Holistic approach to car park fire safety.

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The 23rd International Water Mist Conference, 18-19 September 2024, Antwerp, Belgium

AGENDA

1. Holistic approach
2. Cooperation in research projects – car parks
3. Parking structures – modern layouts
4. ICE – EV cars fire risk in car parks
5. Review of land & marine test protocols fire incidensts & cause
6. Upcoming research

Holistic approach – definition

”A holistic approach simply ensures that all fire safety elements are working harmoniously.

Of course, every building needs to adhere to fire safety regulations, but this approach ensures you can go above and beyond just complying with the rules”

Cooperation in fire research projects is vital point of your success !

How many research projects in area of car park fire safety nowdays (land - marine) ?

1. NFPA Foundation *
2. FSRI - UL Research Institute*
3. Baltic Fire Laboraotry
4. RISE*
5. Research on national level by fire brigade*

*based on own knowledge

Fig. 1 Example of cooperation

Parking structures - historical approach – fire safety

Standards & codes assumed :

- "In an open car park, a vehicle fire is likely to be constrained to the burning car or at most spread to one or two adjacent cars, before fire department response, and be able to be extinguished by the fire service"
- Enclosed car parks were sprinklered, with successful performance experience
- Open car parks did not require sprinkler protection (yet ?)
- Had minimal loss history (deaths, injuries, economic loss)

Car parks – layouts vs risks

Fig. 2 Example of a two-tier car stacker. Source: solidparking.com

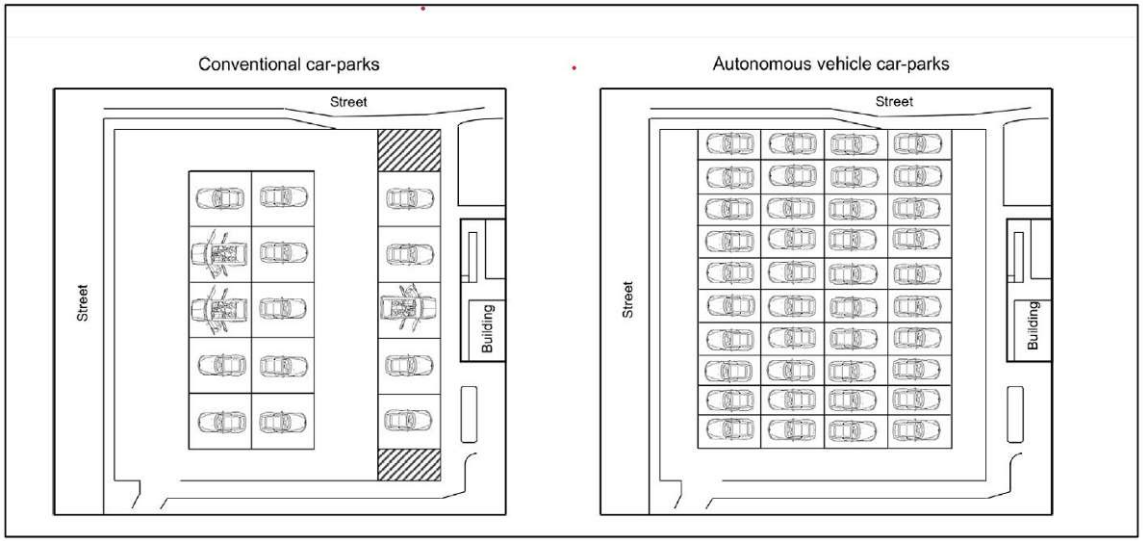
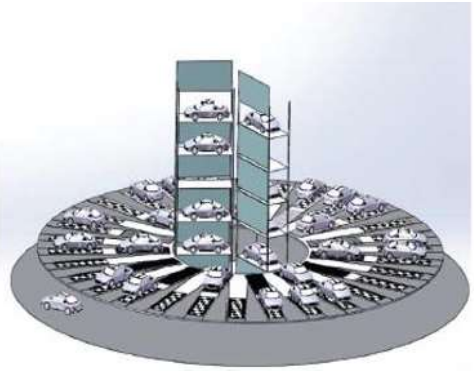


Fig. 3 Potential differences between conventional parking garages (car-parks) and autonomous vehicle parking garages (car-parks)

Source: NFPA Research Foundation, Final Report - Classification of Modern Vehicle Hazards in Parking Structures and Systems – Phase II

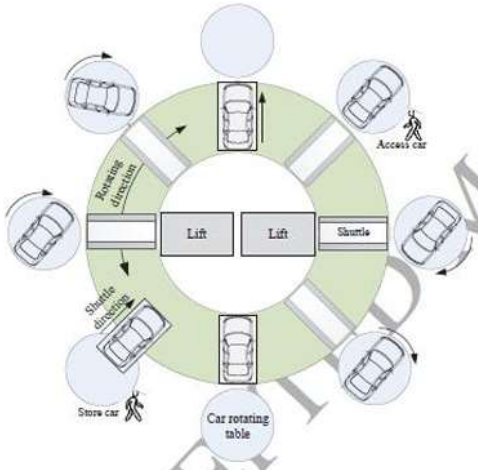
Modern car parks
Challenges in fire proteciton

Fig. 4 Example of car park with residential building - Chicago

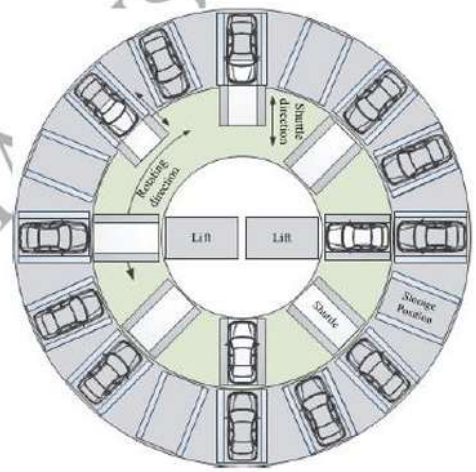


(a) Schematic view

(b) System with two rotating discrete lifts (VW Storage in Wolfsburg)



(c) Top view of ground floor tier



(d) Top view of a higher tier

Fig. 5 Schematic of a conceptual automated parking system.

Parking structures - strong enough nowdays ?

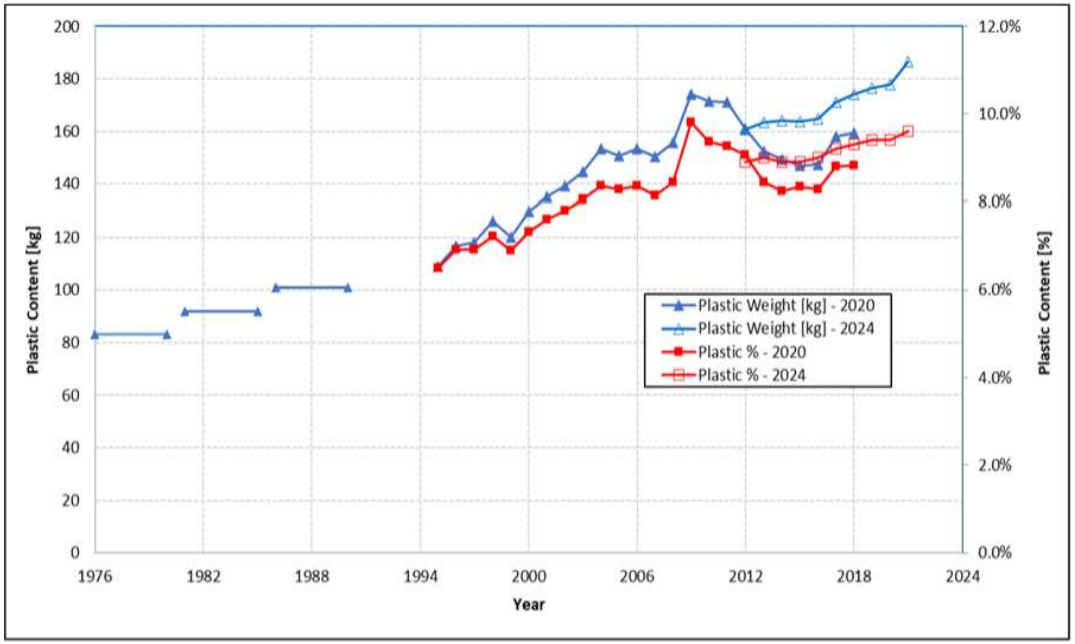


Fig. 6 Vehicle plastic weight and weight percentage as a function of time (data source: American Chemistry Council, 2023)

Fig. 7 Size difference between old and modern cars.

EV vs ICE car - risks

EV

- ✓ Potential toxic gas release
- ✓ Possible vapor cloud explosion
- ✓ Intense jet like, highly directional flames, can burn for extended period of time
- ✓ High temp. flames (~1000+ C)
- ✓ High HRR: can be up to 8 MW
- ✓ Battery cell debris projectiles possible during thermal runaway
- ✓ Reignition Risk

ICE

- ✓ Potential toxic gas release
- ✓ Possible deflagration risk (from fuel)
- ✓ Intense flames – often short lived following suppression
- ✓ High flame temperatures (~1000+ C)
- ✓ High HRR ~ can be up to 8 MW
- ✓ Risk of releasing debris during fire

Source : https://firesprinklerinternational.com/wp-content/uploads/2024/04/H13_Kimball_Update-on-suppression-research-from-the-Research-Foundation.pdf

Hazard Characterization: EV vs ICE

	Electric Vehicles (EV)	Internal Combustion Engine (ICE)
Fuel source	Lithium-ion Batteries	Gasoline
Fire causes	Puncture, overheating, overcharging, over-discharging	Fuel or oil leak, overheating, worn out parts, loose electrical components
Likelihood	25.1 fires/100,000 cars sold	1,529.9 fires/100,000 cars sold
Suppression time	~ 60 – 90+ min	~ 30 min
Water usage	Reports of up to thousands of gallons; Sustained water supply needed	~500 gallons
Reignition potential	Likely, and very common	Rare
Fire size	Can be very large if propagation occurs, Avg HRR: 1.5 - 8 MW Avg THR: 5.9 GJ	Typically limited to one vehicle; propagation is less common Avg HRR: 6.5 MW – 8 MW Avg THR: 5.9GJ

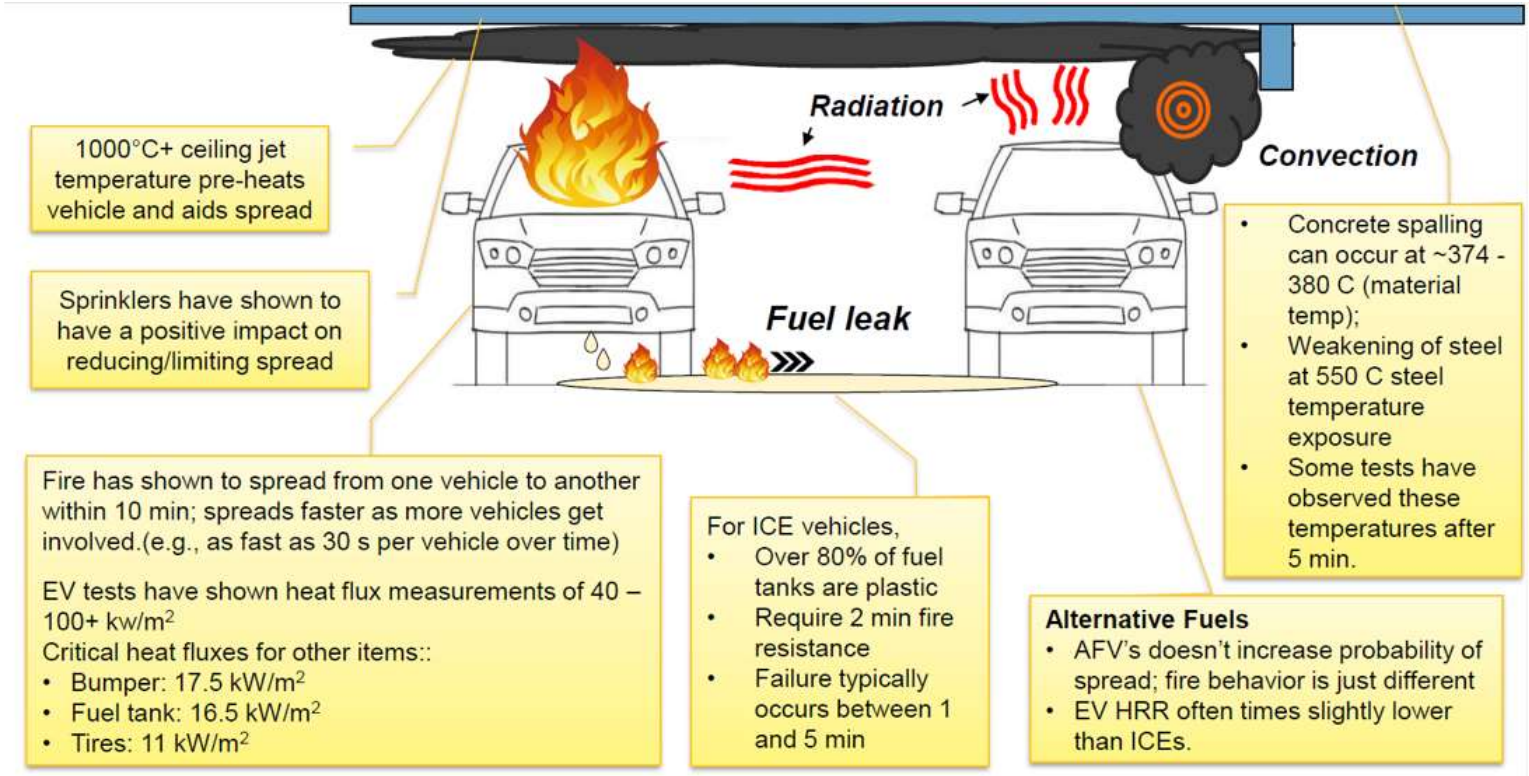
Source : https://firesprinklerinternational.com/wp-content/uploads/2024/04/H13_Kimball_Update-on-suppression-research-from-the-Research-Foundation.pdf

Hazard Characterization: EV vs ICE car

	Electric Vehicles (EV)	Internal Combustion Engine (ICE)
Toxicity of Runoff	Water runoff had a pH of **7.3 - 7.7** copper, antimony, and higher concentrations of manganese, nickel, cobalt, hydrogen fluoride, and lithium	Water runoff had a pH of **2.6 - 2.8** Higher concentrations of lead, copper, polycyclic aromatic hydrocarbons, and volatile organic compounds, testing showed higher toxicity towards aquatic species
Special Post-Fire Considerations	Often towed and placed at least 50 feet away from all surroundings to be proactive against reignition	Vehicles/engines should be inspected to see how much damage was done to determine if repairs can occur
Additional Hazards	Stranded energy, electrocution, second responders, projectiles and explosions, propagation, toxic gas release	Toxic gas release, lots of combustible fuel still accessible to the fire (i.e., a full gas tank)

Source : https://firesprinklerinternational.com/wp-content/uploads/2024/04/H13_Kimball_Update-on-suppression-research-from-the-Research-Foundation.pdf

Fire spread – car park



Source : https://firesprinklerinternational.com/wp-content/uploads/2024/04/H13_Kimball_Update-on-suppression-research-from-the-Research-Foundation.pdf

Research project - Fire spread, can we found critical factors vs celling height – with suppresion system ?

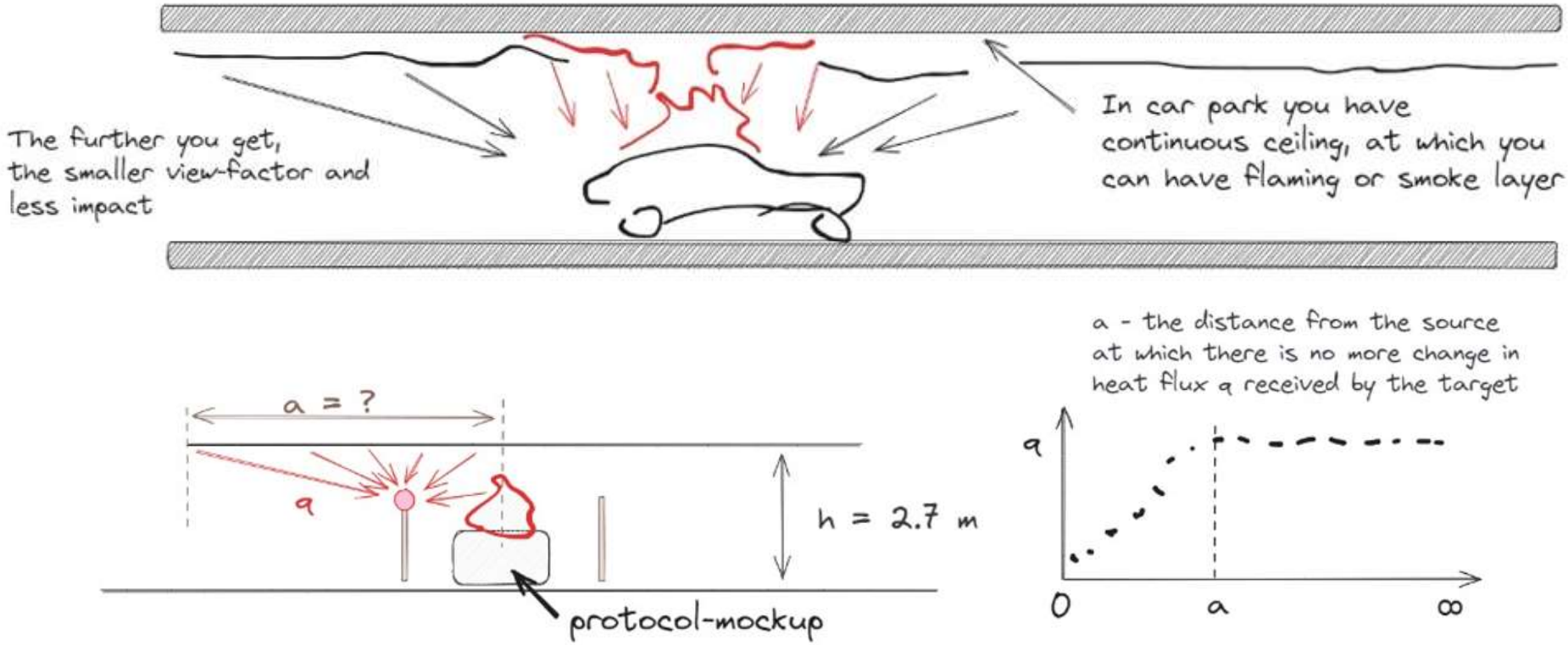


Fig. 8 Fire spread in different ceiling heights – research project

Fire spread – EV fire in tunnel – 5 [m] ceiling with tunnel ventilation

Fig. 9 Example of fire spread, brand new EV fire in undergound structure, laboraotry conditions – tunnel. Acknowledgments to Relaible Sprinklers Inc.

How many cars are needed to proof system performance as per prEN14972-5 ?

prEN14972-5
Water mist standard for car park fire protection

- ✓ Minimum 8 cars if you are good
- ✓ Maximum 24 or more ?
  sky is the limit

Fig. 10 Laboraotry view with cars prepared for prEN14972-5 fire tests

prEN14972-5 – Full scale fire test - factors

How to plan properly successfull test program

A. Ceilling height
B. Nozzle, sprinkler offset from the celling
C. Nozzle – sprinkler type (conventional sprinkler, low & high pressure water mist)
D. Water based system pressure & flow
E. Nozzle, sprinkler spacing
F. WET or DRY system – delay time
G. Type of car*

*cars in all tests should be similar type as possible (sprinkler reference & approvla test)

prEN14972-5 | VdS 3883-4 – full scale fire tets

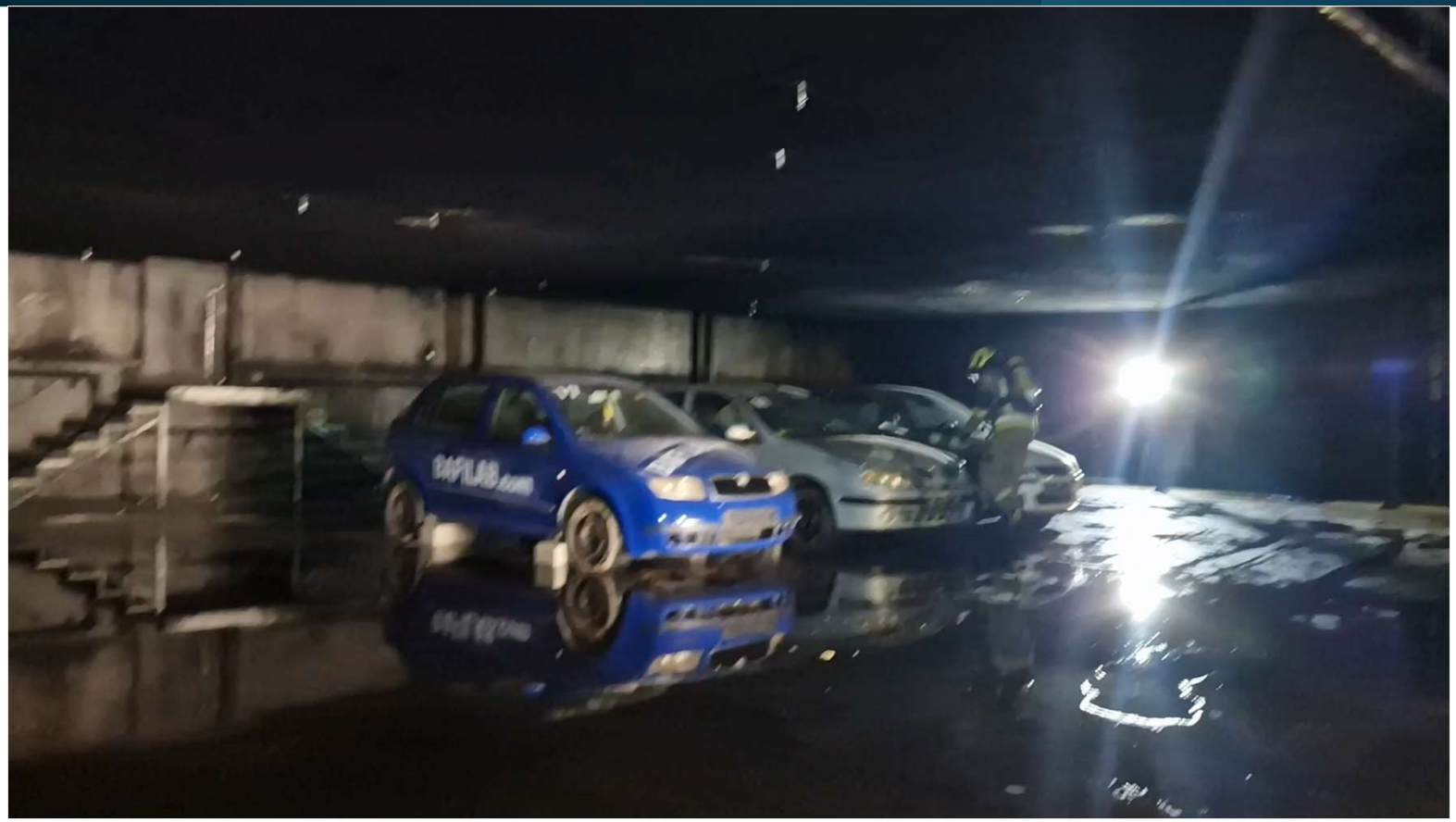


Fig. 11 prEN14972 – full scale fire test

Market discussion
Sprinkler – Water mist density for car parks - prEN1492-5

The sprinkler system for parking garage would have been designed in accordance with VdS CEA 4001, which applies "the same OH2 criteria as EN 12845, i.e. an application density of 5 mm/min over 144 m2 for wet systems". This density relates to something between light (4.1/140 mm/min/m2) and OH1 (6.1/140 mm/min/m2) in accordance with NFPA 13 [2022 edition] [29]. Therefore, with a sprinkler system that provides less water than that required in the United States, both prior to and after the latest changes to NFPA 13, a fire in an EV and charger was controlled until ultimate extinguishment by the Fire Department. This can be considered successful sprinkler system performance. In this case, while it appears that the sprinkler prevented fire spread or certainly significant fire spread beyond the first vehicle, the originating vehicle did burn nearly to completion with a sprinkler positioned directly above it. This behavior is in concurrence with several testing reports in the literature where, despite sprinkler activation, the originating vehicle continued to burn to completion, but further significant fire spread was successfully prevented. The originating vehicle may have continued to burn due to the shielding of the fire from the sprinkler system. It is unknown if a higher sprinkler density would have fully extinguished the fire in the originating vehicle. Conversely, it is unknown if a sprinkler in a different location relative to the origin vehicle would have continued to prevent fire spread to additional vehicles. A further consideration from this case study is that even with a functioning sprinkler system, a fire in a car can do significant damage to the structure and nearby vehicles, even if it does not ignite them.

Source : https://firesprinklerinternational.com/wp-content/uploads/2024/04/H13_Kimball_Update-on-suppression-research-from-the-Research-Foundation.pdf

Car park risks in marine – PCC / RORO decks 2.5 [m] ceililng height

Fig. 12 Example of MSC.1/Circular.1430 mock-up, 2,5 [m] ceiling height

Fig. 13 Example Pure Car Carrier (PCC) – car layouts

Car park risks in marine – PCC / RORO decks
5 [m] ceililng height

Fig. 14 Example of MSC.1/Circular.1430 mock-up, 5 [m] ceiling height – fire test

Fig. 15 Example of RORO deck fire, 5 [m] height

Felicity Ace Car Carrier - fire

- ✓ Cargo section caught fire on 16 February 2022
- ✓ On 1 March 2022, Felicity Ace was reported to have capsized and sunk

- ✓ 22 crew members safley evacuated, No injures-victims reported

- ✓ Porsche lost 1,117 cars
- ✓ Audi lost of 1,944 cars
- ✓ Volkswagen lost 561 cars
- ✓ Bentley lost 189 cars
- ✓ Lamborghini lost 85 cars

Cargo total loss **US$400M**

- ✓ Cargo Fire fighting system high expansion foam system

Fig. 16 Felicity Ace – during fire

Felicity Ace Car Carrier – recovery operation

Fig. 17 Felicity Ace – vessel section during recovery operation

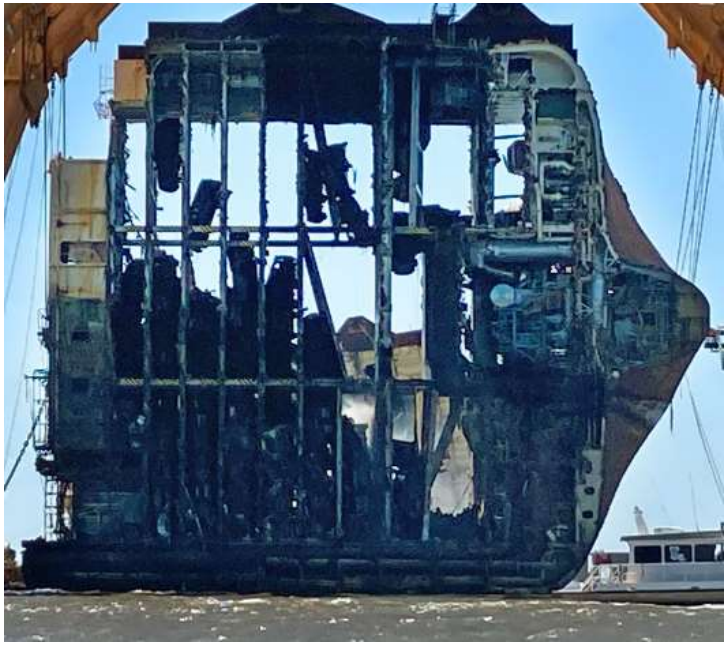


Fig. 18 Felicity Ace – vessel section during recovery operation

Fremantle Highway Car Carrier - fire

- ✓ Cargo section caught fire on 25 July 2023
- ✓ A salvage operation to prevents sinking and an oil spill lasted until 3 August 2023
- ✓ One of the 23-man crew died, 16 crew members injured, evacuated via helicoptrer
- ✓ 3,783 cars on board the ship, 498 were electric vehicles.
- ✓ Cargo Fire fighting system
  high expansion foam system

Fig. 19 Fremantle Highway car carrier – thermal view


Fig. 20 Fremantle Highway – cargo hall post fire view


Fig. 21 Fremantle Highway – under fire investigation

Water based suppresion systems education – vital point for systems understanding and intergation into buildings technical specifications.

2024 Summer School Fire Fundamentals for Performance-Based Fire Safety Design

Team of fire safety experts :

- ✓ Professors
- ✓ PhD
- ✓ PhD candidates

From 30 countries

Ghent University
Liverpol University
University of Queensland
Victora University
ARUP
SWECO
DBI
ZAB
ETH
OFR Consultants
ITB
PROTEC

etc.

Conclusions

A. LAND :

A.1 Water based systems are not widley used in open cark parks
A.2 Celling height in car parks play vital role in fire spread – system performance impact
A.3 Most of the systems are tested for MAXIMUM approval height -
A.4 Each system tested in performance based way as per prEN14972-5 is good
A.5 Bulb nozzles systems as preferable inline with prEN14972-5 standard
A.6 Appear some systems with OPEN nozzles as per EN14972 **Annex A**
A.7 Real cars used for full scale fire tests

B. MARINE :

B.1 Approval for water based systems are devided into two approval heights 2,5 [m] and 5 [m]
B.2 Possibility to approve system for OPEN or BULB nozzles – MDA (most demanding area impact)
B.3 OPEN nozzles systems with LHD are prefered, efficiently form 1st Jan 2026 – imo decison
B.4 Mock-up consist of EURO pallets used for simulation

Acknowledgments

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Thank you for your attention !
Questions ?

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