Water Mist for Ventilated Large Scale Cable Tunnels

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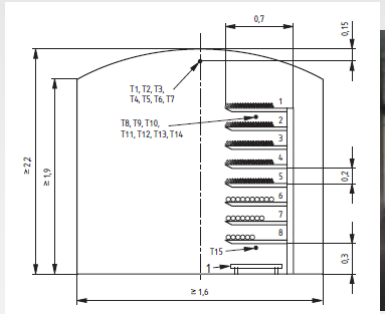
Water Mist for Cable Tunnel Fire Protection



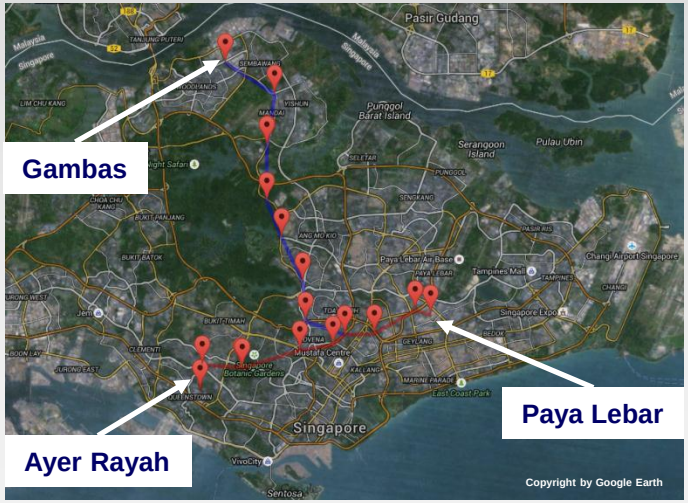
- Water mist technology has been broadly used for cable tunnel fire protection in the past 20 years
- Applications can be found in infrastructure projects, power generation, steel, chemical and other industries
- Water mist offers flexibility, particularly for retrofits into existing structures
- Systems are well tested and certified based on fire tests scenarios of international standards as CEN TS 14972
- Environmental conditions, particularly ventilation conditions, are taken into account
- Down-times in case of fire can be reduced

Large Scale Infrastructure Projects

- Infrastructure projects constantly increase in size
- Due to the growth of the mega cities, power grid networks are under refurbishment or extension and require up to date fire protection measures
- For cable tunnel protection, water mist is identified as optimal solution in many of these refurbishment and extension projects
- With growing power transmission networks, cable tunnel sizes are growing as well and exceed the coverage of current water mist system certifications and approvals

→ Specific fire test scenarios have to be developed to reflect particular project related conditions

Singapore Power Transmission Cable Tunnels

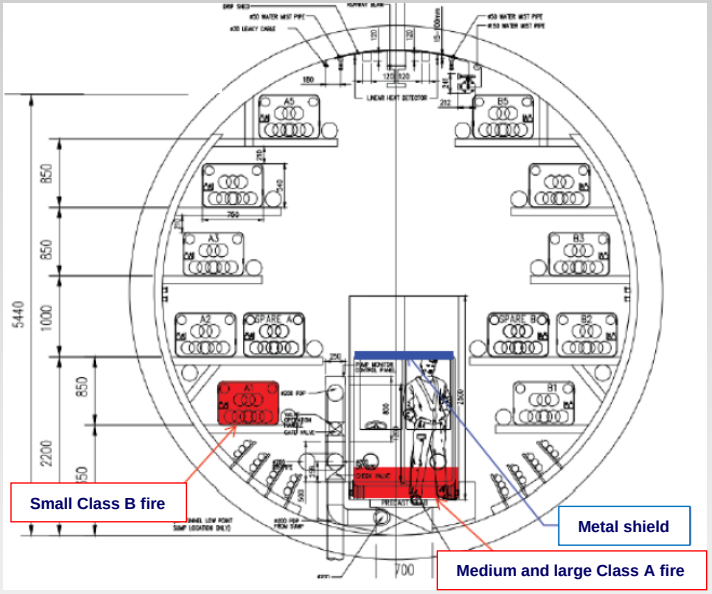


- Singapore Power (SP) operates Singapore's power grid network, ensuring power to 1,3 million industrial, commercial and residential customers
- With Singapore's rapid growth and related increase in power demand, SP invested a total of 1,25 billion USD to build a 35 km long deep level high voltage power transmission cable tunnel being located in 60 m under the surface
- The project consists of the construction of two intersecting tunnels, 14 utility buildings and associated access shafts
- The North-South tunnel has a length of 18,5 km and extents from Gambas to May Road where it intersects with the east-west tunnel of 16,5 km length connecting Ayer Rayah with Paya Lebar

Singapore Power Transmission Cable Tunnels

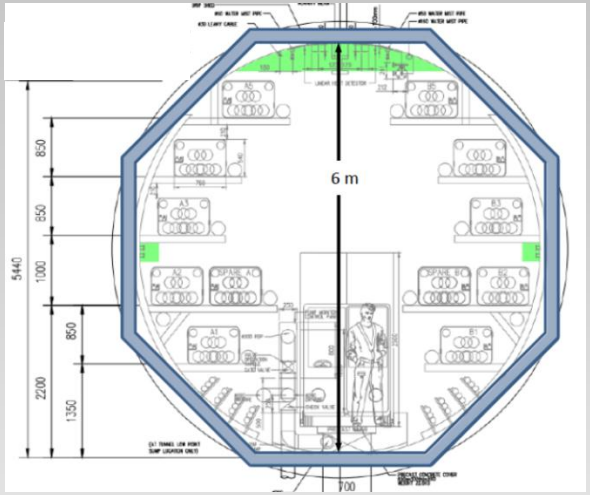
- In 2005 the first part of the project was completed with a 1,7 km long cable tunnel with a diameter of 3,5 m, being the Senoko-Gambas alignment to the Senoko power station on the north of the Singapore island
- High-pressure water mist system was selected as most suitable fire fighting system for this part of tunnel
- Based on the experienced gained with the water mist installation in the Senoko cable tunnel, the technology was adopted to the new high-voltage power transmission cable tunnels
- The challenge was the cross-section diameter of cable tunnels which was extended to 6m diameter and even up to 9 m diameter at the shaft areas

Singapore Power Transmission Cable Tunnels



- The fire protection concept has been developed in close co-operation with the end client and the fire consultant (Aecom)
- Since the power cables are routed via cable troughs, the fire risk has been assessed to the connection points between the cable troughs and to the service vehicle running trough the cable tunnels
- High speed longitudinal ventilation conditions are present in the cable tunnels and had to be taken into account in the fire protection concept
- The water mist system had to be full scale fire tested in conjunction with the fire detection system
- The fire tests have been conducted by a fire test laboratory (IFAB) and the results have been evaluated by a third party expert (MPA)

Fire Tests for Large Diameter Cable Tunnels



Fire Test Arrangement

- Cable tunnel of 6 m diameter and length of 60 m
- Cable troughs arranged in 20 m length
- Dimensions of the tunnel and cable troughs arrangement equivalent to the dimensions in the real cable tunnel
- Forced longitudinal ventilation by a jet fan with adjustable air velocity up to 10 m/s

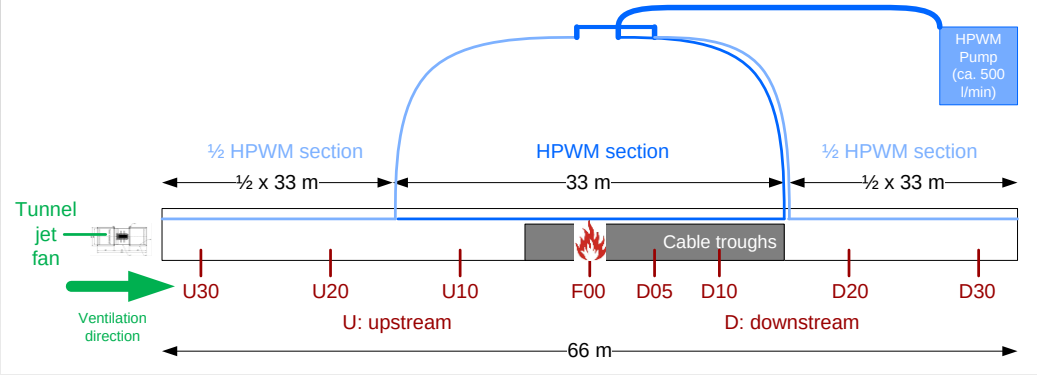
Fire Test Duration

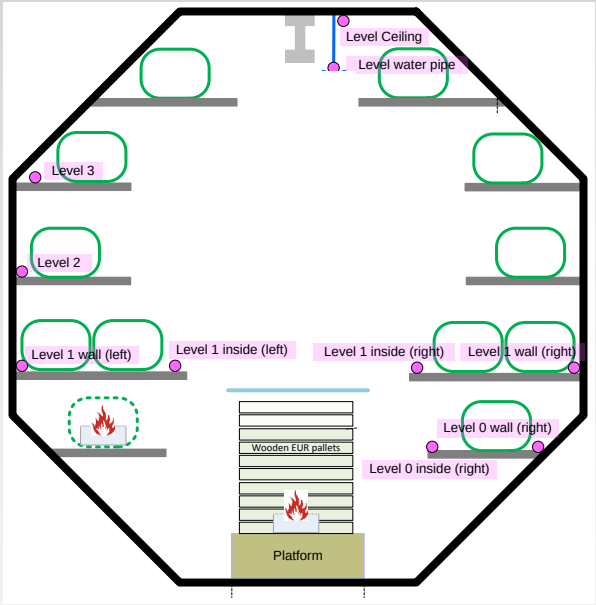
- 20 minutes after activation of the water mist system

Fire Tests for Large Diameter Cable Tunnels

Water Mist System Arrangement

- Nozzle positioning at ceiling level to avoid any interference with the cable tunnel operation (accounting for the centrally located crane runway beam)
- 33m section length (3 adjacent sections activated simultaneously)





Linear Heat Detection System Arrangement

- LHD cable installed in loops along the cable tunnel in various heights

Fire Tests for Large Diameter Cable Tunnels

Fire Test Scenarios

- Fire scenario 1: Medium solid fuel (Class A) fire size positioned in center line at floor level with a shield placed over the fire at a height of 1,5 m from the floor level
- Fire scenario 2: Large solid fuel (Class A) fire size positioned in center line at floor level
- Fire scenario 3: Small liquid fuel (Class B) fire size positioned within the lowest cable trough
- All three fire scenarios were carried out with high longitudinal ventilation, being reduced to a lower air velocity on system activation
- Additional tests were carried out with high air velocity throughout the fire test

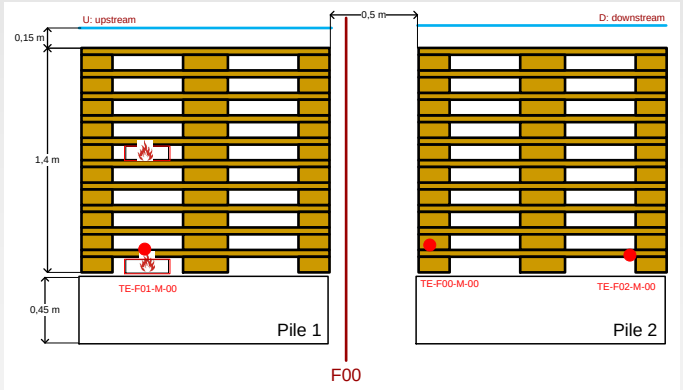
Fire Tests for Large Diameter Cable Tunnels

Class A Fire Load and Arrangement

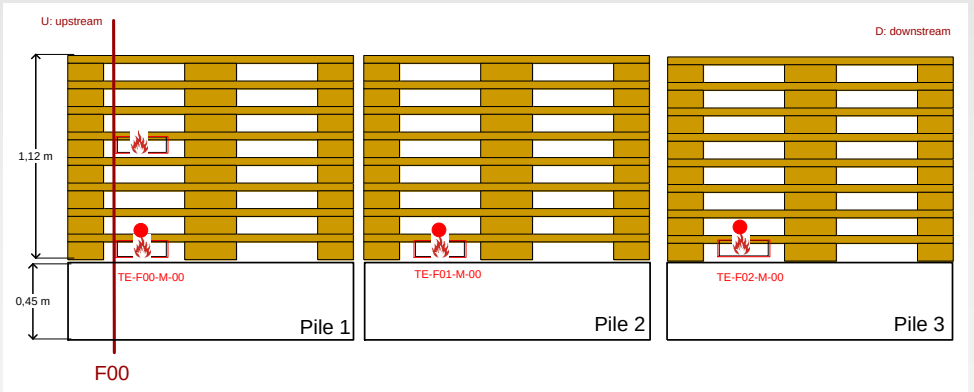
- Wooden pallets with dimensions 1,2 m x 0,8 m x 0,14 m
- Ignition with 1 l of n-Heptane in trays with dimensions 0,72 m x 0,12 m x 0,07 m

Fire load	Determined HRR	Class	Material	Size of fire load (wooden EUR pallet* A ≈ 1 m²)			
				Height [m]	Burning time [mm:ss]	Amount of wooden pallets	Surface area [m²]
1	Medium Fire Load	A	Wood	1,40	>15:00	2 x 10*	2
2	Large Fire Load	A	Wood	1,12	>15:00	3 x 8**	3

Side view of fire load 1



Side view of fire load 2



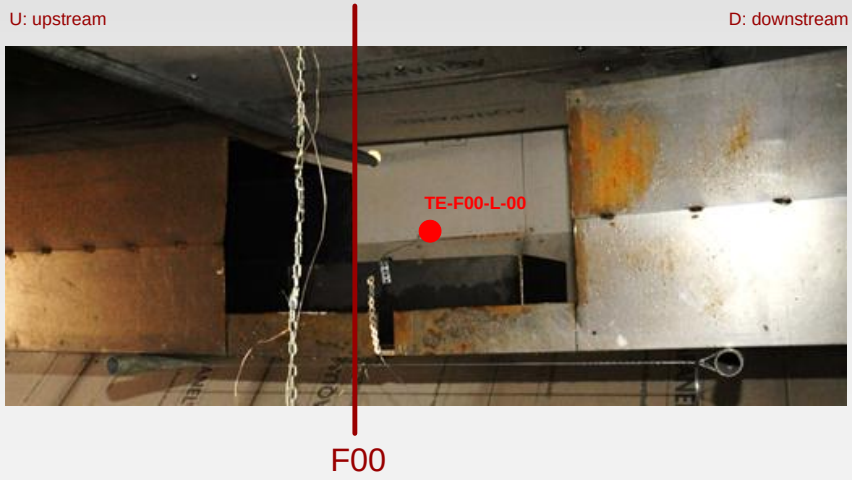
Fire Tests for Large Diameter Cable Tunnels

Class B Fire Load and Arrangement

- Diesel in a tray with dimensions 0,6 m x 0,5 m x 0,2 m
- Ignition with 1 l of n-Heptane

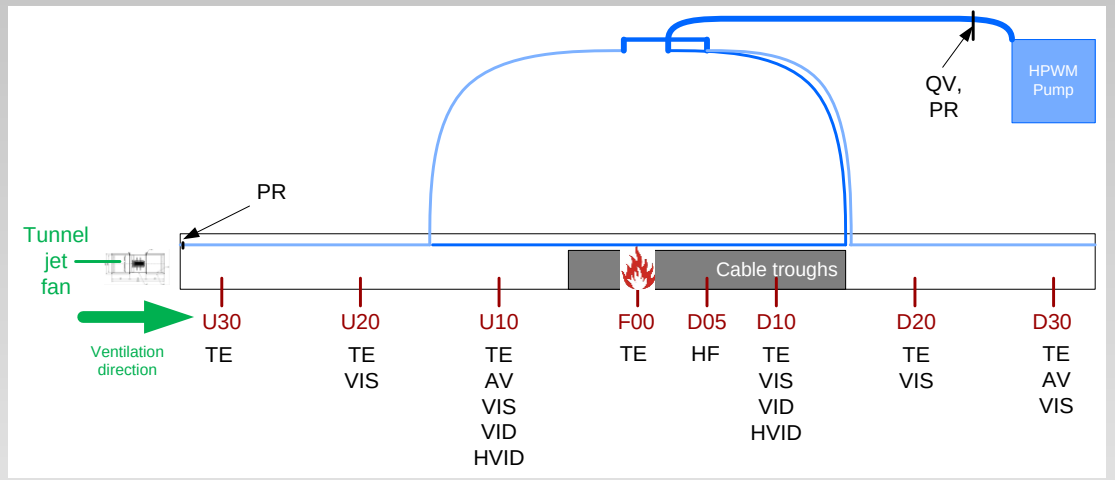
Fire load	HRR	Class	Material	Size of fire load			
				Dimension of pool (l x w x h) [m]	Burning time [min:ss]	Amount of Diesel [l]	Surface area [m^2]
3	Small Fire Load	B	Diesel	0,6 x 0,5 x 0,2	20:00	13,2	0,3

Side view of fire load



Fire Tests for Large Diameter Cable Tunnels

Instrumentation

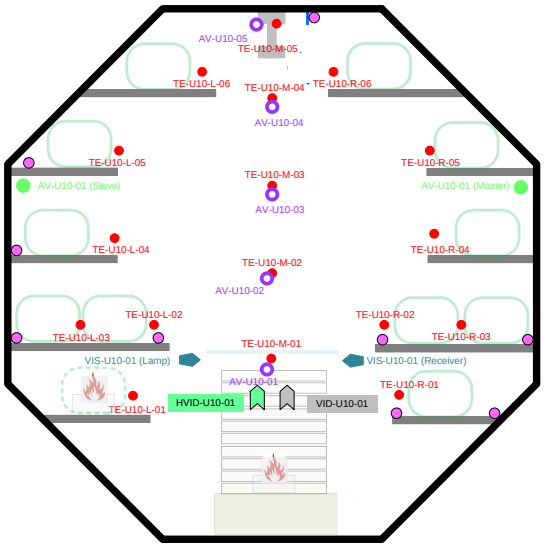


Variables	Measurement level										
	at the pump	U 30	U 20	U 10	0	D 05	D 10	D 20	D 30	D 33	Total
Temperature	0	5	5	17	19	0	17	5	5	0	**73**
Visibility	0	0	1	1	0	0	1	1	1	0	**5**
Heat Flux	0	0	0	0	0	1	0	0	0	0	**1**
Air velocity	0	0	0	1+5*	0	0	0	0	1+5*	0	**2+10**
Water pressure	1	0	0	0	0	0	0	0	0	1	**2**
Water flow rate	1	0	0	0	0	0	0	0	0	0	**1**
Video	0	0	0	1	0	0	1	0	0	0	2
IR video	0	0	0	1	0	0	1	0	0	0	2
									Total		**94**

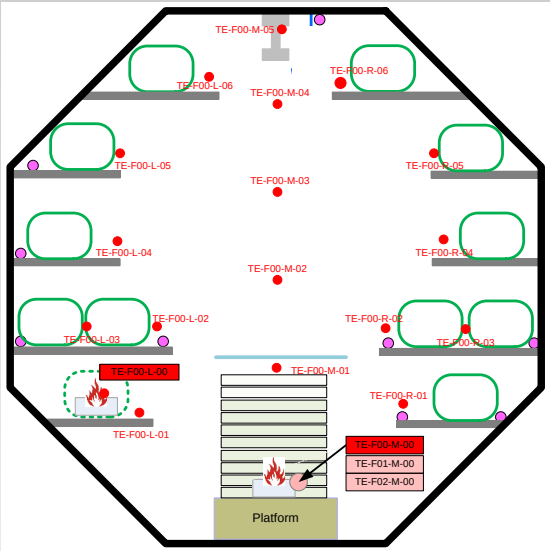
Fire Tests for Large Diameter Cable Tunnels

Instrumentation

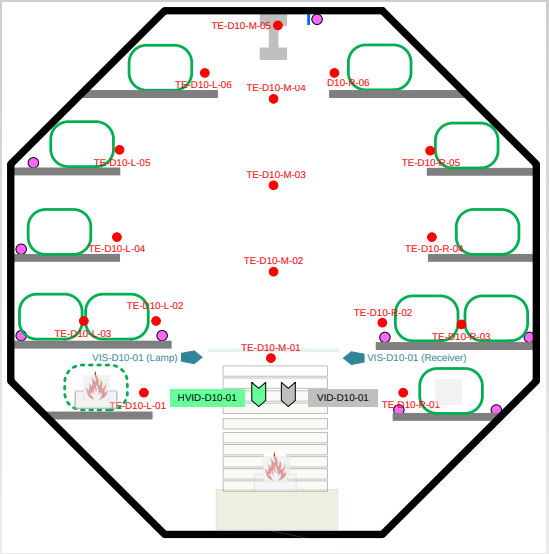
Section U10



Section F00



Section D10



Symbol	Description
●	Temperature (TE)
⬟	Visibility (VIS)
◆	Heat flux (HF)
⬟	Video camera (VID)
⬟	Infrared camera (HVID)
●	Air velocity (ultrasonic, AV)
○	Air velocity (differential pressure, AV)

Fire Tests for Large Diameter Cable Tunnels

System Performance Criteria

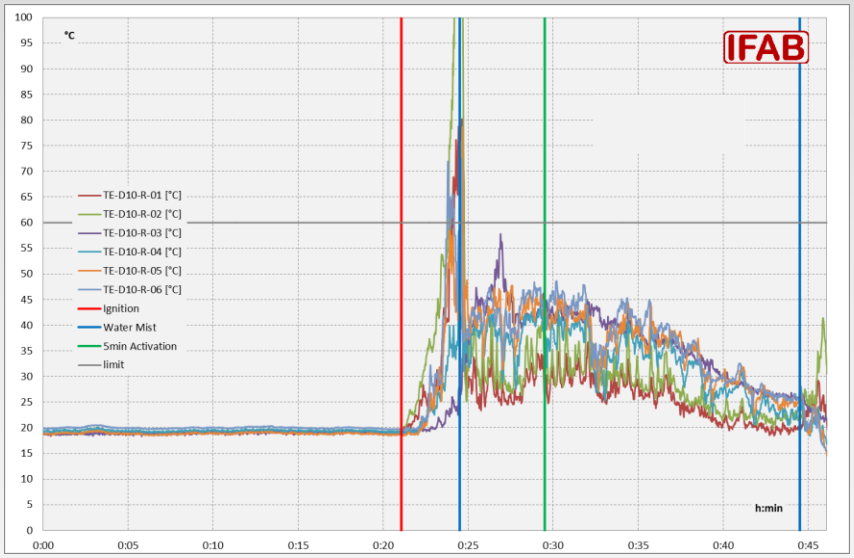
Linear Heat Detection System

- Detection time of < 60 s for the small fire load (Class B) fire test
- Detection time of < 120 s for the medium and large fire load (Class A) fire test

Water Mist System

- Rapid suppression of the air temperature in the vicinity of the fire (outside the flame zone) upon water mist system activation
- Reduction of temperature to less than 60°C within 5 min of water mist system activation
- Maintain top half of the tunnel below 300°C throughout water mist activation
- Average air temperature within the tunnel shall remain below 60°C
- No fire growth or spread shall be observed

Fire Tests for Large Diameter Cable Tunnels



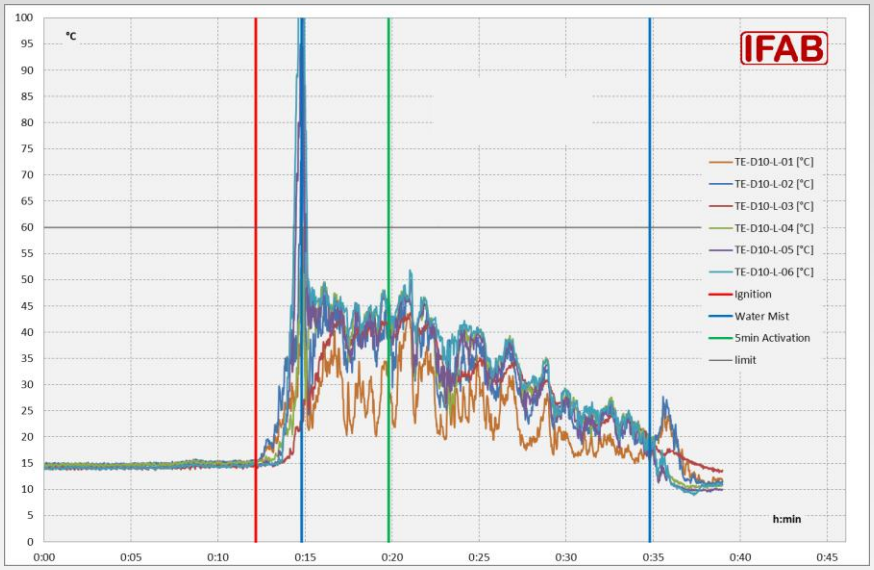
Scenario 1

- Air velocity: High air velocity during pre-burn reduced to lower velocity upon water mist system activation
- Fire load: Medium Class A fire load with a shield placed over the fire

Achieved Results

- Fire Detection: 2 min after ignition
- Pre-burn time: 3 min and 25 s
- Visibility: 18 m in section D10
- All temperatures <60°C after water mist system activation
- All system performance criteria were passed

Fire Tests for Large Diameter Cable Tunnels



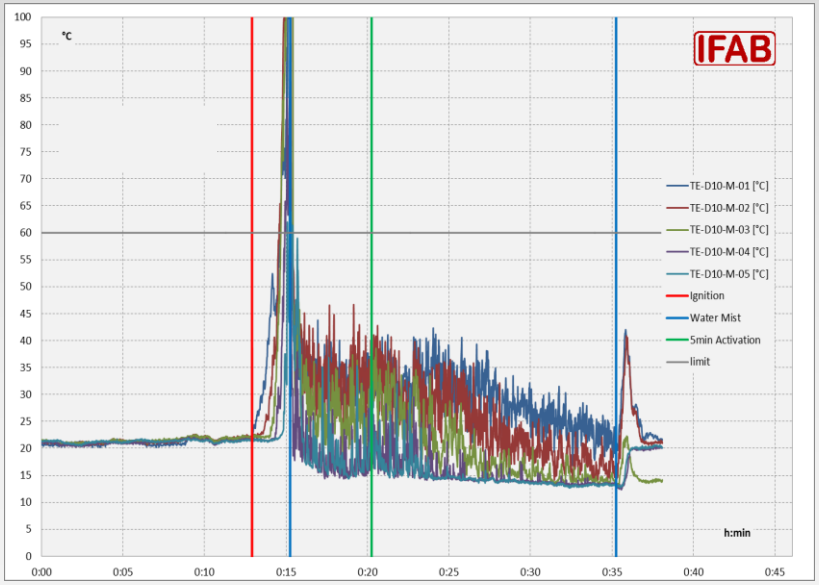
Scenario 2

- Air velocity: High air velocity during pre-burn reduced to lower velocity upon water mist system activation
- Fire load: Large Class A fire load

Achieved Results

- Fire Detection: 1 min and 30 s after ignition
- Pre-burn time: 2 min and 40 s
- Visibility: 8 m in section D10
- All temperatures <60°C after water mist system activation
- All system performance criteria were passed

Fire Tests for Large Diameter Cable Tunnels



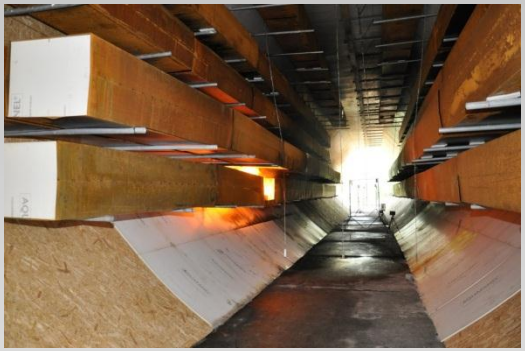
Scenario 2 (additional)

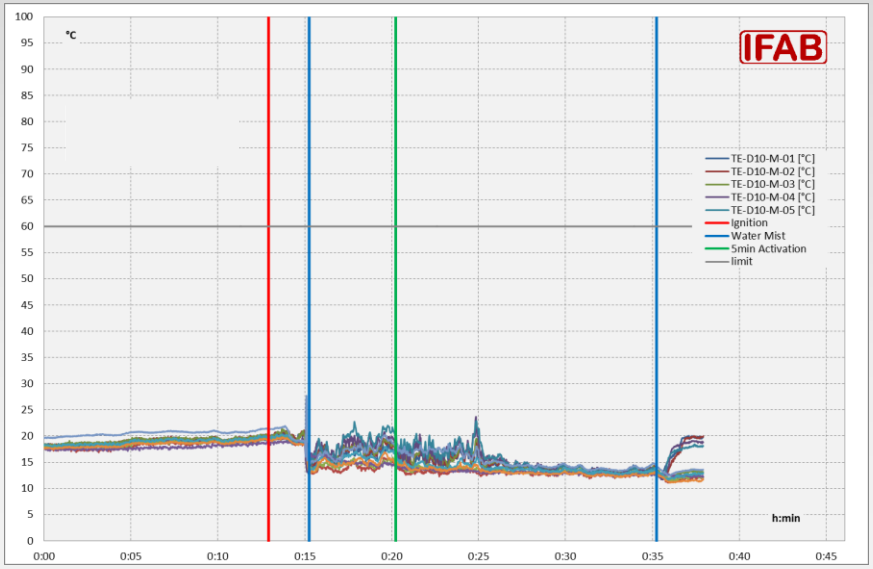
- Air velocity: High air velocity throughout the fire test
- Fire load: Large Class A fire load

Achieved Results

- Fire Detection: 1 min and 30 s after ignition
- Pre-burn time: 2 min and 20 s
- Visibility: 13 m in section D10
- All temperatures <60°C after water mist system activation
- All system performance criteria were passed

Fire Tests for Large Diameter Cable Tunnels





Scenario 3

- Air velocity: High air velocity during pre-burn reduced to lower velocity upon water mist system activation
- Fire load: Small Class B fire load

Achieved Results

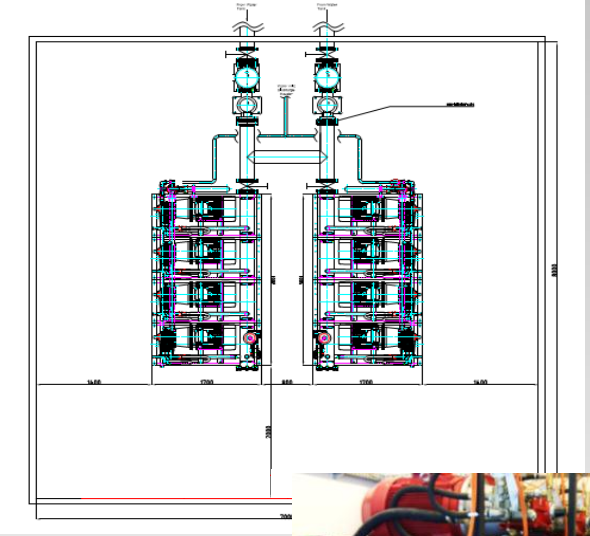
- Fire Detection: 30 s after ignition
- Pre-burn time: 2 min
- Visibility: 13 m in section D10
- All temperatures <60°C throughout the test
- All system performance criteria were passed

Singapore Power Transmission Cable Tunnels

Protection Concept

- Deluge system along 35 km of cable tunnel with open nozzles based on full scale fire test results (25.700 nozzles)
- Cable tunnels are zoned into fire fighting sections of 33m each equipped with a section valve (1.100 section valves) being activated by the fire alarm system
- Fire detection by linear optical heat detection
- Safety concept foresees simultaneous activation of 3 adjacent fire fighting sections in case of fire
- Cable basements in the equipment buildings at the tunnel access shafts are also protected by water mist

Singapore Power Transmission Cable Tunnels



Protection Concept

- Small bore stainless steel pipework installed at the cable tunnel ceiling to avoid interference with service vehicle
- High degree of pipework pre-fabrication (75.000 m of stainless steel pipes)
- Jockey pump to prefill main pipe from pump unit to decentralized section valves, assuring shortest delays between system activation and water mist discharge
- High pressure water supply via 6 pump stations located in the equipment buildings at the tunnel shafts each with a main high pressure pump unit and additional 100% redundancy
- Water mist system supplied by fresh water from water tanks at each pump station assuring 30 minutes autonomy (+20% safety)

Conclusion

The application fields for water mist in large infrastructure projects are continuously growing

High pressure water mist has proven to effectively fight fires even in ventilated large scale cable tunnels

Due to its physical properties, water mist is assuring best possible fire protection for cable tunnels, representing an important asset to power network operators and all businesses depending on energy supply

Thank You for Your Attention