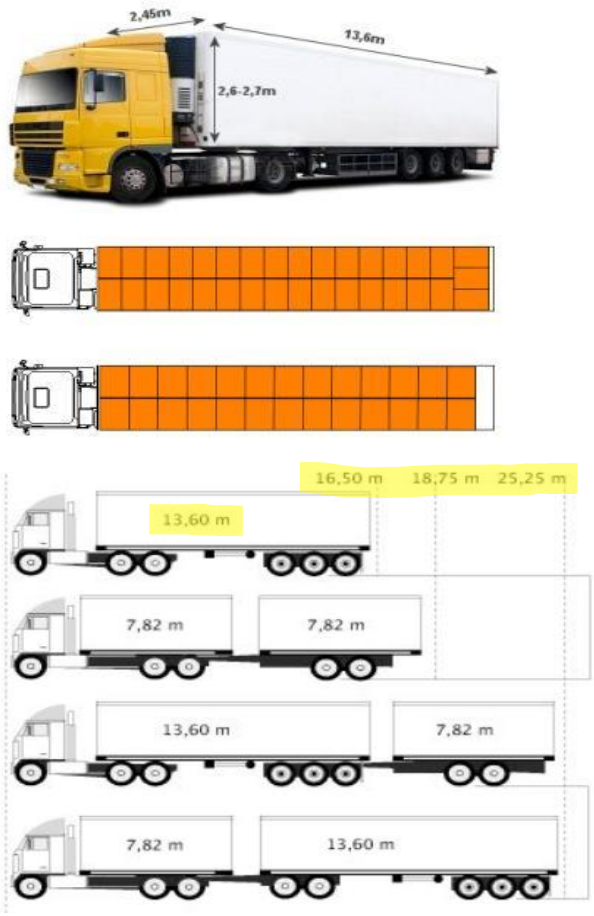
“big droplets beats flow”

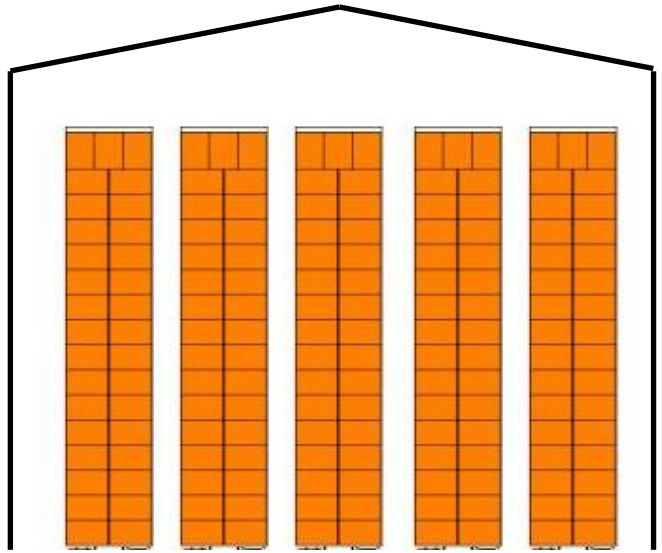
Henrik Johansson
Business Development Manager

Johnson Controls

Commodity & Risk



Design Risk: Heavy goods vehicle (HGV) represents the highest risk in road tunnels and which the full-scale testing of FFFS normally is dimensioned for.



Is it a risk that we are familiar with?

Warehouse vs Tunnel

- Horizontal storage
- Horizontal fire development
- Short distance from nozzle to the fire
- Strong air velocity from forced ventilation. May cause drifting of smaller water droplets
- Ventilation feed open fires with oxygen
- The back, top, front and sides (Tarpaulin) of the truck shields the fire from water discharge from above, but also slows down the fire development
- Less air is allowed to move freely into the fuel compared to rack storage

Warehouse vs Tunnel

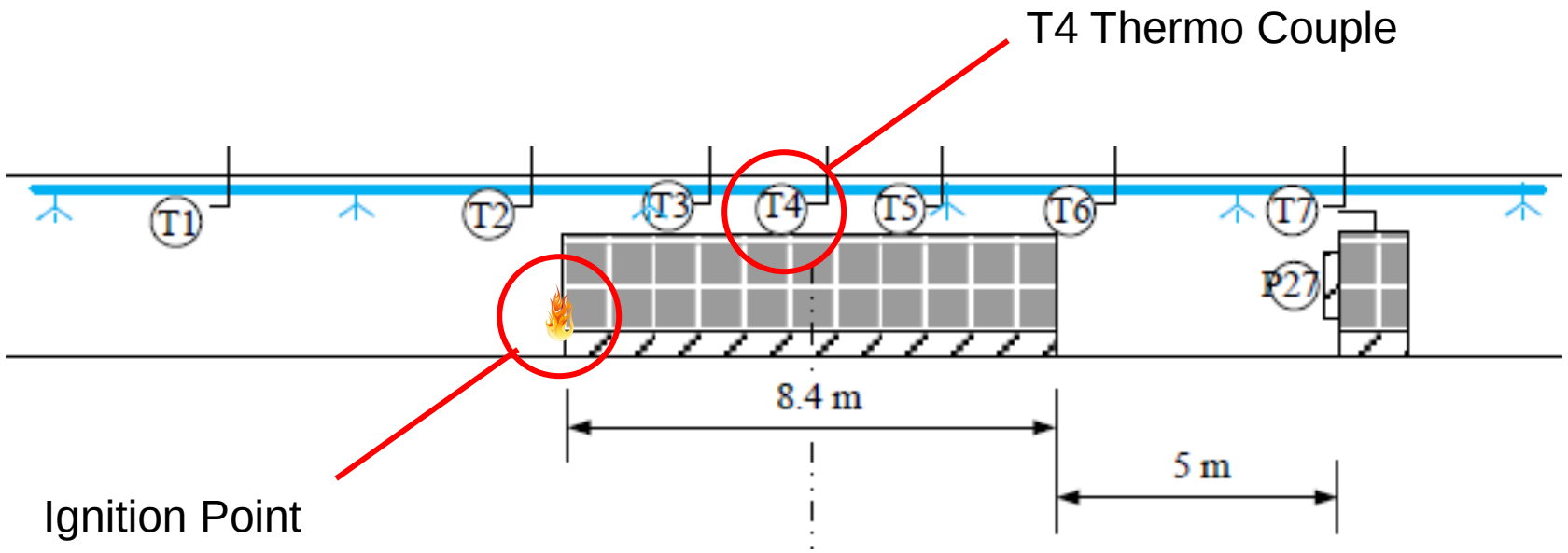
- Vertical storage
- Vertical fire development
- Long distance from nozzle to the fire.
- Updraft - up to 20 m/sec towards the water discharge
- Small droplets cannot penetrate through neither the storage or the fire plume.

- Small droplets = no effect – may cause skipping
- Big droplets = large effect
- Faster fire development than in Tunnel Fire with the same fuel
- The fuel blocks the water discharge
- The rack configuration allows constant supply of oxygen to the fire

Runehamar test series (100 MW)

- Delay time - calculated from T4 reach 141º C after ignition
- Average time for T4 to reach 141º C is 4 minutes
- Water delivery time = T4 at 141º C + delay time

- Fuel 440 wooden pallets = 100 MW
- Target 20 pallets
- Wind Velocity 3 m/sec
- One zone activated



Test flows

Nozzle	K-factor	Flow rate (lpm)	Pressure (bar)	Total flow rate (lpm) 30 m zone	Total flow rate (lpm) 25 m zone
TN-25	360	375	1,1	2250	1875
TN-25	360	300	0,69	1800	1500
TN-25	360	268	0,55	1608	1340
TN-17	240	268	1,25	1608	1340
TN-17	240	233	0,95	1400	1165
SW-24	160	233	2,13	1400	1165

Initial Stockholm ByPass design scope

- The testing and design of TN for the Stockholm ByPass tunnel has been driven by Swedish Road Administration and RISE

- 10 mm/m^2/min – based on earlier testing and experience
  - Tunnels in Australia, Japan and Belgium
  - IMO – testing on HGV's on RO-RO ship

- All testing and installations in the past are with standard sprinklers or MW nozzles

- SP Report 2009:29 (RISE) shows that MV nozzles provided fire control at 5 mm water density, while High Pressure Water Mist needed 5,8 mm for reaching fire control
  - Why MV nozzles – Commonly used on RO-RO deck drencher (deluge) systems
  - MV provides larger droplets than Water Mist but smaller than sprinkler

Source:

Droplet size vs Flow

Approximately 8-minute water delivery time after ignition

(141º ceiling temp center fuel package + 4 min delay time)

Test No	Model	K-Factor	Pressure	Flow/ nozzle	Pallets Consumed	Pallets Consumed %
4	TN 25	360	0,55	268	53	13 %
1	TN 25	360	0,7	300	76	18 %
2 (2013)	TN 25	360	1,1	375	85	20 %
3	TN 17	240	0,95	233	104	25 %
2 (2016)	TN 17	240	1,25	268	113	27 %
5	SW 24	240	2,1	233	181	43 %

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Spray Pattern

TN25 – 2250 l/min, 1,1 bar

TN25 – 1608 l/min, 0.55 bar

Water Mist, HV and MV nozzles in Road Tunnels

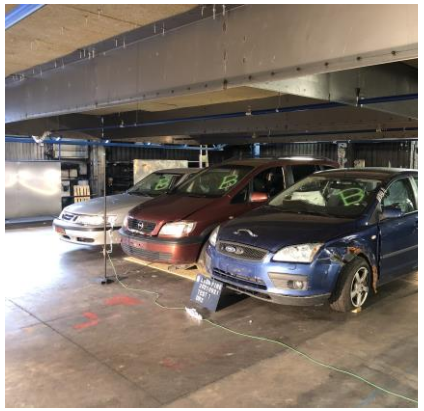
DO

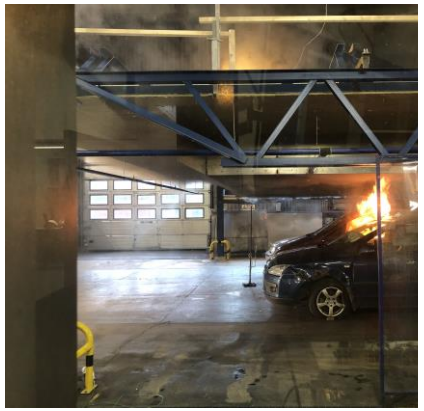
- Cool air and reduce radiation heat better than sprinklers. The smaller droplets, the better cooling
- Move with the air flow (drifting), not stable in ventilated areas

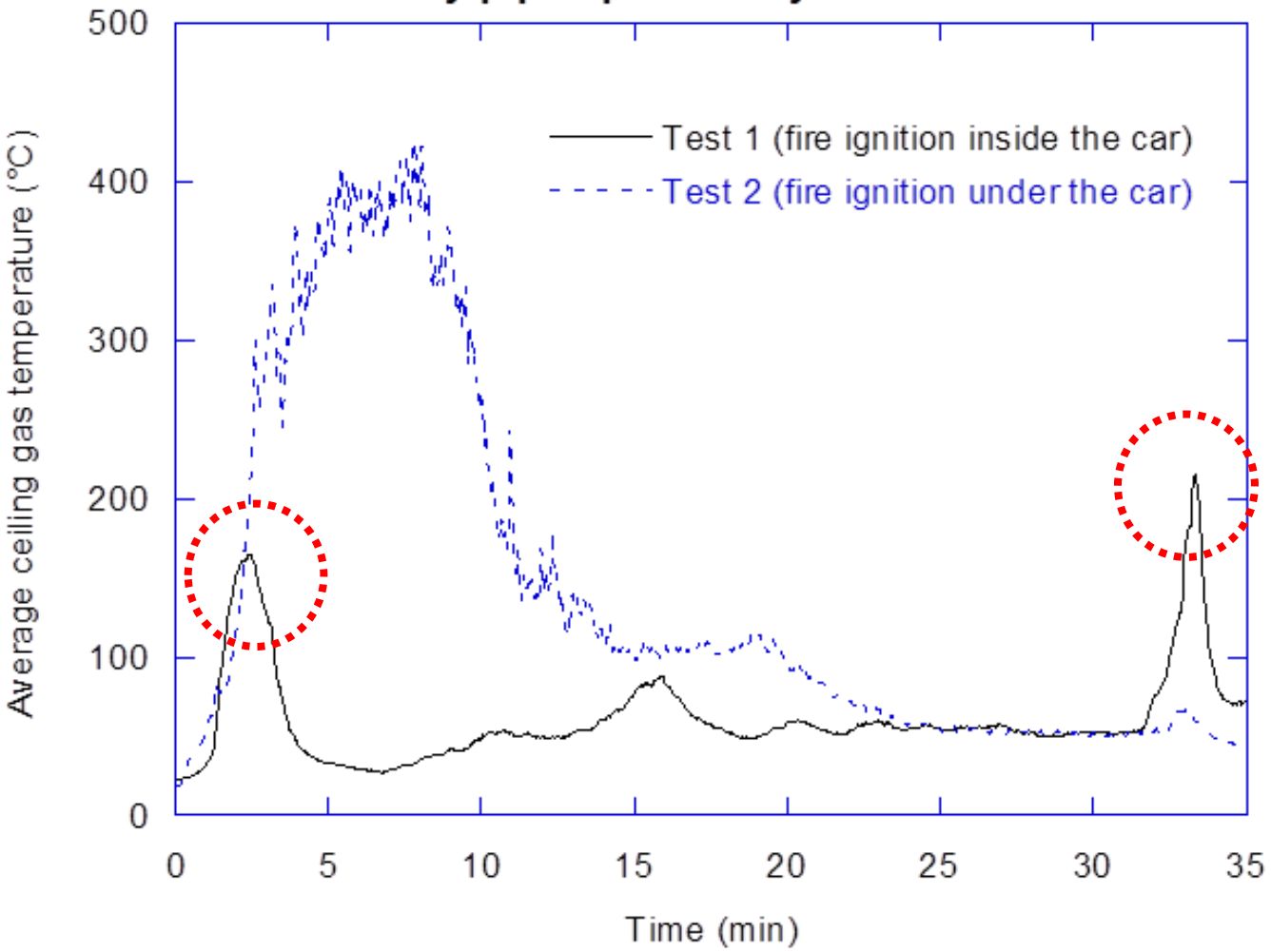
DO NOT

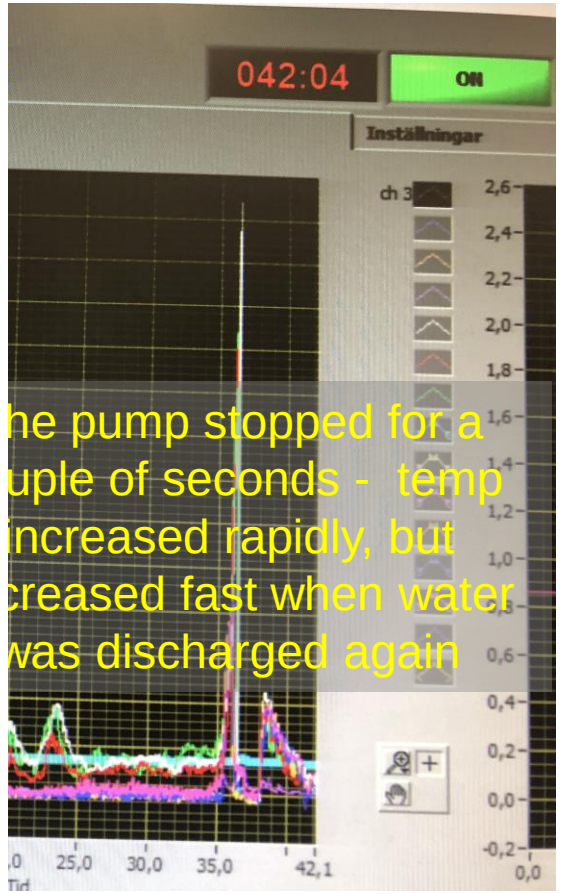
- Block oxygen from the fire in tunnels. Much too high air velocity feeding oxygen to the fire
- Cool surfaces and structures better than sprinkler. Total water density counts
- Have good effect on the Heat Release Rate (HRR)
- Provide good visibility

Testing with Standard Sprinklers for RO-RO deck with vehicles, 2022



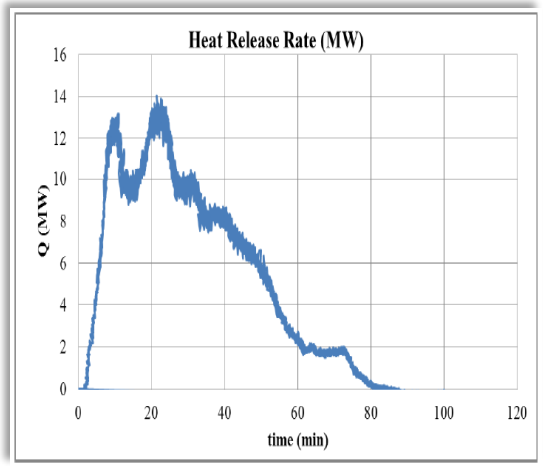






TN – Large Droplets

- High Performance - good effect on the Heat Release Ratio (HRR), controlling and suppressing the fire
- Less radiation produced
- Very good cooling of structures and surfaces
- Keeping the fire within the envelope
- Provides very good visibility
- Stable spray patterns in high wind speeds
- Low water demand



- Only need one zone in operation – minimum length equal to the longest vehicle allowed in the tunnel - normally 20 – 25 m

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THANK YOU?

QUESTIONS, COMMENTS or REMARKS?