Tunnel Fire Suppression with Low Pressure Mist

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Mosen Ltd

LOW PRESSURE WATERMIST

Utilises the best from 2 technologies

High Pressure Watermist

- Low water consumption
- Small water droplets

Sprinkler/Deluge

- Robust & low maintenance
- Cost efficient: standard PN 16 components
- Low power consumption

Objective

- The objective of the tests was to evaluate the performance of Model TUNPROTEC® with regard to fire, smoke and structural temperature control and tenability conditions in simulated HGVs 250 MW fires in a full scale tunnel with longitudinal ventilation with high ventilation rates 5 m/s

The test set-up

- Efectis designed a test setup for VID Fire-Kill by considering the requirements and specifications in NFPA 502:2017
- Previous tests carried out by Efectis in which a deluge sprinkler system was tested with a similar, but smaller fire load and with a lower ventilation velocity
- Measurement of key parameters for life safety and structural fire protection

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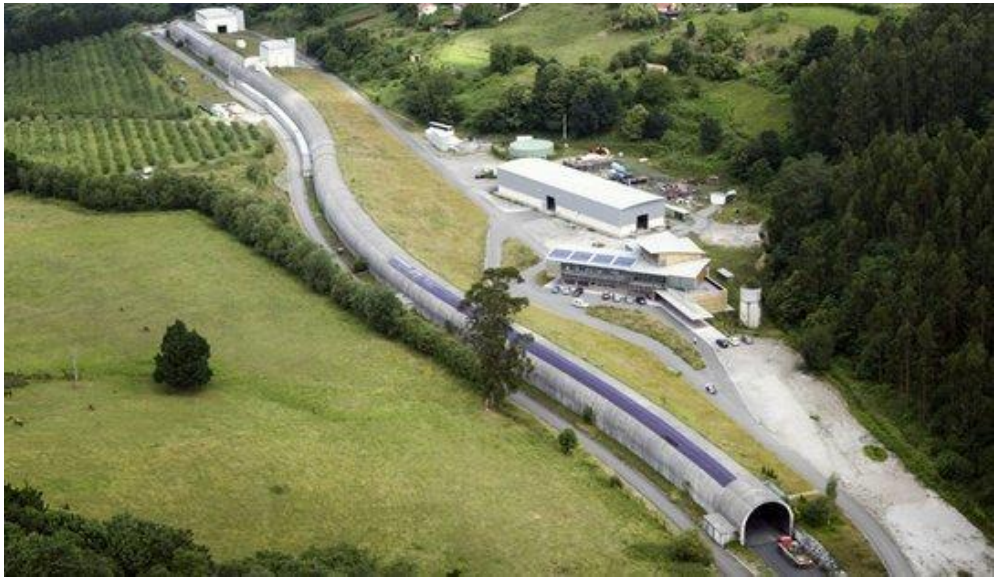
The test facility

"SAN PEDRO DE ANES" FULL SCALE TUNNEL FIRE TEST

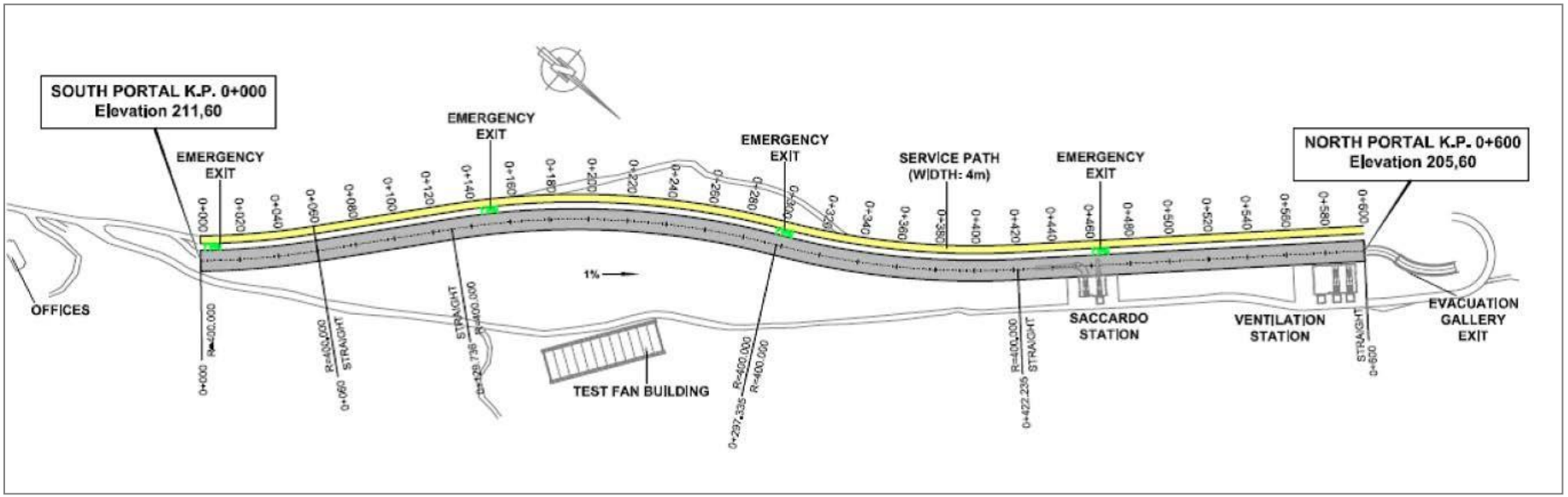


TEST FACILITY

The tests were conducted in the TST tunnel facility located close to Oviedo and Gijon in the Northwest of Spain. The tunnel is used for fire tests and fire brigade training and is made of reinforced concrete. The tunnel is owned by Applus Laboratories.

The test facility

"SAN PEDRO DE ANES" FULL SCALE TUNNEL FIRE TEST

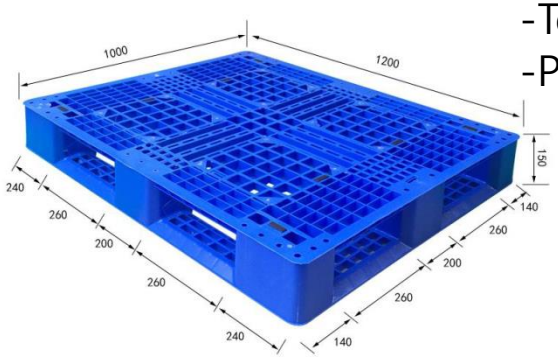


TEST FACILITY

The south portal of the test tunnel and office building/control room on the right-hand side. The length of the test tunnel is 600 m with a curvature as displayed here.

Test set-up

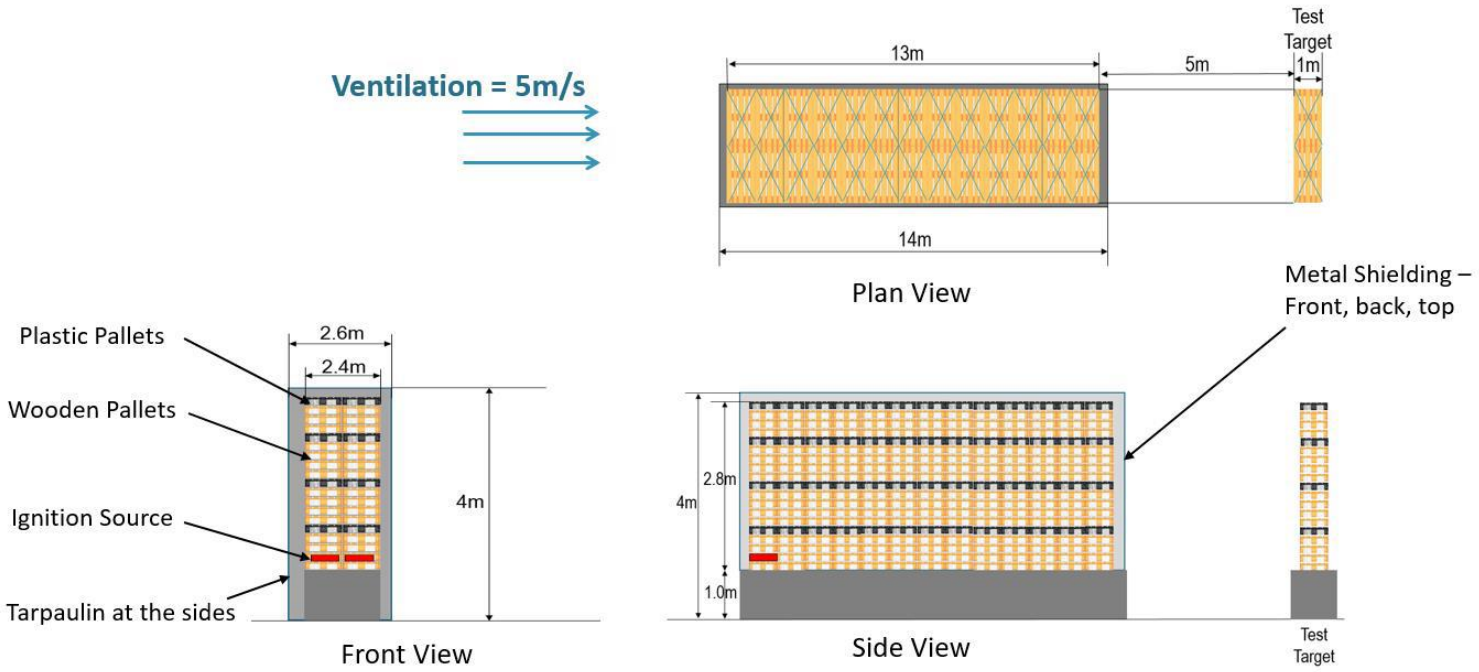
"FIRE LOAD" A SIMULATED HEAVY GOODS VEHICLE



Fuel Load –390 Wood (80%) and 104 Plastic (HDPE) Pallets (20%)
-Each stack comprises of 19 pallets
(15 wooden 4 plastic pallets)
-Total number of stacks = 26
-Total number of pallets = 494
-Pallet Dimensions: 1.2m x 0.8m x 0.15m

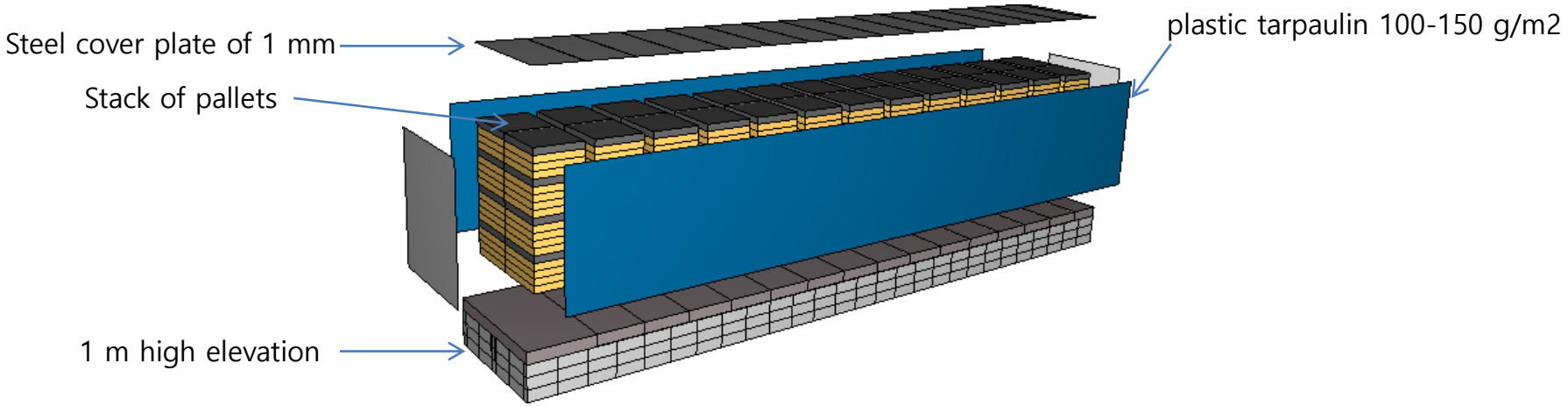
Test set-up

"FUEL PACKAGE" A SIMULATED HEAVY GOODS VEHICLE



Test set-up

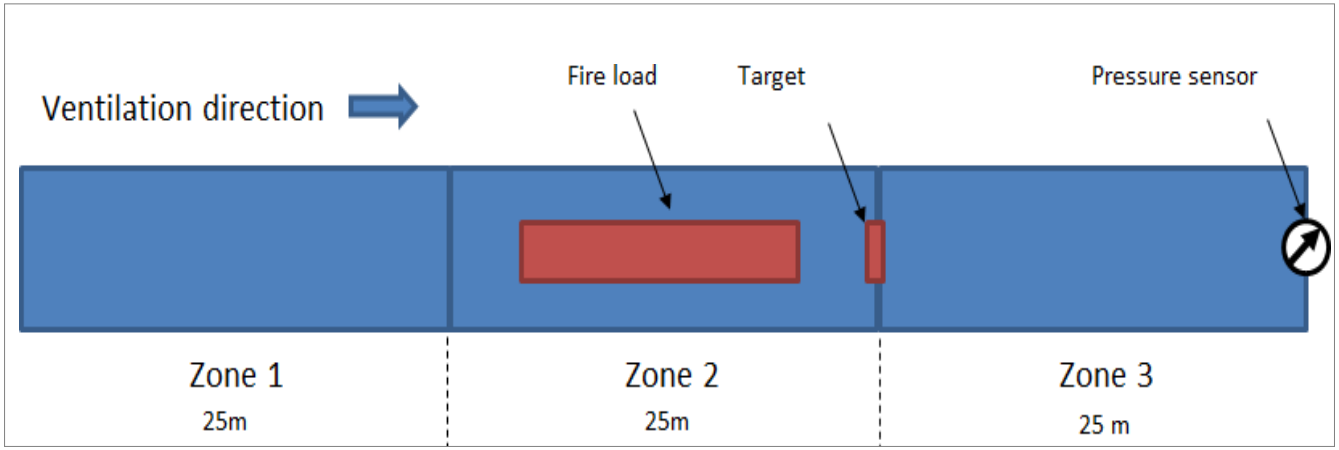
"FUEL PACKAGE" A SIMULATED HEAVY GOODS VEHICLE



Covers around the pallets; Grey: Metal sheet, Blue: Tarpaulin.

Test set-up

"FIRE LOAD" A SIMULATED HEAVY GOODS VEHICLE



Zone alignment in the tunnel with regard to fuel load. (not scaled)

Results full scale fire test (May 2018) High ventilation velocities

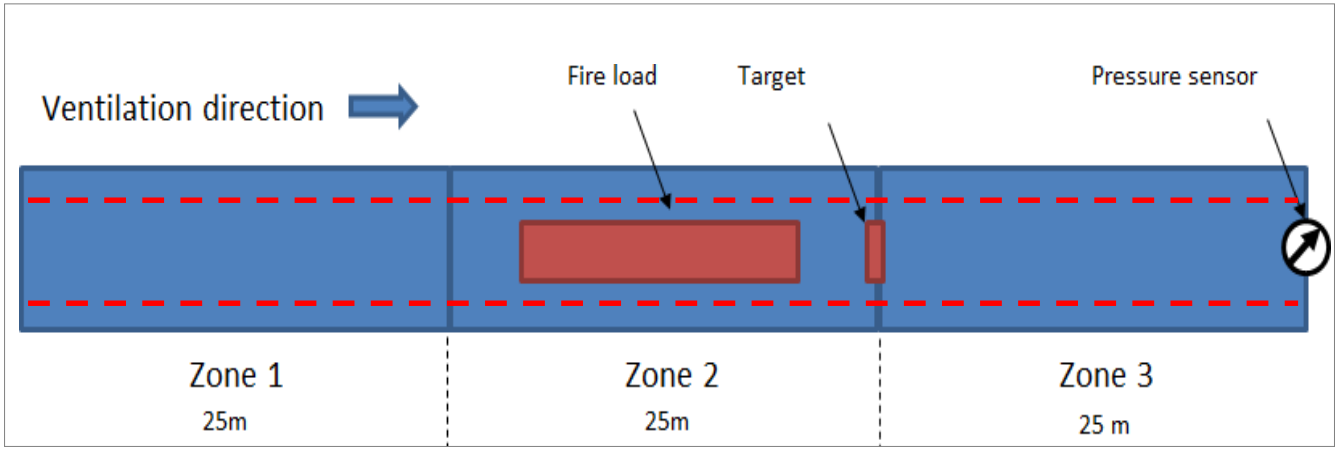
Results

FIXED FIRE FIGHTING SYSTEM

<table>
<tr><th colspan="4">DESCRIPTION</th></tr>
<tr><td rowspan="3">Zone 1, 2 and 3</td><td colspan="3">TUNPROTEC® Water mist system
Length of each zone: 25 m
2 longitudinal pipeline – 6 m appart, Nozzles at every 0.33 m
K-factor: 72,1 for 6 m long pipe Total K-factor of each zone: 300</td></tr>
<tr><td>Nozzle type</td><td>Both sides (70°)</td><td>K-factor: 4.0</td></tr>
<tr><td></td><td>Downwards</td><td>K-factor: 2.0</td></tr>
<tr><td></td><td>Water density</td><td colspan="2">5 mm/min./m2 for a 12 m wide tunnel</td></tr>
<tr><td>Fuel</td><td colspan="3">Fuel load’s centre point was at the centre of Zone 2.
5 mm gap between top metal sheets on the fuel load.</td></tr>
</table>

Test set-up

FULL SCALE TUNNEL FIRE TEST 24TH OF APRIL 2018

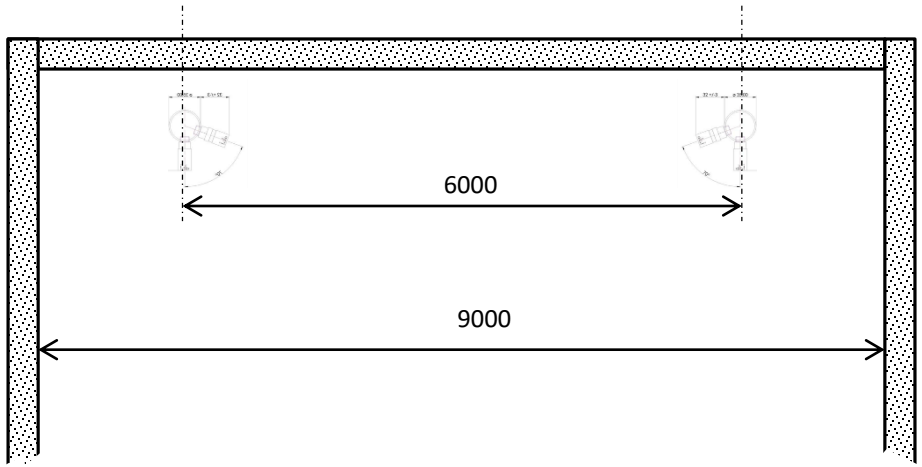


Two nozzle lines TUNPROTEC model 5MS (not scaled)

Test set-up

"FULL SCALE TUNNEL FIRE TEST 24TH OF APRIL 2018"

Technical Specifications	
N-Pipe Dimensions:	Ø35x1.5 mm Ø42x1.5 mm Ø54x1.5 mm
Maximum Operation Pressure:	16 bar
Minimum Operation Pressure:	10 bar
Pressure Class:	PN16
N-Pipe Length:	6 m
N-Pipe Connections:	Open end for press-fitting
Maximum Installation Height:	8 m
Maximum Ventilation during Operation:	5 m/s
Spacing pr. Pipe:	Length: 6 m Width: 6 m
K-factor: (for 6 m pipe)	60 (metric)
Nominal Flow: (at 10 bar)	190 l/min
Nominal Water Density: (for 6 m wide tunnel)	5.3 mm/min
Material - Nozzle:	AISI 316L, EN1.4404
Material - N-Pipe:	AISI 316L, EN1.4404



Results

FULL SCALE TUNNEL FIRE TEST APRIL 2018 - SPAIN

TIME	REMARKS
00:00	Ignition
02:05	Detection
06:10	Water activation
36:00	No pallets fell during the test
36:10	Test ended

Results

TENABILITY - GRAPHS

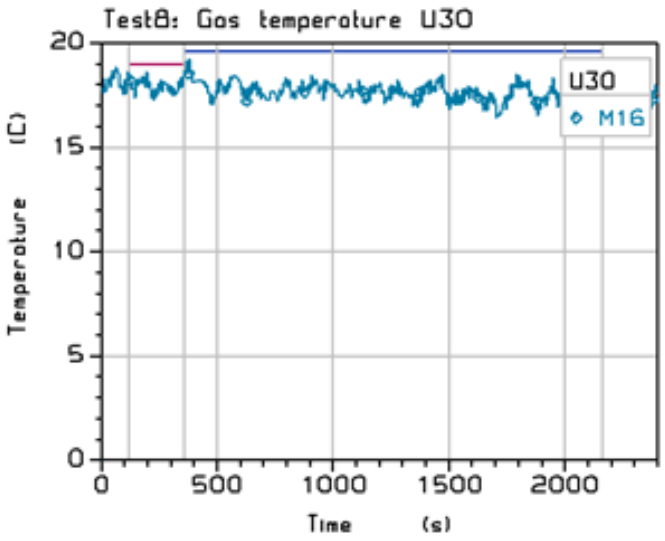


Figure A: Gas temperatures at upstream 30 m

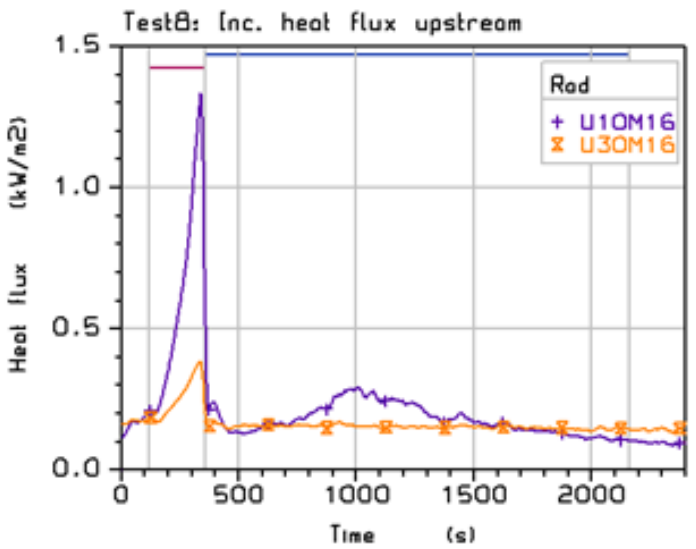


Figure B: High heat flux values for upstream 10 & 30 m

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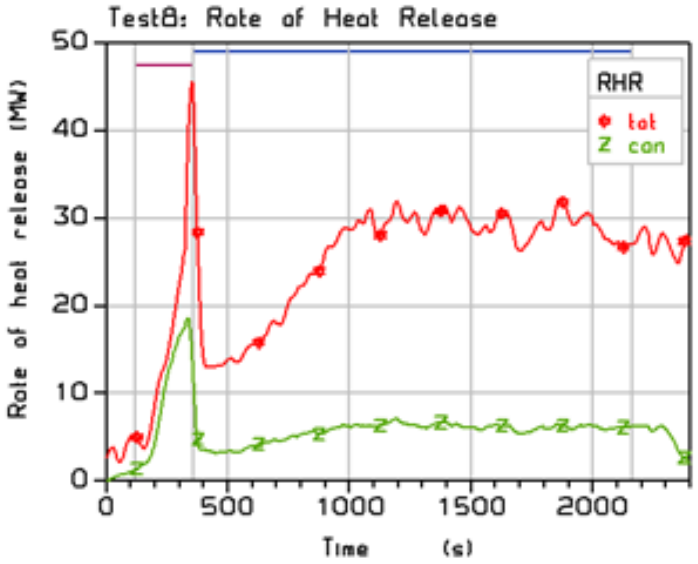
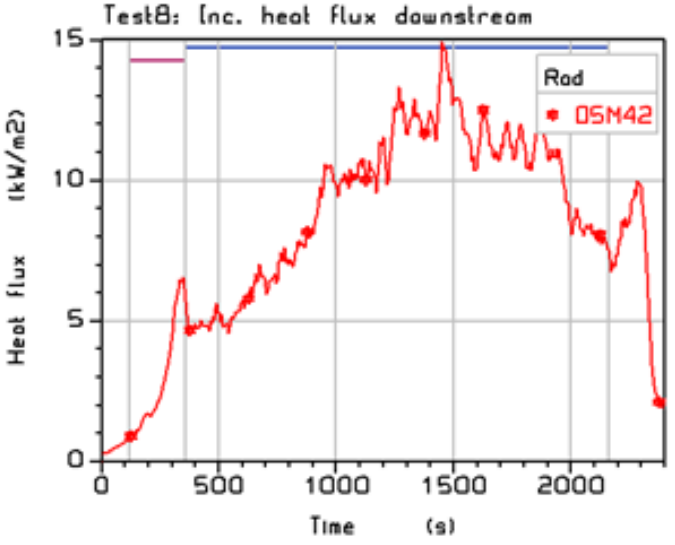
Results

STRUCTURAL PROTECTION - HRR & HEAT FLUX



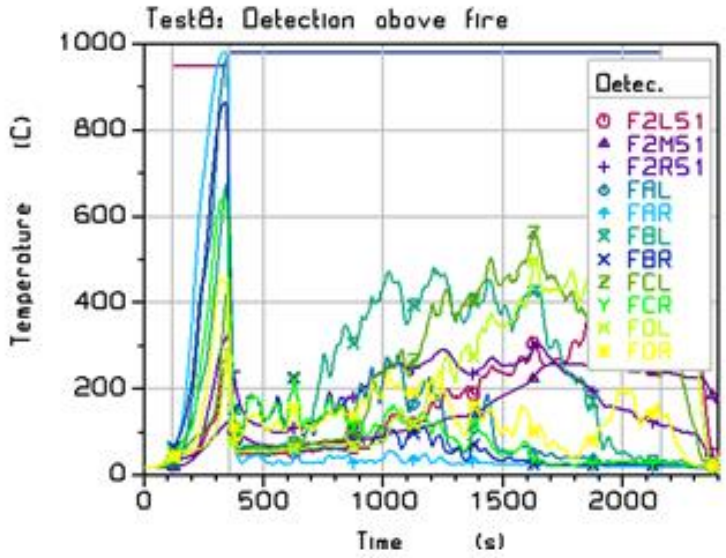
HRR values



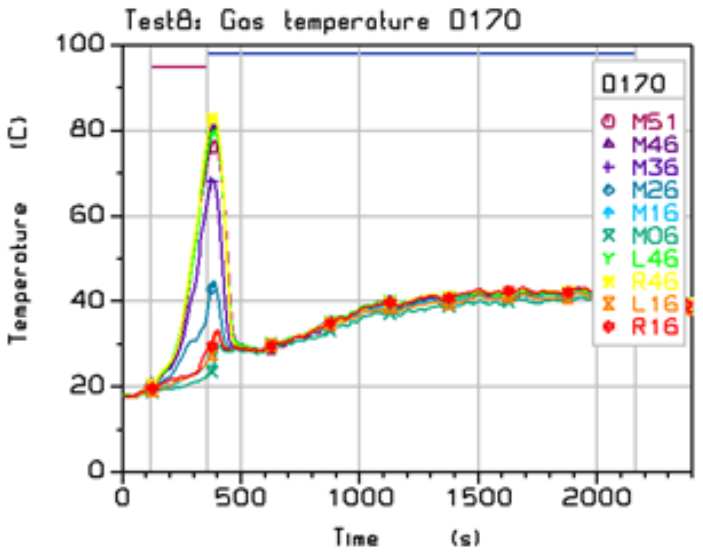
Heat flux values - no fire spread was observed

Results

STRUCTURAL PROTECTION - TEMPERATURES



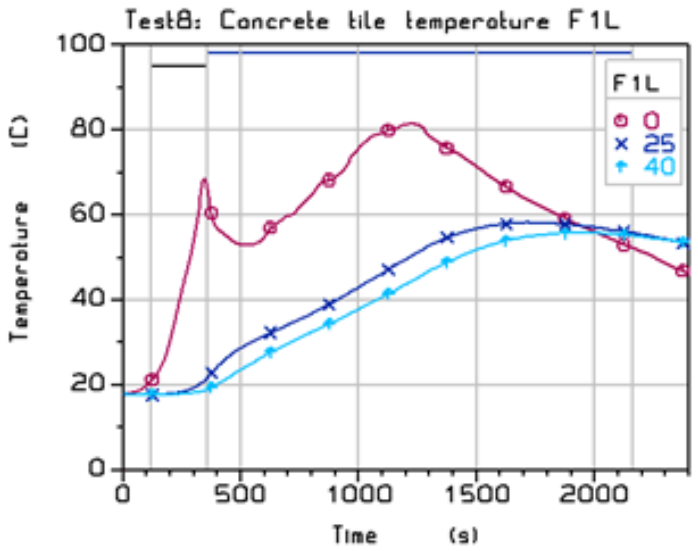
Temperatures above the fire



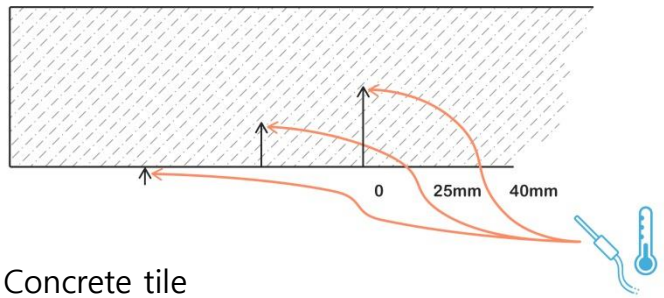
Temperatures immediately dropped when watermist activated

Results

STRUCTURAL PROTECTION – CONCRETE TILES



Temperature at the surface 0, at 25 mm & 40 mm



Concrete tile

Results

TOPIC	MEASURED	CRITERIA
Max heat release rate	See figure 1F1 HRR	50 MW
Max. convective heat release rate	7 MW	50 MW
Fire spread to target pallets	No	No fire spread allowed
Max ceiling surface temperature	82 °C (Tile at F1)	380 °C
Max temperature steel reinforcement in concrete tile	58 °C (Tile at F1)	250 °C
Tenability at upstream 30 m	– Beacons remained visible – Max temp: 20 °C – Max heat flux: 0,15 kW/m^2 – CO remained 0 ppm	- Visibility - Temperature (limit: 60 °C) - Heat Flux (limit: 2.5 kW/m^2) - Carbon monoxide
Detection	60 ℃	60 ℃
Min. activation time of water system	04:05 after detection at 60 ℃	04:00 [min:sec] after detection at 60 ℃
Initial ventilation speed	4,9 m/s	5 m/s (±25%) = (3.75-6.25 m/s)
Water density	5,0 mm/min./m2	5,0 mm/min./m2 for a 12 m tunnel

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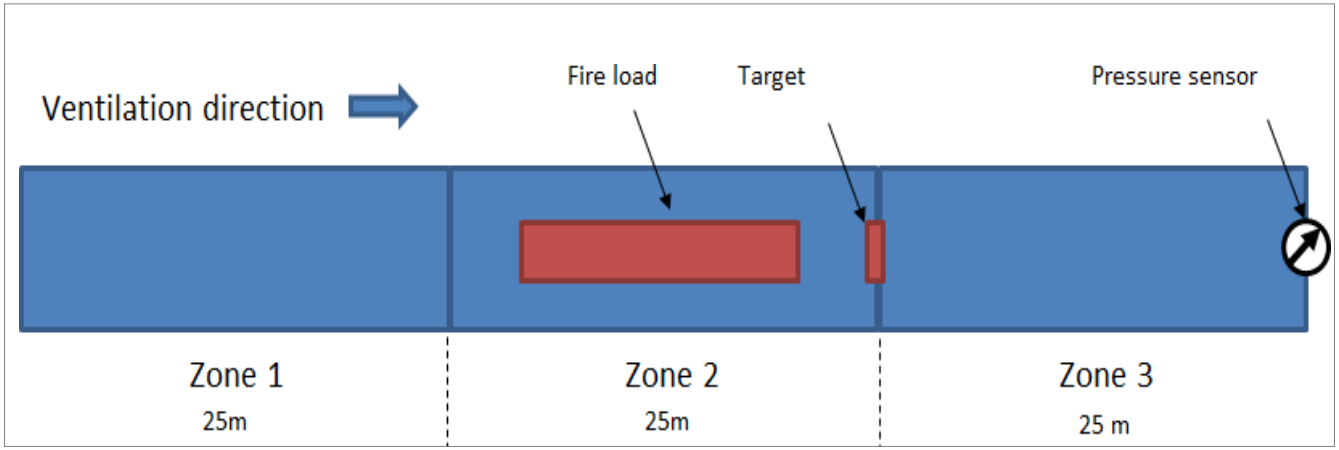
Results full scale fire test (October 2018)"Free-burn"

Set-up

FULL SCALE TUNNEL FIRE TEST APRIL 2018 - SPAIN



Free burn set-up (not to scale)

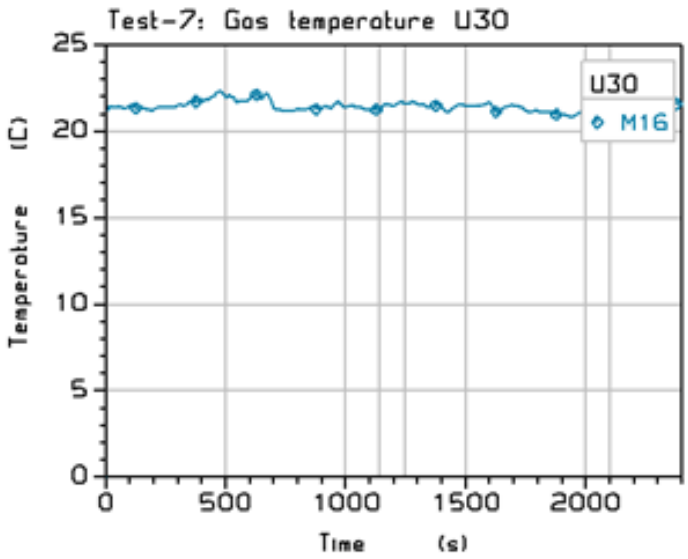
Observations

TIME	REMARKS
00:00	Ignition
03:17	Detection
08:30	Tunnel ventilation speed is too low
09:00	Back-layering up to U5 observed. Extra two jet fans activated
09:00	1 pallet falling down
11:30	Additional one jet fan activated
12:00	Velocity measurements at D170 stopped working
19:00	Steel frame collapsing
20:45	Velocity measurement at D170 stopped working
20:50	One fan deactivated
28:40	Minor/initial intervention by fire brigade
31:10	Full/additional intervention of fire brigade
33:50	Test ended

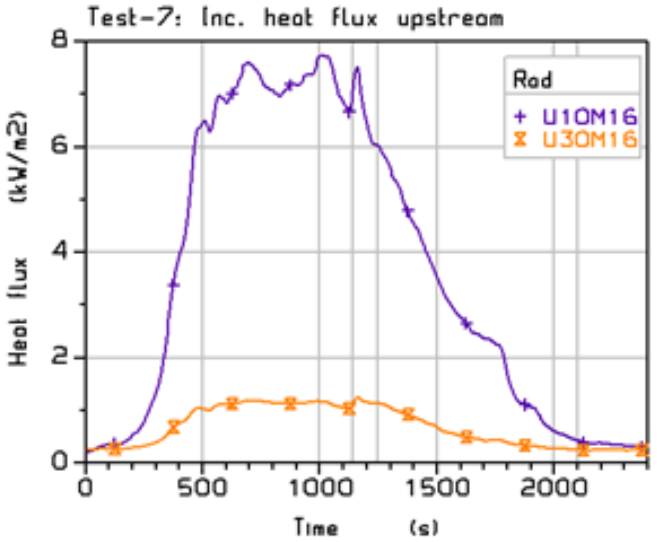
GENERAL OBSERVATIONS	
Visibility at U30	Visibility was maintained throughout the test
CO at U30	0 ppm throughout the test
Remaining unburnt pallet after the test	Approximately 95 % of the fuel burnt
Target	Completely burnt

Results

TENABILITY - GRAPHS



Gas temperatures at upstream 30 m



High heat flux values for upstream 10 & 30 m

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Results

STRUCTURAL PROTECTION - GRAPHS HRR – HEAT FLUX

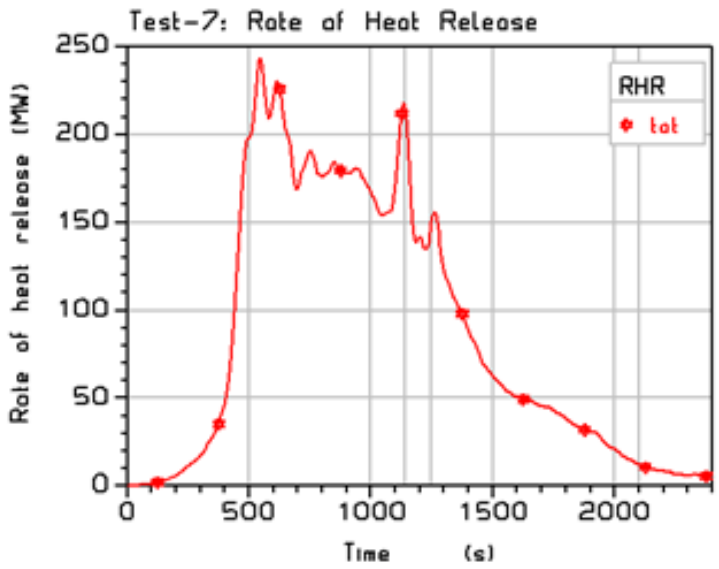

Figure 1F: HRR went from 0 – 250 MW within 8 minutes

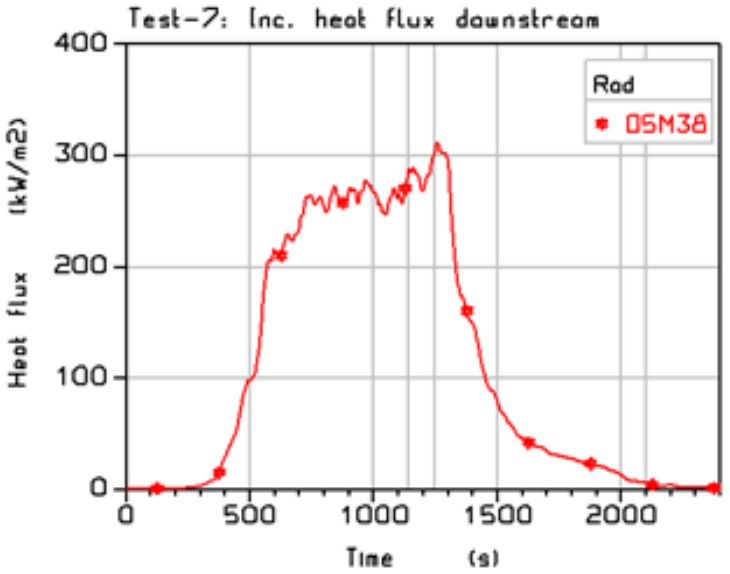

Figure 2F: High heat flux values initiated fire spread downstream

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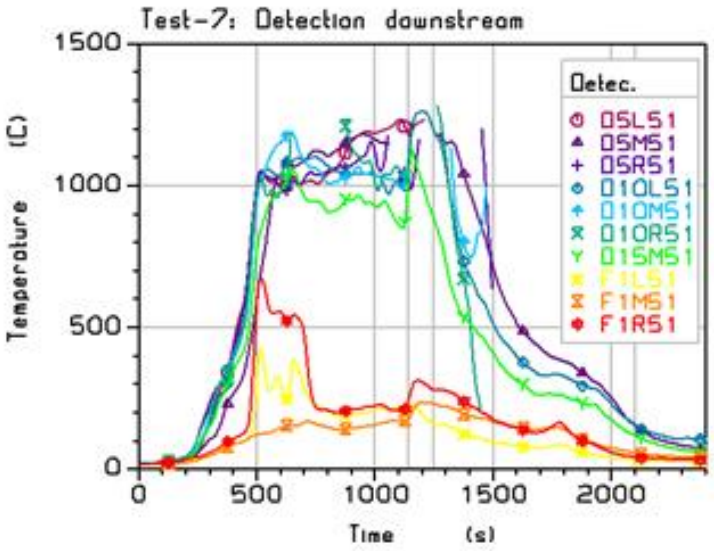
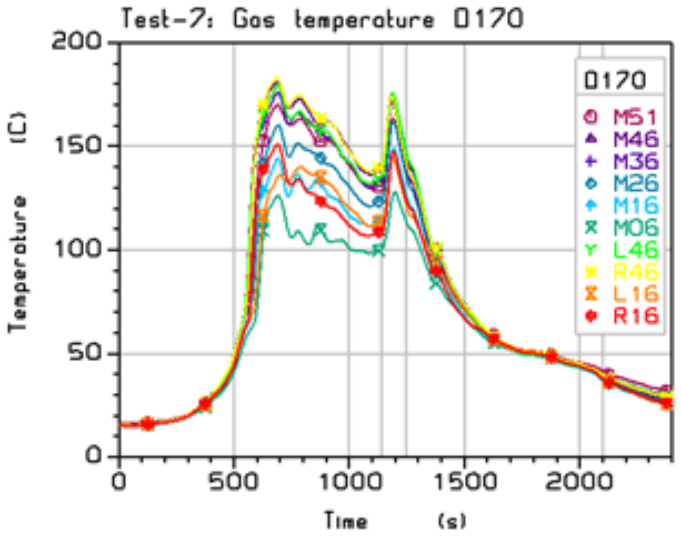
Results

STRUCTURAL PROTECTION - GRAPHS TEMPERATURES



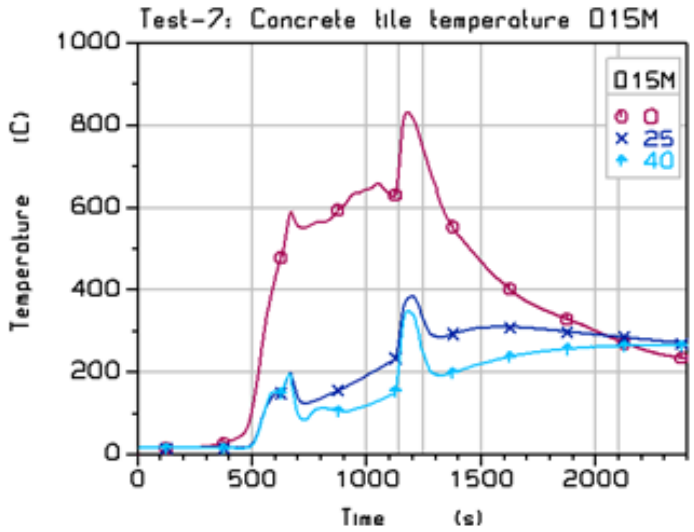
High and rapid temperature rises observed above and near the fire



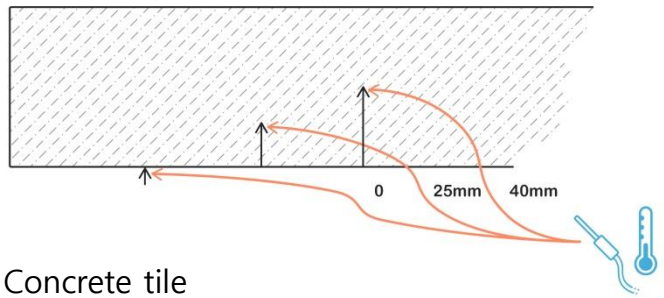
High temperatures even at 170 m downstream

Results

STRUCTURAL PROTECTION – CONCRETE TILES



Temperature at the surface 0, at 25 mm & 40 mm



Concrete tile

Results

TOPIC	MEASURED	CRITERIA
Max heat release rate	243 MW	50 MW
Fire spread to target pallets	Yes (completely burnt)	No fire spread allowed
Max ceiling surface temperature	832 °C (Tile at D15)	380 °C
Max temperature steel reinforcement in concrete tile	385 °C (Tile at D15)	250 °C
Tenability at upstream 30 m	– Beacons remained visible – Max temp: 25 °C – Max heat flux: 1.3 kW/m^2 – CO remained 0 ppm	- Visibility - Temperature (limit: 60 °C) - Heat Flux (limit: 2.5 kW/m^2) - Carbon monoxide
Detection	60 ℃	60 ℃
Max. number of suppression zone & length	N/A	N/A
Initial ventilation speed	5,0 m/s	5 m/s (±25%) = (3.75-6.25 m/s)

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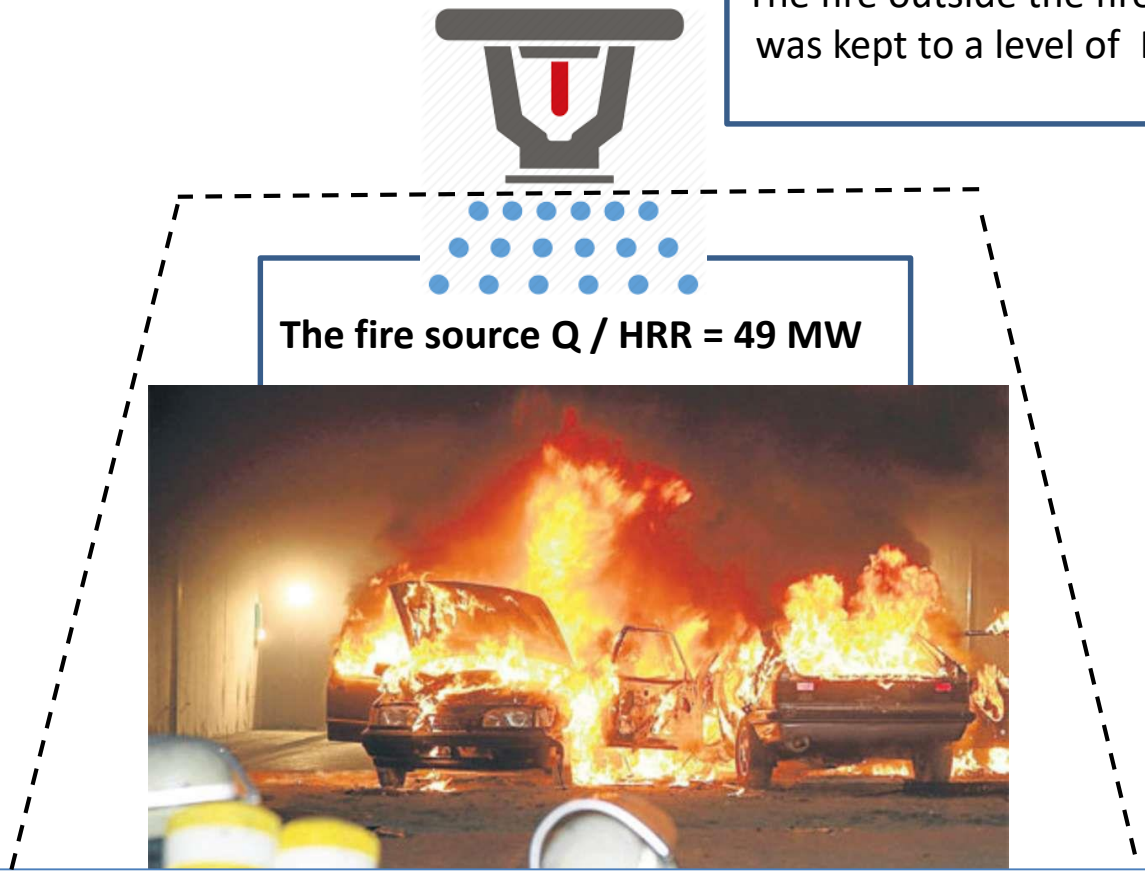
How to utilise results obtained?

Convective Heat Release Rate

The fire outside the fire source = Q HRR total was kept to a level of $HRR_{convective}$ of 7MW



COMPENSATING EFFECTS FOR INSTALLING A FIXED FIRE FIGHTING SYSTEM

Ventilation & critical velocity

Thanks to the significant smoke reduction and cooling of smoke:

- The number or capacity of jet fans can be substantially reduced.

- In certain cases longitudinal ventilation can be used instead of planned semi-transverse or transverse ventilation systems, or smoke extraction systems.

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COMPENSATING EFFECTS FOR INSTALLING A FIXED FIRE FIGHTING SYSTEM

Structural protection

Due to the cooling effect of the Fixed Fire Fighting System and its ability to absorb heat from a tunnel fire, makes it possible to:

- Eliminate or reduce planned passive fire protection
- Allow for lower fire rated components within the tunnel

COMPENSATING EFFECTS FOR INSTALLING A FIXED FIRE FIGHTING SYSTEM

Improved risk assessments

Due to the excellent cooling effect of the Fixed Fire Fighting System and its ability to absorb heat from a tunnel fire:

- Improve occupant tenability
- Allow better evacuation procedures
- Assist fire brigade intervention

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Conclusions

- Low-pressure mist systems can combine many of the advantages of low- and high-pressure fire suppression
- Now accepted by Land Transport Authority of Singapore on their two CTE tunnels
- Also accepted in Europe, e.g. Nordhavnsvejens Tunnel, Copenhagen

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