in EN3.



AVD APPLIED TO POLYSTYRENE



AVD FIRE – PRODUCT RANGE



EN3



CE
0029



LITHIUM BATTERY FIRE STANDARDS

- At present there are no recognised test standards for lithium battery fires in the UK which provide a BS certificate.
- There are no recognised test standards for lithium battery fires across Europe which provide an EN certificate.
- There are no recognised test standards for lithium battery fires in North America which provide a UL certificate.

**THE STANDARDS NOW REQUIRED IN REGIONS
TO MITIGATE THE RISK OF LI-ION BATTERY FIRES**



Proven results on
lithium-ion battery fires



Effectively extinguishes
Class A and Magnesium fires



Suitable for
portable & fixed systems



Environmentally
friendly



NTA 8133 (KIWA TEST)

- Dutch Standard created in 2021
- The NTA 8133 is the first publication for lithium ion battery fires with medium capacities up to 600 Wh.
- 6 fully charged lithium pouch cells
- third cell is put into thermal runaway by deliberate overcharging
- As soon as the first flames occur, the extinguishing effort will start.
- The fire must be extinguished within 3 minutes.
- During 20 minutes after the fire has been extinguished, no re-ignition may occur. After 20 minutes minimum 1 pouch cell must be saved and operating.
- When 2 out of 3 attempts are successful, the test has succeeded.



VEHICLE FIRES REQUIRE A FORMAL STRATEGY



ELECTRIC VEHICLE STRATEGY NEEDS TO BE DIFFERENT

Hybrid

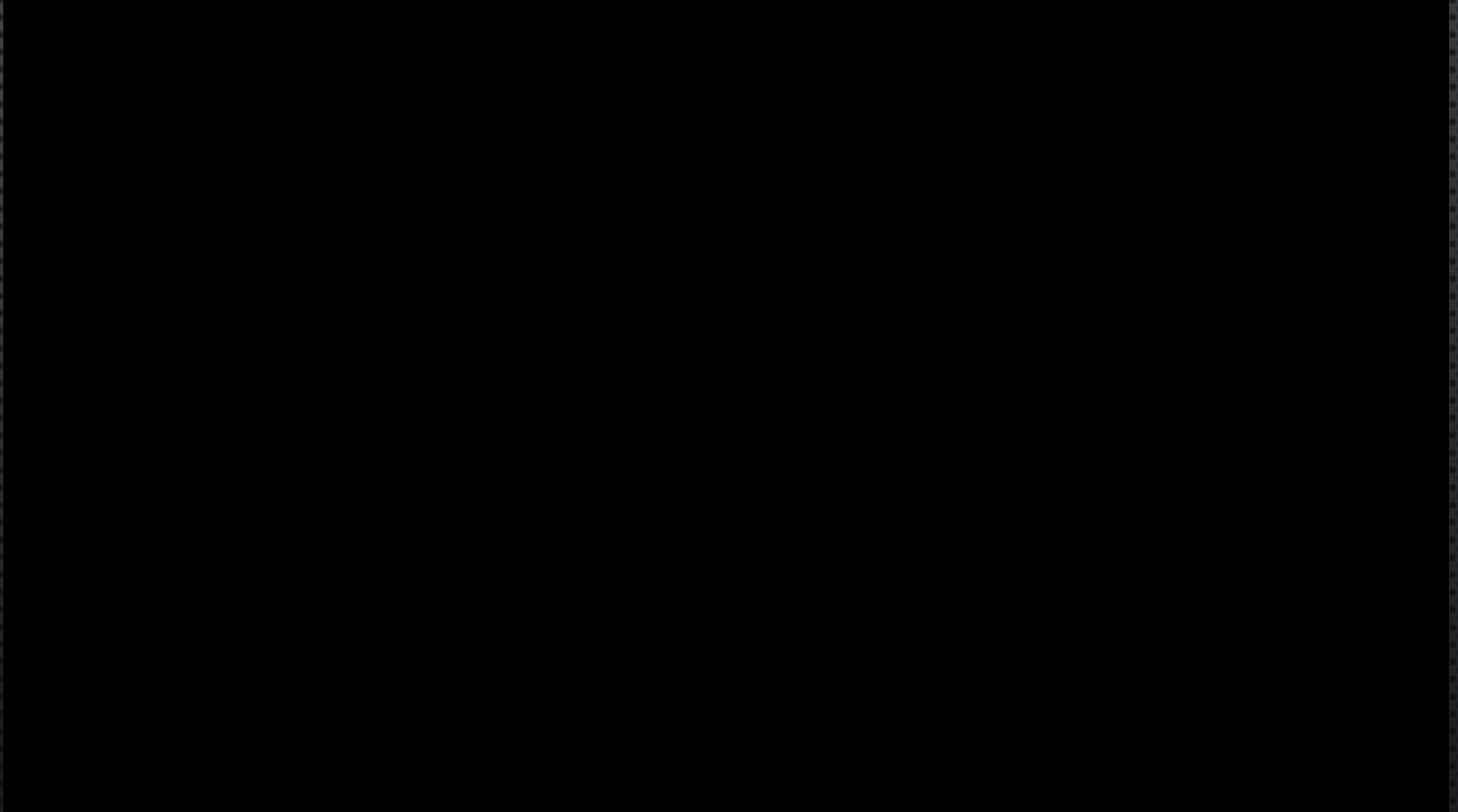
Water required to
extinguish
1000 – 4000 litres

EV vehicle

Water required to
extinguish
from 3000 to 10,000
litres

EV vehicle in Tesla footage

Around 90,000 litres



BATTERY & FIRE BREAK FIRE TESTING



- Custom dispersion system
- Offers scalable approach
- Air pressured system
- Tailored by vehicle type
- 3rd party tested with UK Airport Emergency services
- Battery test and fire break



STRATEGY FOR FIRE BLANKETS –

Not all Fire Blankets are the Same

Are you prepared for a Li-Ion vehicle fire?

- Temperatures > 1000°C
- Fireproof fabric with additional fire resistant coating
- Fire resistant reinforced multi-layered edge lining
- Eyelets for tethering or suspending
- Handling loops on all corners
- Fire resistant stitching throughout



FORMAL STRATEGY FOR VEHICLES

- UNDERSTAND THAT VEHICLES POSE A SIGNIFICANT CHALLENGE EVEN TO THE FIREBRIGADE.
- MAKE THE FIRE STRATEGY SPECIFIC TO THE LOCATION e.g. COMPARTMENTALISATION.
- MAKE CHARGING LOCATIONS AS EASILY ACCESSIBLE AS POSSIBLE FOR THE EMERGENCY SERVICES
- SPECIALIST FIRE DETECTION FOR LITHIUM BATTERIES – Protec/Lion Tamer/Amphenol
- FIRE BLANKETS PROVIDE AN IMMEDIATE RESPONSE WHILST AWAITING THE FIREBRIGADE
- PROVIDE BUNKERS/ DELUGE/FLOODING SYSTEMS/FIRE BREAKS/ VENTILATION/PRESSURISED WATER JET FROM BELOW
- CONSIDER THE BUILDINGS STRUCTURAL INTEGRITY
- MAKE SURE THAT KEY PEOPLE ARE TRAINED



AUTOMATIC / MANUAL FIXED SYSTEMS



What do we recommend?



SUMMARY & DISCUSSION

Many thanks for your time any questions?



AVD Fire:
Michael Fricker
Head of Risk Management
mfricker@goodwingroup.com
Tel: 01782 383143
Cell: 07974 074890