Innovative Solutions for Active Fire Protection in Road/Rail Tunnels and Underground Facilities

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FOGTEC tunnel systems

- Services from consulting to commissioning
  - Fire fighting, detection and control systems
  - Fire tests
  - Reliability (RAMS) studies
  - References from installations in 5 countries
- Very active in international research projects
- Member of important working groups / standardisation

Leading in Fire Protection
## Full scale fire tests

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Project/Program/Organisation</th>
<th>Project</th>
<th>Class A – HGV tests (up to)</th>
<th>Number of tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Hungary</td>
<td>Metro Budapest</td>
<td></td>
<td>10MW</td>
<td>5</td>
</tr>
<tr>
<td>2004</td>
<td>EU</td>
<td>UPTUN</td>
<td></td>
<td>30MW</td>
<td>60</td>
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<tr>
<td>2006</td>
<td>Germany</td>
<td>SOLIT – Safety of Life in Tunnels</td>
<td></td>
<td>100-200MW</td>
<td>55</td>
</tr>
<tr>
<td>2006</td>
<td>Spain</td>
<td>Madrid Bomberos</td>
<td></td>
<td>25-150MW</td>
<td>10</td>
</tr>
<tr>
<td>2006</td>
<td>Spain</td>
<td>Madrid Municipality – M30</td>
<td></td>
<td>150MW</td>
<td>3</td>
</tr>
<tr>
<td>2008</td>
<td>France</td>
<td>CSTB scaled tests</td>
<td></td>
<td>Scaled</td>
<td></td>
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<tr>
<td>2010</td>
<td>UK</td>
<td>UK Highways Agency</td>
<td></td>
<td>100MW</td>
<td>20</td>
</tr>
<tr>
<td>2010</td>
<td>France</td>
<td>Eurotunnel</td>
<td></td>
<td>200MW</td>
<td>4</td>
</tr>
<tr>
<td>2011</td>
<td>Germany</td>
<td>SOLIT – Safety of Life in Tunnels</td>
<td></td>
<td>100-150MW</td>
<td>30</td>
</tr>
<tr>
<td>2011</td>
<td>Germany</td>
<td>Sprinkler reference tests</td>
<td></td>
<td>100MW</td>
<td>5</td>
</tr>
</tbody>
</table>

**Total:** 187
Some large reference projects of FOGTEC

- **EUROTUNNEL (Channel tunnel)**
  - 2 rail tunnels
  - SAFE stations (4 pcs)

- **TYNE TUNNEL SYSTEM**
  - 2 road tunnels

- **DARTFORD TUNNELS**
  - 2 road tunnels
FIXED FIRE FIGHTING SYSTEM TO TUNNELS?
Fixed fire fighting systems to tunnels – Why needed?

- Why?
  - Fires do happen

- Why?
  - Problems occur when HGVs (trucks) or busses get involved

- Why?
  - Improving life safety
  - Safety of fire services
  - Asset (tunnel) protection

OSLO
28.3.2011 (again in June)

HAMBURG
31.3.2011

SIMPLO
Tunnel
11.6.2011

Bergen
16.6.2011

Zurich
19.6.2011

Brynglas
26.7.2011
Fixed fire fighting systems to tunnels – Why needed?
Tunnel fires – Free development

FREE FIRE DEVELOPMENT

I: Early development
II: Growth
III: Stabilization

FIRE (HRR) vs TIME
Tunnel fires – Life, fire services and tunnel structure safety

I

II

III

LIFE SAFETY

FIRE SERVICES SAFETY

STRUCTURE PROTECTION

BAD

GOOD

TIME

the smarter way
Main enemies to fight – Time & Fire size?

- Time typically up 4-10 minutes / HRR up to 10-20MW
  - Depends on ventilation, fire scenario, tunnel design, location
  - Smoke (toxic gases, visibility), temperatures and radiant heat are main problems

- Time typically up to 10-20 minutes / HRR up to 20-40MW
  - Depends on ventilation, fire scenario, tunnel design
  - Smoke (visibility) and especially radiant heat are main problems

- Strongly dependent on structure protection and fire scenario
  - Damages occur immediately, level of damages is related to time / temperature
  - Different design curves ISO/RWS/HC/RABT
Tunnel fires – Fire fighting systems (FFFS)

I: Early development
II: Growth
III: Stabilization

FREE FIRE DEVELOPMENT

WITH FFFS

Activation!

TIME

FIRE (HRR)
FIXED FIRE FIGHTING SYSTEMS BACKGROUND
FOGTEC (FOG = small droplets) “Smarter way of fire fighting“

- Applying high-pressure system to generate small droplet sprays that have been noticed to extremely effective fire fighting method (big surface area)

=> 1 liter of water has 20m² surface are with 100µm droplets

Works by COOLING:
  - Energy absorption of 1 liter of water:
    • 2257 kJ by transition from liquid to gas

=> No other agent with such heat absorption effect!

Works by INERTING locally

=> 1 liter of water will be 1640 liters of vapor!
Fixed fire fighting systems to tunnels – PIARC, NFPA, UPTUN

- **Safety of tunnel users**
  - Temperature, toxic gases, tenability

- **Minimizing fire spread**
  - Next truck (target) 5m downstream, no ignition

- **Safety of first responders (access)**
  - Radian heat, smoke production, temperatures

- **Improving performance of ventilation**

- **Limiting structural damages**
SOLIT2 RESEARCH PROJECT – FUTURE OF TUNNEL FIRE SAFETY
Changing from Current Status to holistic approach!

Since a lot of years FOGTEC is realizing, what approved research projects now confirmed (e.g. SOLIT 2):

![Graph showing the relationship between Safety Level and Costs]

- Increasing Safety Level → higher costs
- Increasing Safety Level → same costs
- Same Safety Level → lower cost

Quelle: Solit2

Smart Concepts Scenario
CASE STUDY – TYNE TUNNELS
Tyne Tunnels

- Location in Newcastle, UK. Tunnels go under river Tyne.
- Two tunnels (approx 1.5km):
  - Existing tunnel built 1967
  - New tunnel opened 2011
- Traffic amount 38 000 vehicles per day
- Several different tunneling methods / cross-sections
- Very modern tunnel (new tunnel)
- Very important for operator and surrounding society
## Tyne tunnels – Design Parameters

- **Section length:** 25 meters
- **Number of sections:** 60 (new) + 68 (existing)
- **Activation:** 3 sections simultaneously
- **Total pump capacity:** 3250 l/min
- **Maximum pressure:** 140 bar
- **Design basis:** SOLIT fire tests
- **Engineering basis:** UPTUN Engineering guideline – Report R251
Tyne tunnels - Design
CASE STUDY – EUROTUNNEL SAFE PROJECT
EUROTUNNEL (Channel tunnel):

- Two rail tunnels and one service tunnel, length of tunnels is ~50km
- About 3300 employees in total
- Average traffic per day:
  - 21,000 passengers
  - 5250 cars and 150 busses
  - 2500 trucks
  - 27,000 tons of freight
- Short crossing time: 35 minutes
- Very reliable and independent on weather
- Environmental friendly
Eurotunnel – Major fires

- 1996:
  - Tunnel damaged on 400m distance (concrete from 0,4m to 0,02m), tracks replaced 500m, 800m of catenary/cooling pipes replaced, signaling equipment damaged for 1500m, 4 escape doors replaced.
  - Train burned with the distance of 400m with trucks on board.
  - Loss of traffic 1996, -60% (5mths)

- 2008:
  - Tunnel damaged for over 650m distance, over 1000°C temperature, almost whole train 800m as well as trucks damaged.
  - Fire lasted 16 hours
  - Loss of traffic -50% (4mths)

=> Financial impact of fires very high and additionally loss of positive image
Eurotunnel – Major fires
EUROTUNNEL: SAFE project background

- Eurotunnel could not suffer anymore such fire incident
- SAFE project to further improve fire safety:
  - Developed for HGV fires (main hazard similar than in road tunnels)
  - No major modifications to infrastructure
  - Short recovery time after fire
  - Full RAMS studies and high design availability for FFFS (99.98%)

- Several technologies were considered. Only high-pressure water mist was seen suitable for the purpose
EUROTUNNEL: SAFE project

SAFE stations are installed to 2 locations along the tunnel (4 SAFE stations in total)

- Meant for shuttles carrying trucks
- All SAFE station are 870m
- Fire protection sections is 30m and 3 of them are activated simultaneously
- SAFE station includes additionally:
  - Integrated fire detection/ localisation system
  - Control/SCADA system
  - Video surveillance system
BEFORE ARRIVAL TO SAFE STATION

The four planned fire stations, two in each tunnel are each covering 870 meters.
The four planned fire stations, two in each tunnel are each covering 870 meters.
The nozzles of the water mist system are placed on the tunnel ceiling on each side of the train at a distance of three meters. In total there are 600 nozzles installed in each fire station.

The Water mist system has been tested under real conditions in a test-tunnel similar to the Channel Tunnel which had shown the capability to reduce the temperature from 900°C to 250°C in less than three minutes.

By using fiber optic sensors that detect fire the water mist system is activated in the entire section. Moreover, the sections both before and after the affected section will be activated, preventing a chimney effect in the complete 50 km long tunnel.

The microscopic water droplets reach the flames, they instantly evaporate and lower the flame temperatures. The steam displaces the oxygen in the air, which will subsequently cause the fire to become more powerless.
PROJECT SAFE - IMPLEMENTATION
PROJECT SAFE – Challenges

• Implementing the tested system to real tunnels
  – Very limited installation times (slots) available for rail tunnels
  – Reaching the installation areas (long distances)

• Full integration in the Eurotunnel safety concept
  – Integration of control systems
  – Integration of operating protocols

• Very challenging design aspects
  – Material tolerance against possible high temperatures before activation
  – Harsh environment
  – Extreme high availability 99.98% (proper RAMS studies)

=> Robust and maintenance free components
Eurotunnel installation
Tests with installation have shown:

- No negative effects with 25kV catenary and activated water mist
- Visibility for fire services and evacuation is sufficient
- Water mist will be equally spready to activation area and ventilation has very minor effect to water distribution
- Integration of water mist system locally to fire detection and control system has worked successfully, integration to RCC under work
- Eurotunnel very satisfied for the system
Underground Facilities for Public Transportation Systems
Case Study
On-Board-Fire Suppression System Affects Infrastructure Requirements
What means **Smart Concepts?**

Fire Protection in underground facilities

- **Fire Scenario Rolling Stock**
  - "Pure Fleet – one operator"

- **Fire Scenario Technical Areas**
  - "mixed traffic – mixed operators"

- **Fire Scenario Plattform/Sales Areas**

**Application Specific Concept Development**
Application Specific Concept Development

Pure Fleet – One Operator

Mixed Traffic – Mixed Operators
FOGTEC - Smart Concept – Case Study Phase 1
FOGTEC - Smart Concept – Case Study Phase 2

Transfer from reality to test mock-up
FOGTEC - Smart Concept – Case Study Phase 2

Full Scale Fire Test with Activation of FOGTEC System

Full Scale Fire Test without Activation of FOGTEC System
Comparison with and without system (cushion on seats)
FOGTEC - Smart Concept – Case Study Phase 3
FOGTEC - Smart Concept – Case Study Phase 3
FOGTEC - Smart Concept – Case Study Phase 4

Approval Assessment done by IFAB and TÜV Nord
After all the fire and approval tests...a new scenario...
What does it mean?

During the study done with the city of Essen in Germany, the result show an

- decrease in investment by 89%
- increase in safety
- decrease in amount of needed energy
- increase in attractiveness!

Attractivity?

Yes, caused by smaller smoke extraction systems, other materials than normally required…
NFPA 130 is moving right...first standard taking care about...

Annex G  On-board Fire Suppression System

G.1 On-board fire suppression systems (e.g., mist systems) while relatively new in the passenger rail and fixed guideway industry have been successfully used on a number of passenger rail and diesel powered light rail systems outside of the United States. The applications for this type of system can range from protection of diesel engine compartments to the interior of passenger rail vehicles. The use of a fire suppression system may save lives in the incident vehicle during a fire condition; minimize damage to the train, tunnel and the station which it has entered; reduce or eliminate potential use of station sprinklers; reduce or eliminate the need for downstands; significantly reduce the impact of designing for fire emergencies on station architecture; reduce tunnel ventilation capacities by approximately 40 percent; reduce the number and/or diameter of emergency ventilation fans at each end of each station and within the tunnels, thus reducing structure sizes; decrease shaft airflow cross section areas by approximately 40 percent; and decrease tunnel ventilation shaft portal areas that correspond to the required fans sizes/velocities. When considering the addition of a fire suppression system, several design challenges should be met by the rail vehicle manufacturer. These challenges include the type of extinguishing medium used, which all must be approved by the AHJ the size and number of medium canisters and where on the vehicle to place them for easy access for maintenance; the resultant increased energy consumption caused by the increase in weight of the suppression system; the maintenance intervals; the cost of the system; the testing and commissioning of the system; and the cost and difficulties associated with retrofitting vehicles.
Q & A
Thank you very much for your kind attention!

The Smarter Way of Fire Fighting!