

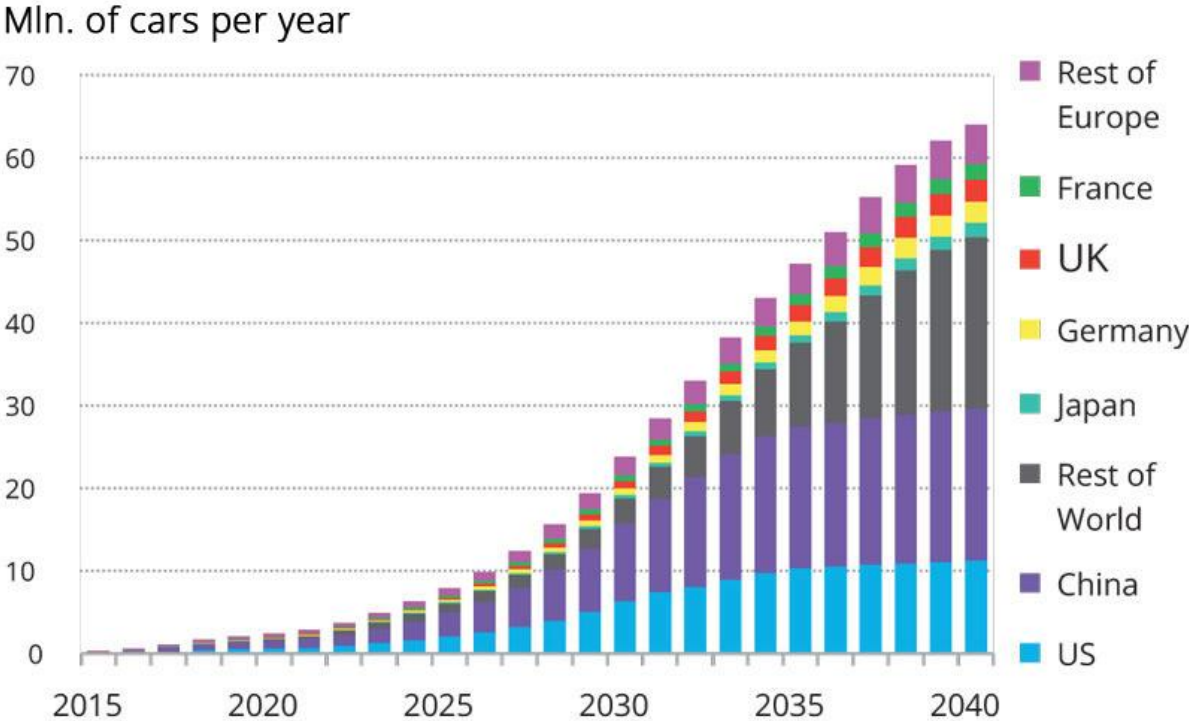


# Michael Belsham

*BelshamFire Ltd*

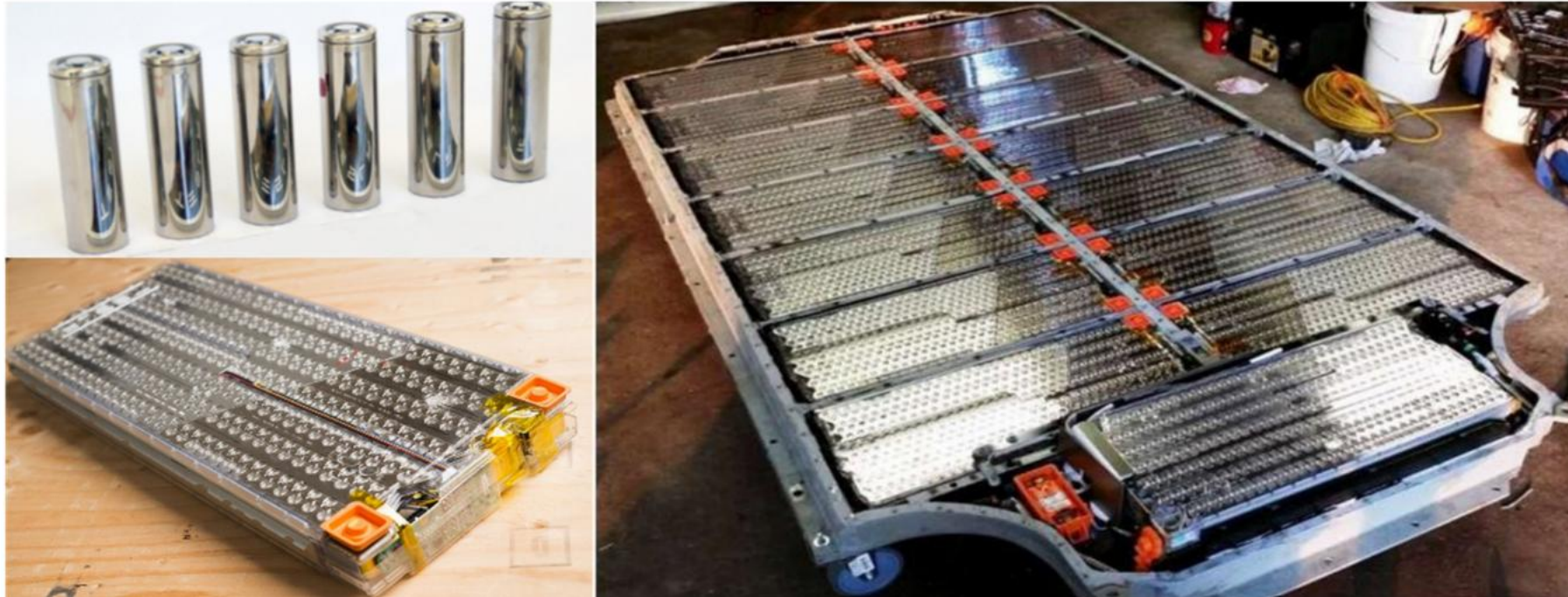


# Number of Electric Cars



40 million EVs worldwide  
20% of new cars sold are EV  
Aim 50% of all cars EV by 2030

# Electric Vehicle Batteries



Tesla S consists of 7104 single cylindrical cells

# Electric Vehicle Batteries

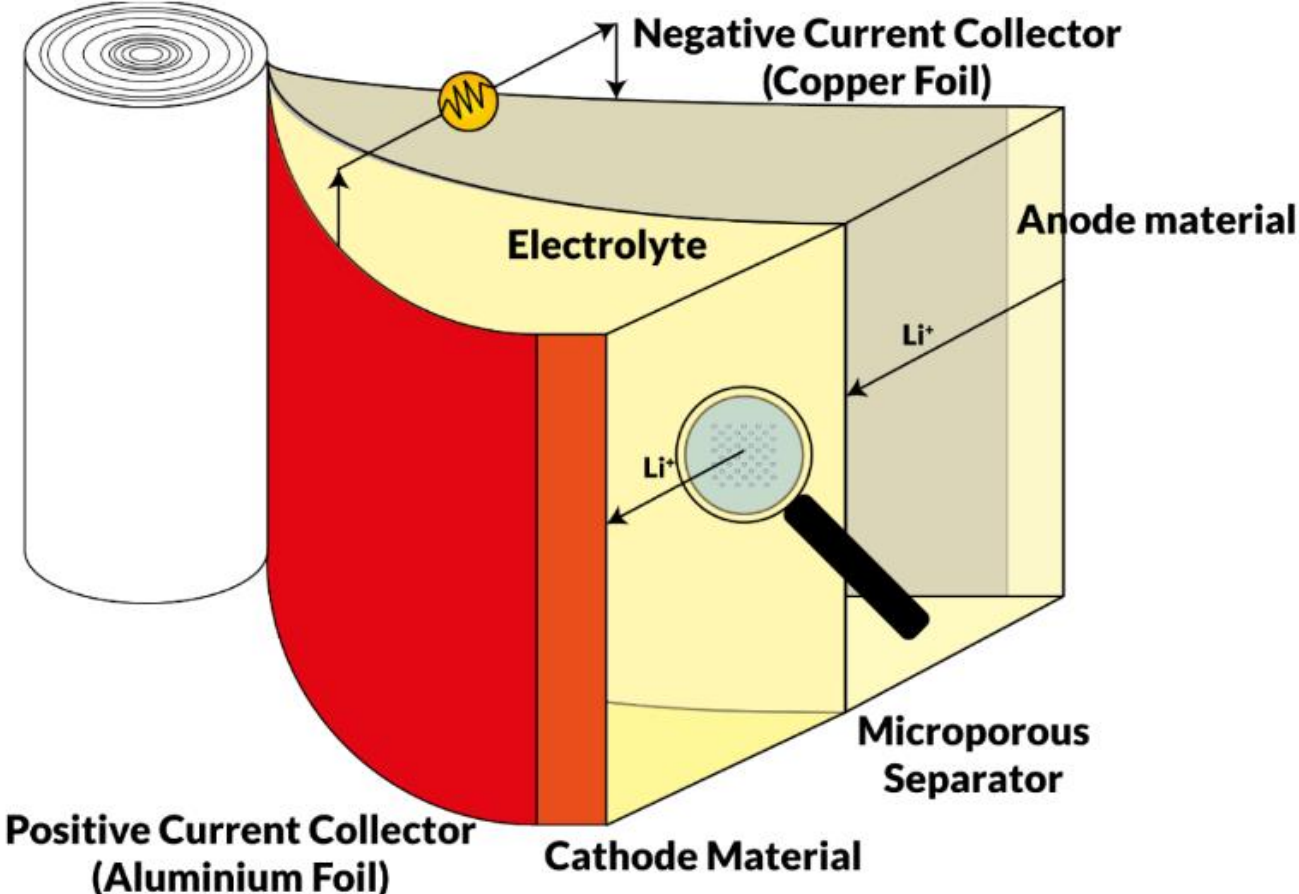


Figure 10 Working principle of a lithium-ion battery when discharged.

# Electric Vehicle Batteries

**Electrolyte** -  $\text{LiPF}_6$  solution is Category 3 flammable liquid. Li combustible metal




**Separator** – Polypropylene combustible plastic 46 MJ/kg

**Coolant** - Propylene glycol combustible liquid 23.9 MJ/kg



Safety Data Sheet

# Battery Risk Factors

Factors leading to fires	Factors leading to fires
	Thermal abuse
	Electrical abuse
	Mechanical abuse

**Thermal** – Abnormal Heating/Cooling.  
**Electrical** – Overloading / Short circuit  
**Mechanical** – Physical Damage

A. Dorz, Power Engineering Institute, Poland

# Thermal Runaway

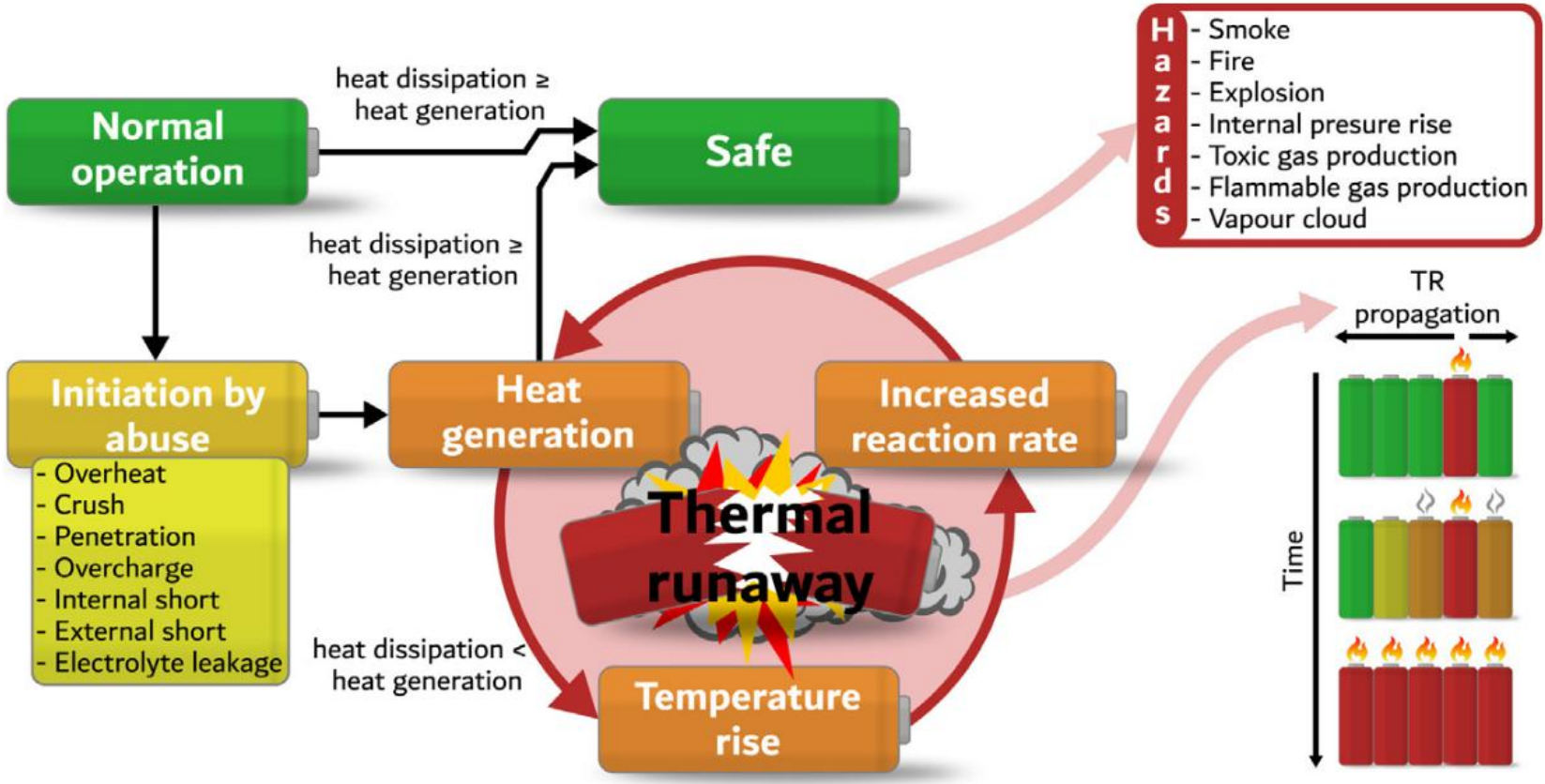
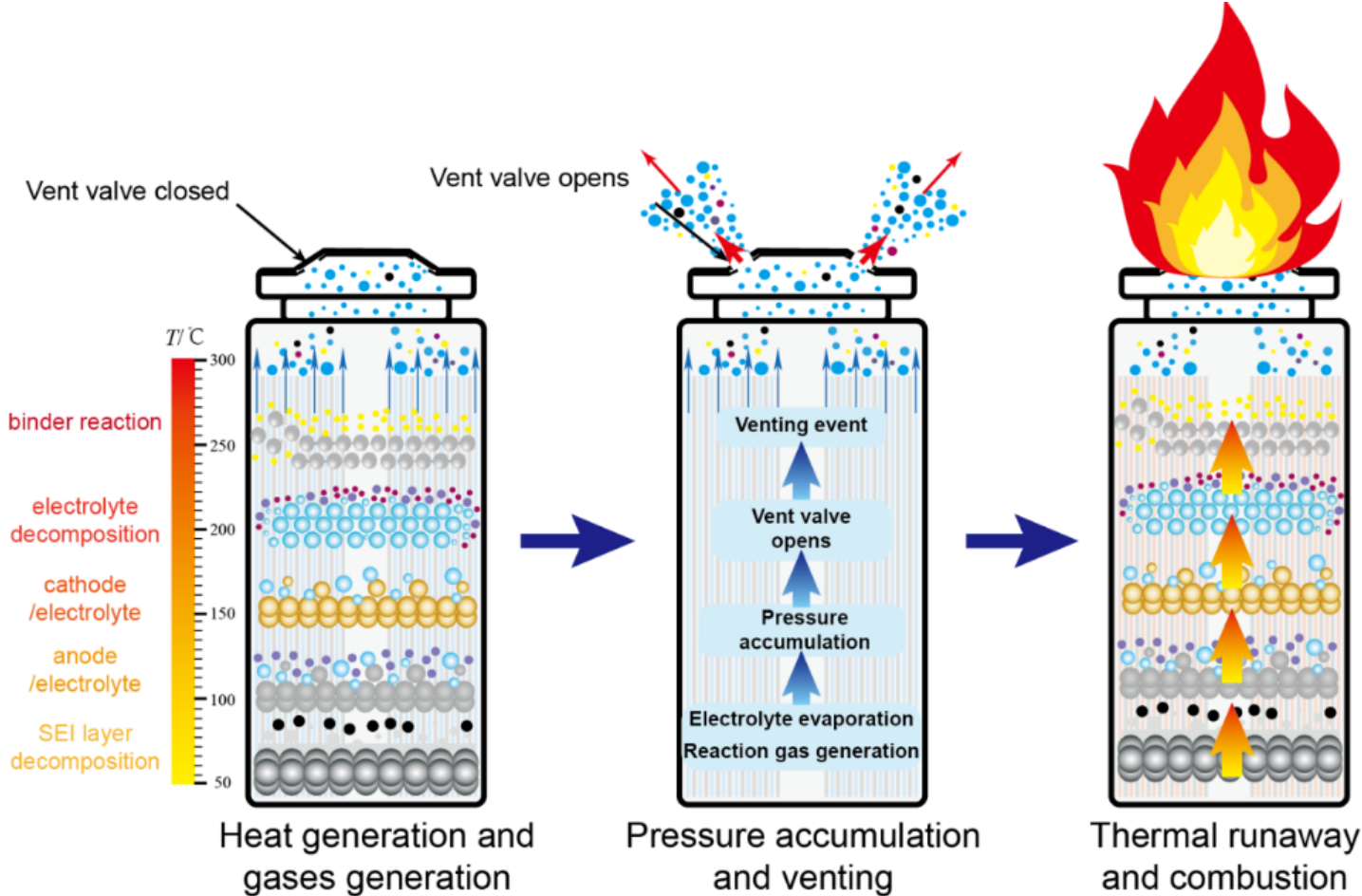


Fig. 1. Process of thermal runaway from initiation to propagation and resulting hazards [22].

P. Bugryniec, University of Sheffield, UK

# Thermal Runaway

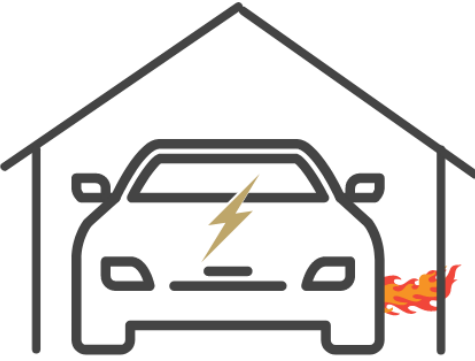


D. Kong Center for Offshore Engineering and Safety Technology, China

# Likelihood

Since 2010, EV FireSafe has been able to verify:

**511** incidents of thermal runaway in electric passenger vehicles (BEV and PHEV\*).



**117**

Underground / enclosed spaces



**80**

EV connected to energised charging

# Likelihood

Probability of EV fires are low however;

🔥 EVs are still relatively few.

🔥 EV fleet is younger than ICEV (less wear / charge cycles)

🔥 More common for vehicles older than 15 years

J. Hynynen, RISE, Research Institutes of Sweden

# Consequence



Stavanger Airport Sola, Norway, 2020



Apartment Car Park, South Korea, 2024

# Vapour Cloud



**Toxic Gases** HF, CO, NO, SO2 and HCl  
**Hydrogen Fluoride** is the most critical gas  
**Particulate-bound metals**  
Li, Al, Co, Mg, Ni

Substance	Exposure Limit 8h (mg/m3)	Exposure Limit 15 min (mg/m3)
CO	23	117
HF	1.5	2.5
HF	2	8

Paul Christensen, University of Newcastle UK



# Jet Fires

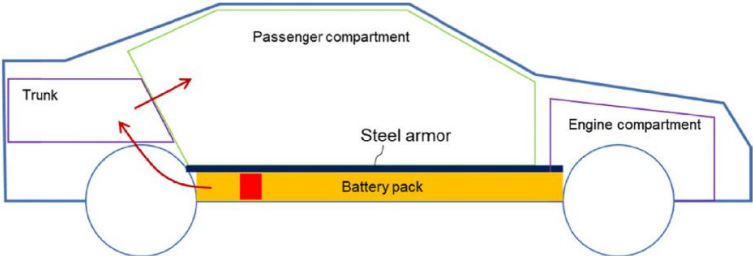


Fig. 6. Paths of flame and smoke propagation (early stage).



Fig. 8. The longest jet flame.

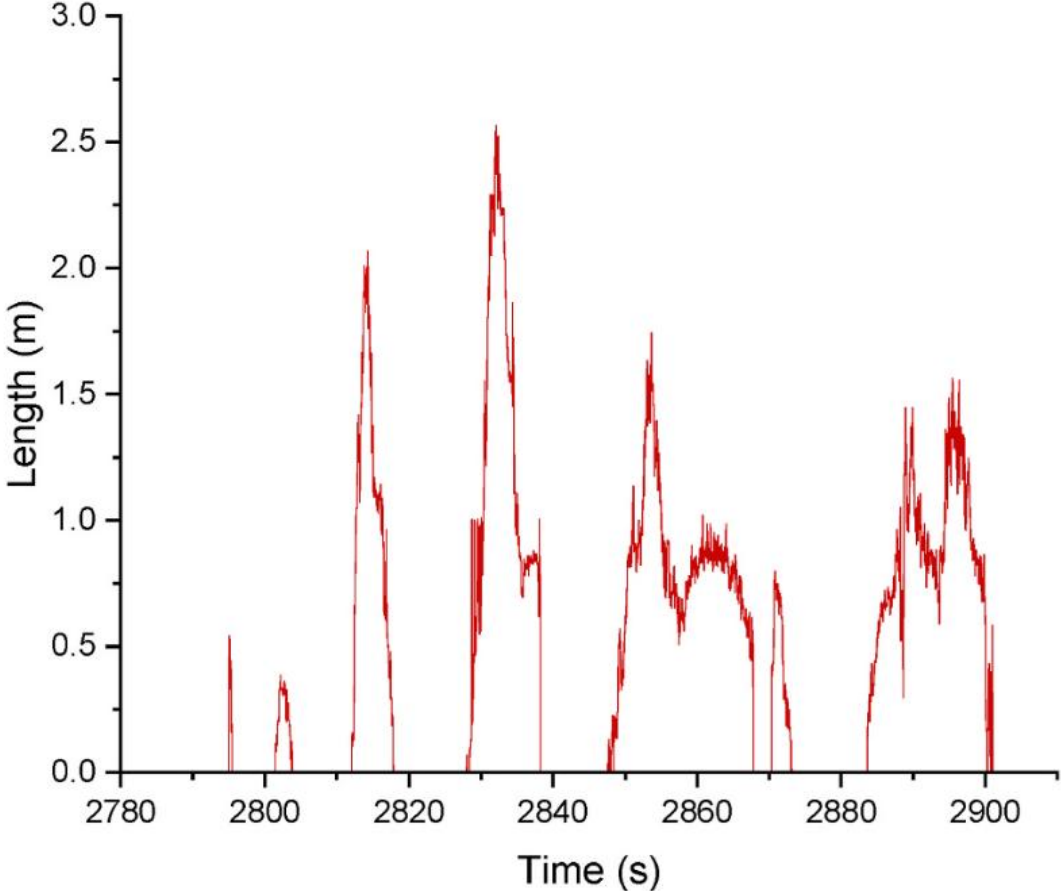
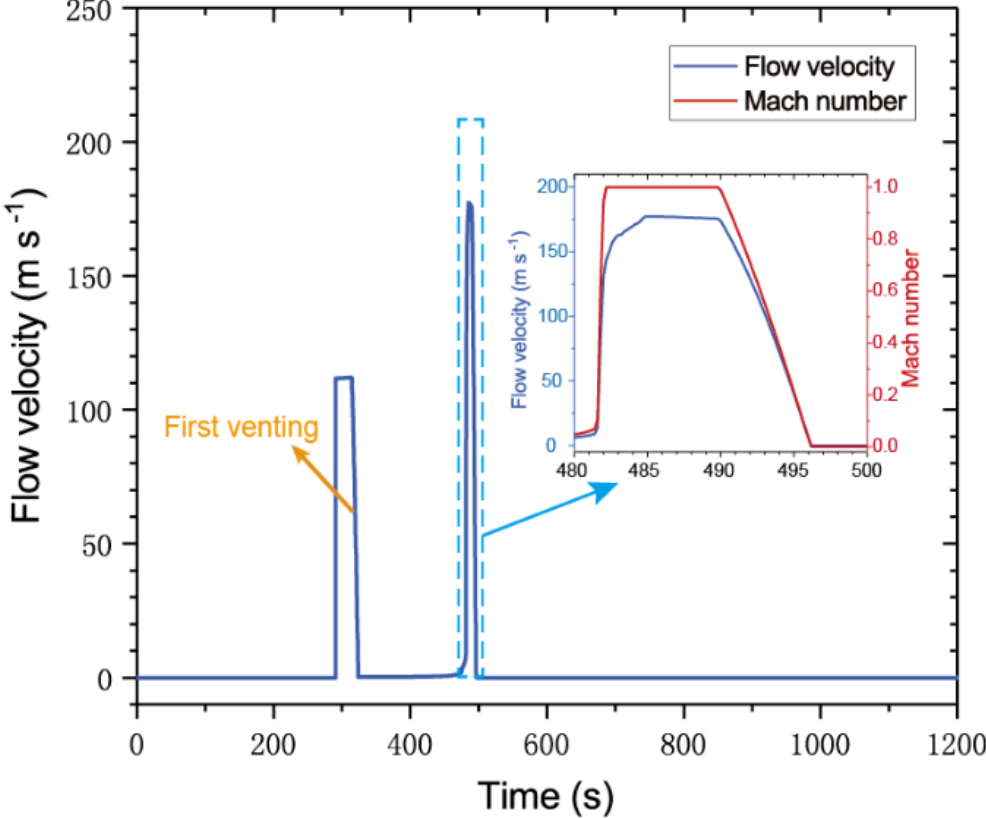
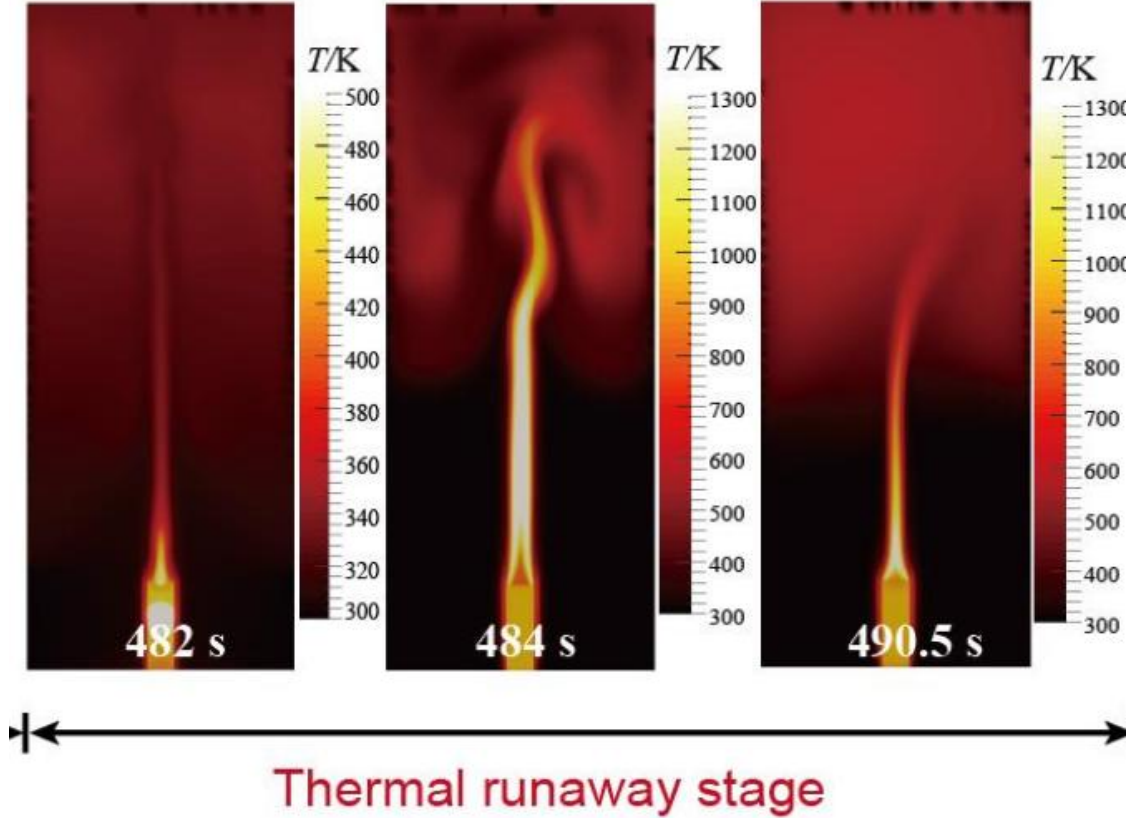


Fig. 9. Variation curve of Jet flame length.

Z. Chenxi, State Key Laboratory of Fire Science, China.

# Jet Fire



(c) 75% SOC

D. Kong, Center for Offshore Engineering and Safety Technology, China

# Fire Fighting

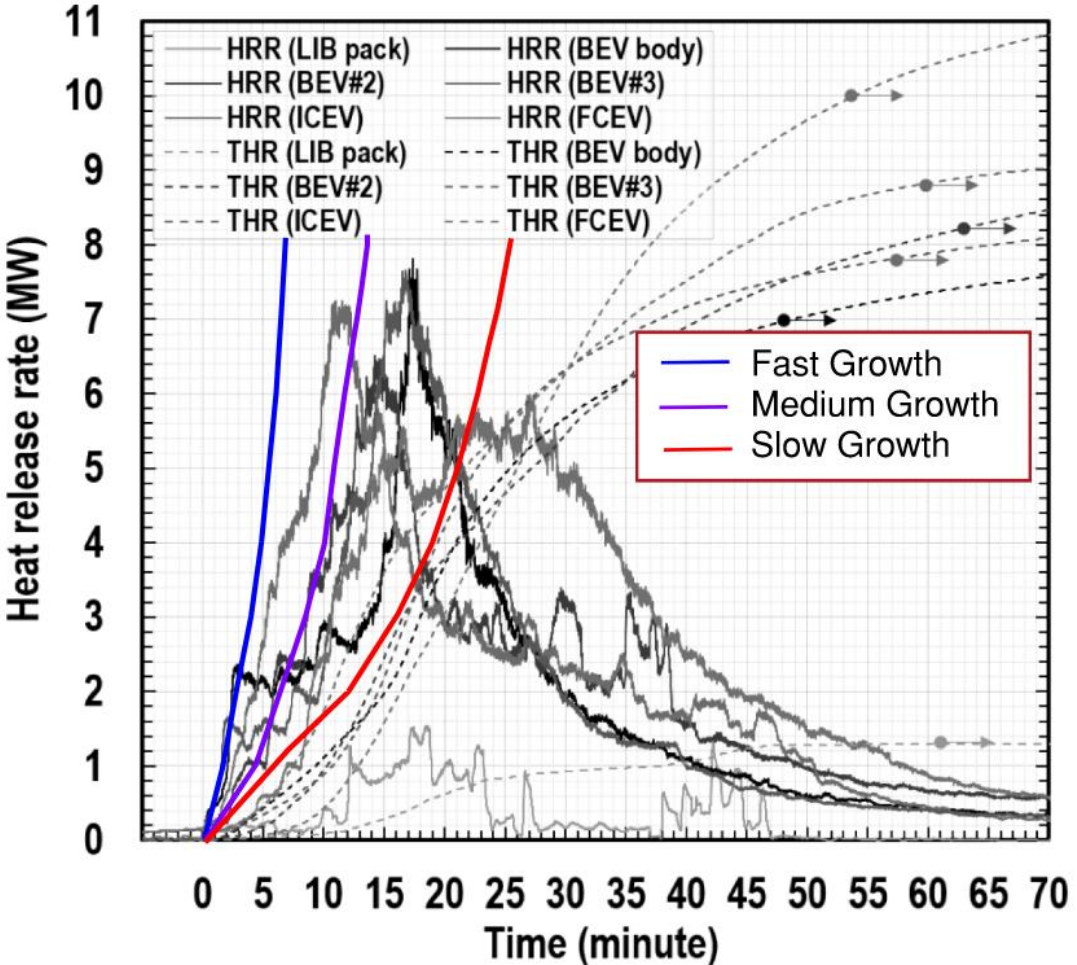
## Challenges:

- 🔥 Battery pack situated under the car
- 🔥 Well protected against water ingress
- 🔥 Can only be stopped by cooling
- 🔥 Cooling requires 10,000L and up to 60 minutes
- 🔥 Flare ups can occur



A. Brandt, RISE Research Institutes of Sweden

# Fire Growth Rates



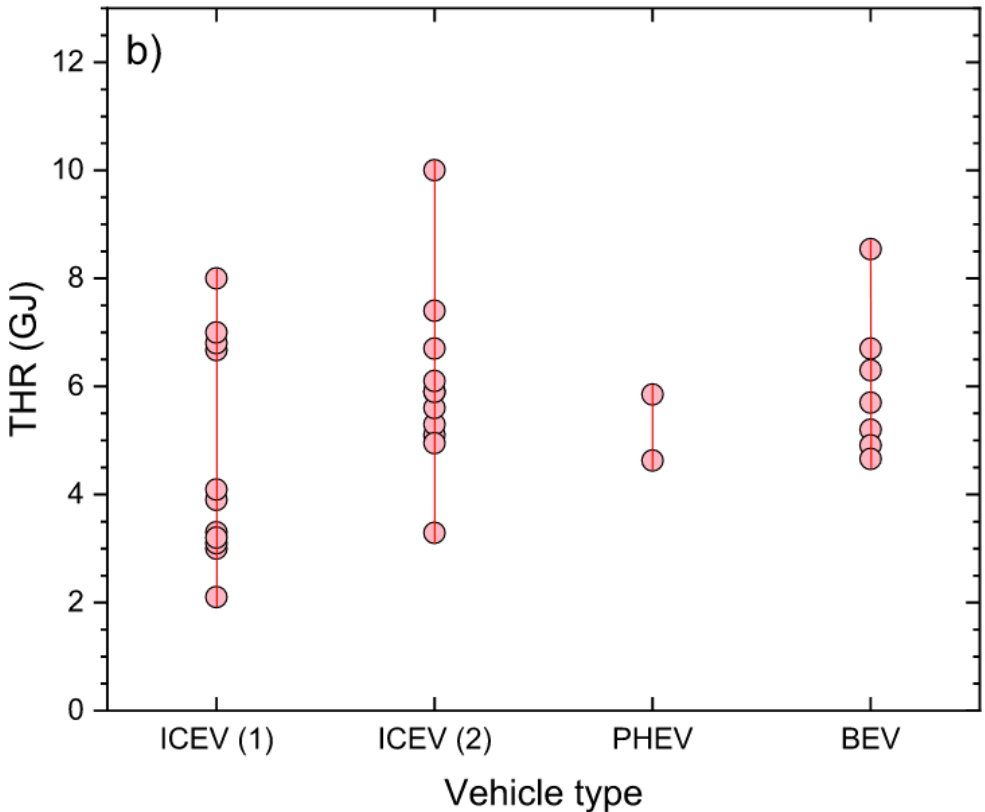
Full scale fire testing of BEV categorized fire growth rates as being ‘fast-medium’

“Fire growth rate to represent an EV fire should be **‘fast’ t<sup>2</sup>**”  
M Spearpoint



S. Kang, Fire Testing & Research Centre, Republic of Korea

# Fire Load



Increase in vehicle weight and plastics EVs is 9 GJ & 10 GJ for ICEVs (2023). ICEV 7GJ (2013).

Car park of 1:20m<sup>2</sup> ratio equates to **500 MJ/m<sup>2</sup>**

M. Spearpoint, Ollson Fire Risk, UK

# Fire Load



Heat of combustion heat  
30 MJ/kg to 31 MJ/kg

C/VM2 - 20MJ/kg

A. Dorz, Power Engineering Institute, Poland

# Charging Stations

Charger	Power	Protection	Socket
Mode 1	7kW	None	Standard 3 Pin Plug
Mode 2	15kW	In-Cable	Standard/Dedicate Socket
Mode 3	22kW	Built-In	Standard/Dedicated Chargepoint
Mode 4	50kW	Built-In	Dedicated Chargepoint

AC destination	DC destination
3 kW – 22 kW (Mode 3)	11 kW – 50 kW (Mode 4)
3 – 20 hours	1 – 3 hours
	

Arup, Office for Zero Emission Vehicles (OZEV)

# Charging Stations

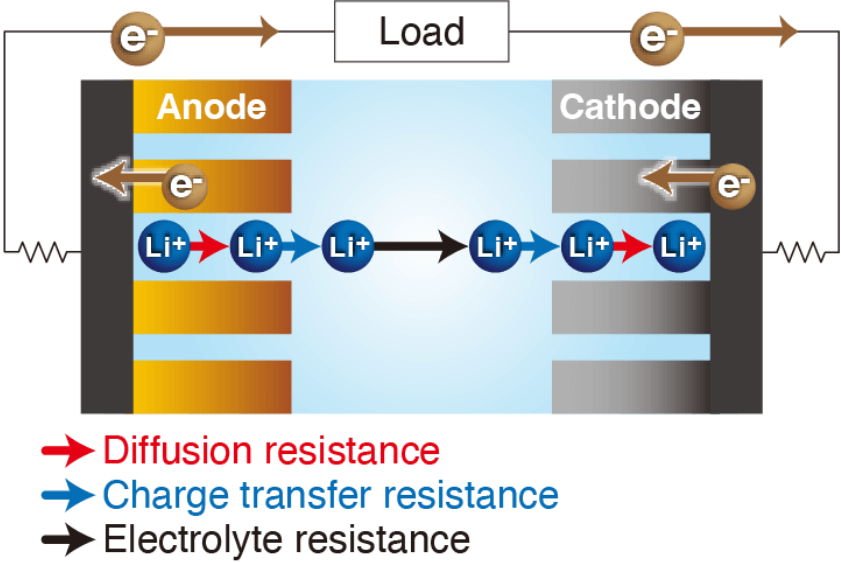
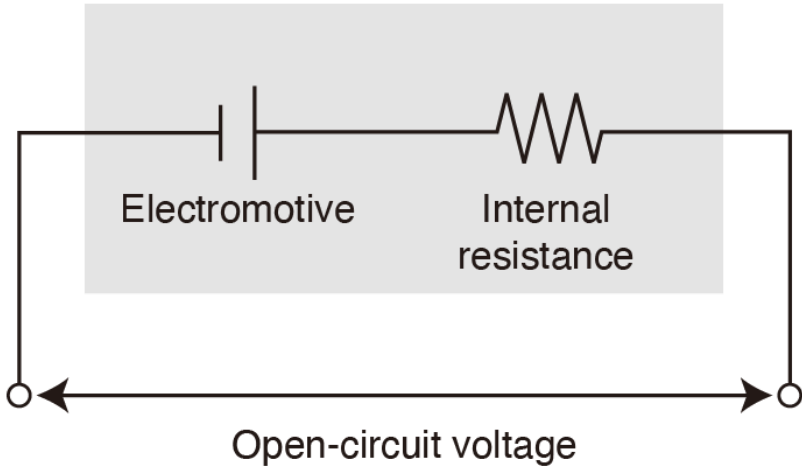


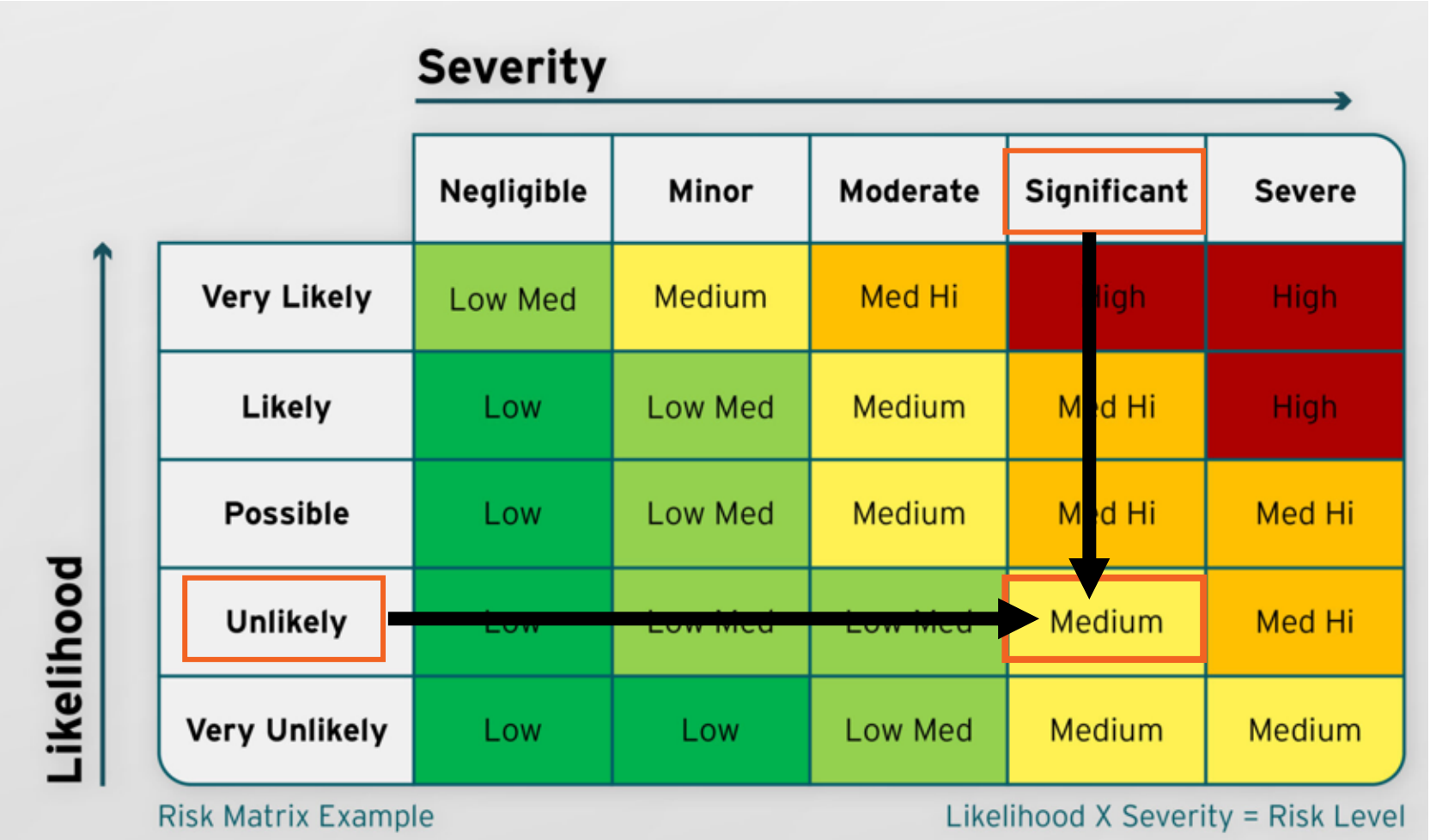
Diagram of a discharging battery

# Insurer Requirements



Firecell 120 min. FRR  
Charging areas 60 min. FRR  
Fire sprinkler system  
Smoke ventilation system  
Separation of 10m combustibles  
Spacing between vehicles

# Fire Risk Assessment



Handbook SNZ HB 4525 Fire Risk Management



# Risk Management



**WORKSAFE**  
Mahi Haumaru Aotearoa | **Energy Safety**

October 2019

ADDENDUM: SECOND EDITION

## Electric vehicle charging safety guidelines

### Introduction

This Addendum to the Electric Vehicle Charging Safety Guidelines – Second Edition (the guidelines) provides updated advice on electric vehicle charging safety to address emerging technology and applications. It should be read alongside the guidelines noting that in some instances this additional advice replaces the advice given in the guidelines.

This Addendum applies from the date of publication.

### Principles of safety for EV charging

The following principles are intended to ensure that charging equipment will provide acceptable levels of safety when connected to supply of electricity in New Zealand, consistent with New Zealand supply configuration and earthing arrangements.

1. The charging supply to an electric vehicle, vessel or aircraft must provide protection from electric shock through a system that is compatible with an EV charging supply and minimises waveform distortion. The system must also provide safety if AC and/or DC leakage occurs and must also include a means of monitoring and ensuring the continuity of the earthing connection to the vehicle, vessel, or aircraft, during the charging process.
2. Where any safety function is not provided as part of the installed charging station or IC-CPD, the safety function shall be installed at the origin of the supplying final subcircuit.
3. Where an EVSE is installed at a residential installation, the charging final subcircuit shall be protected by a type B RCD and the subcircuit shall originate from a MEB switchboard.

4. All safety function fittings operating at low voltage shall be rated to operate at 230 or 400 V as applicable.
5. Every RCD shall comply with the relevant IEC Standards for that type of RCD.
6. Every charging station shall comply with IEC 61851 as appropriate.
7. Any RDC-DD shall comply with IEC 62955.
8. Every IC-CPD shall comply with IEC 62752.

### Use of RDC-DDs

While the guidelines do not recognise the use of an RDC-DD incorporated into an IC-CPD, they do not prevent the use of an RDC-DD in compliance with IEC 62955 in combination with a type A RCD as an alternative to the use of a type B RCD, provided the RDC-DD and the type A RCD are installed in accordance with the relevant IEC Standards.

While the guidelines do not recognise the use of EVSE that incorporates a type B RCD, they do not restrict the use of EVSE that incorporates a type B RCD without the need to install a Type B RCD protecting the final subcircuit.

**Note:** AS/NZS 3000 requires an RCD that provides protection for new final subcircuits installed in a residential installation.

### Use of 32 A or similarly rated socket outlets

Installing a socket outlet to supply a 32 A or higher rated IC-CPD is not restricted for residential (domestic) installations. However the impact on the supplying

WORKSAFE\_2019\_10CT19

New Zealand Government

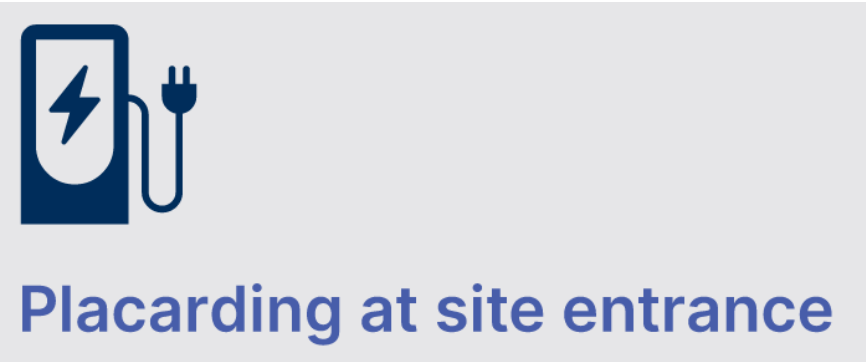
worksafe.govt.nz 0800 030 040 1/2



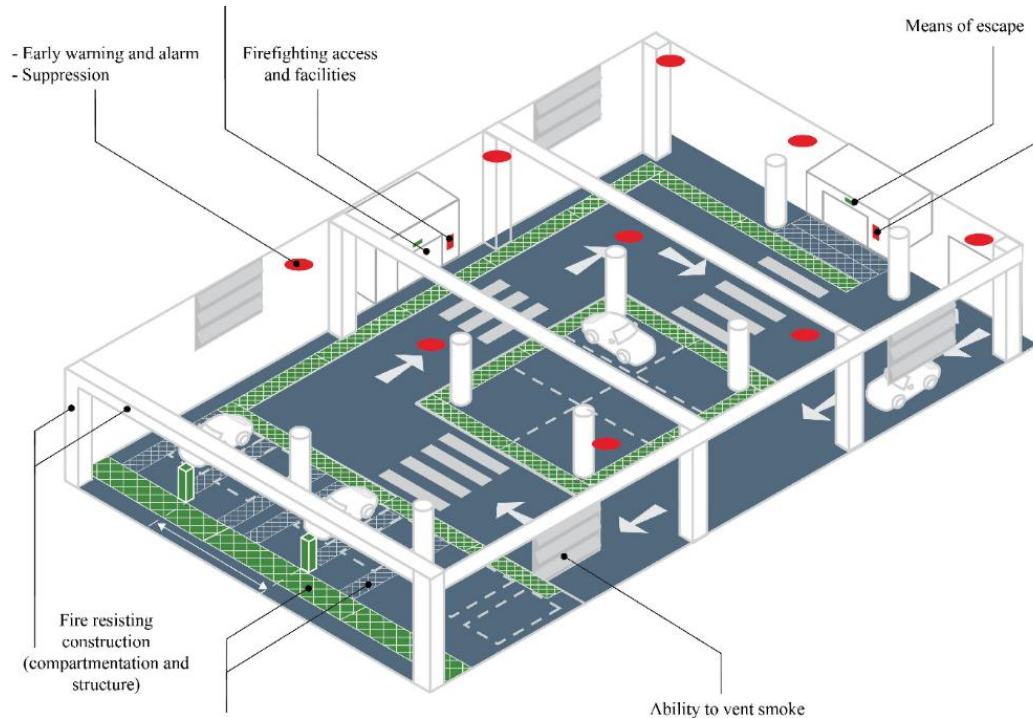
# Risk Management



- Master Isolation Switch
- Smart Charging
- Collision Protection
- Placarding Site Entrances
- AS/NZS 3000 Compliance



# Treat Risk



- Detection Systems
- Suppression Systems
- Smoke Ventilation
- Escape Route/ Exit Points
- Fire Fighting Access
- Fire Ratings

Arup, Office for Zero Emission Vehicles (OZEV), UK

# Sprinkler Systems



- Limit fire spread to adjacent vehicles
- Reduce damage to structure
- Assist with firefighting activities.
- Dilute toxic gases

Arup, Office for Zero Emission Vehicles (OZEV), UK

# Risk Management

# Not Dangerous!



**fire**  **NZ**  
**2024**

