

## **PROTECTION OF TUNNELS WITH WATER MIST SYSTEMS**

*Stefan Kratzmeir  
IFAB*

### **ABSTRACT**

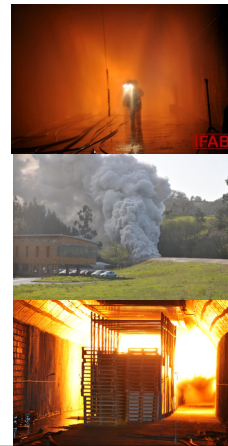
Water Mist Systems are more and more used for the protection of tunnels. The development started with the European research project UPTUN and was continued with the SOLIT and SOLIT<sup>2</sup> project. The presentation gives an overview of fixed fire-fighting systems (FFFS) based on water mist technology in tunnels. Special focus is given to the real scale fire test series within the SOLIT and SOLIT<sup>2</sup> project and the effect of water mist systems on fire in tunnels. Furthermore using the example of the New Tyne Crossing (Newcastle) it is shown how test results of a full scale fire test are transferred into a real project.



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## Protection of Tunnels with Water Mist Systems

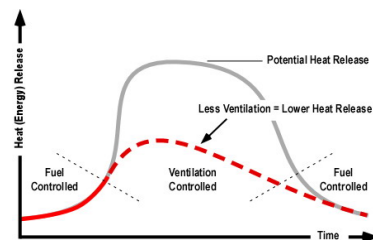
*Stefan Kratzmeir  
Managing Director*



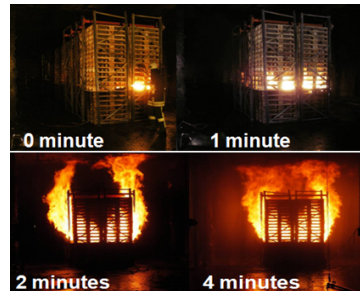
## Agenda

- Fire suppression Systems in Tunnels - Principles
- SOLIT<sup>2</sup> Full Scale Fire Tests
- Compensation with Water Mist Systems
- Case Study: New Tyne Crossing

- Fires in tunnels and underground stations can develop much faster than expected in the past.
- People do often not react as they are intended to do.
- Rescue services can not be considered as a support for people inside the tunnel (time!)
- Smoke caused the majority of fatalities in tunnel fires
- Time for fire fighters approach is significantly increased due to reduced visibility, temperature and radiation.
- Most larger tunnel fires are ventilation controlled fires.



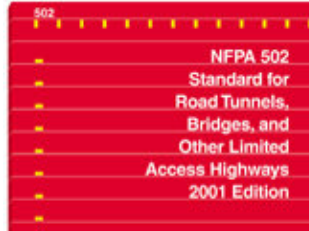
- Two major "enemies":
  - A. HGVs
    - Real fires and research programs have shown the severity of fires when HGVs are involved.
    - Design HRRs have changed from 30MW to 100+MW within a decade
  - B. Time
    - Fires can develop extremely fast



### Higher Heat Release Rates than expected

	PIARC	French	NFPA	Tests	HRR estimates from real fires (MW)
Car	2.5 - 8	2.5 - 8	5	2.5 - 9	3 - 10
Van	15	15	-	-	-
Bus	20	20	20	29 - 34	36
HGV	20 - 30	30	20 - 30	15 - 203	300 - 400
Tanker	100	200	100	20 - 100	120 - 300

SP  
National Testing and Research Institute

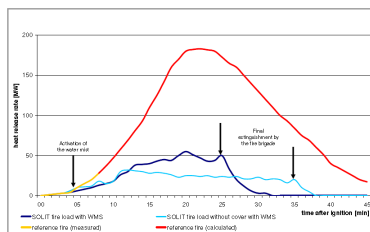


Notice! NFPA502 Edition 2008 has already increased fire sizes acc

Table A.10.5.1 Fire Data for Typical Vehicles

Vehicles	Peak Fire Heat-Release Rates (MW)
Passenger car	5-10
Multiple passenger cars (2-4 vehicles)	10-20
Bus	20-30
Heavy goods truck	70-200
Tanker*	200-300

- Fire Suppression / Fire Fighting



- Protection of fire spread





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- Facilitate the approach of rescue services
- Increase the life safety for tunnel users



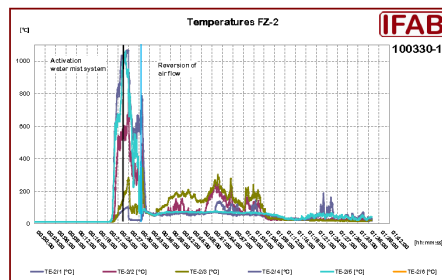
- Improving performance of ventilation systems
- Protection of tunnel structure
- Compensation of other safety measures within an integrated approach



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## Effect of Water Mist for Tunnel Fires

- Cooling Effect
  - Small droplets are converted into steam
  - Enormous and rapid cooling
- Reduction of Radiant Heat
- Oxygen Depletion
  - Limited effect due to forced ventilation
  - Only necessary for fires with burnable liquids





## FFFS Technologies for Tunnels

- Deluge
  - 6 – 12 l/m<sup>2</sup>/min.
  - Droplets above 1-2 mm
  - Used in Japan and Australia
  - No fire test above 30 MW known
- Foam (Premix or CAF)
  - Used in US
  - Some fire tests presented
- Water Mist
  - More than 100 full scale fire tests up to 200 MW
  - Used in France, UK, Spain, Italy, Russia
  - Approx. 20 % of water compared to Deluge



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## SOLIT<sup>2</sup> Fire Tests





## SOLIT<sup>2</sup> - Research Project

### Compensation of safety measures by FFFS Integration of FFFS into a holistic tunnel safety system

- Run time: 10/2010 – 02/2012
- Supported by the German ministry of economy and technology
- Budget: ~ 4 Mio €
- Large scale fire test program in 2011
- Workshop/Conference in 2011
- Scientific advisory board

Information at [www.solit.info](http://www.solit.info)



## SOLIT<sup>2</sup> - Partners



FFFS, Project Manager



Engineering, Simulation, Compensation



Engineering, Simulation, Literature



Economical Evaluation, Integration



Integration, Reliability, Guidance

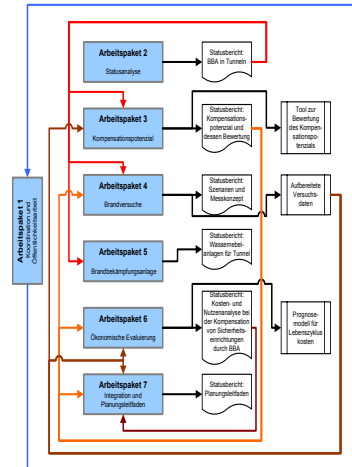


Full Scale Fire Tests



Measurements, Data evaluation

- State of the art analysis
- Potential of Compensation
- Simulation
- Base data for risk analysis
- Effects of FFFS
- Economical Evaluation (LCC)
- Integration and Engineering Guidance

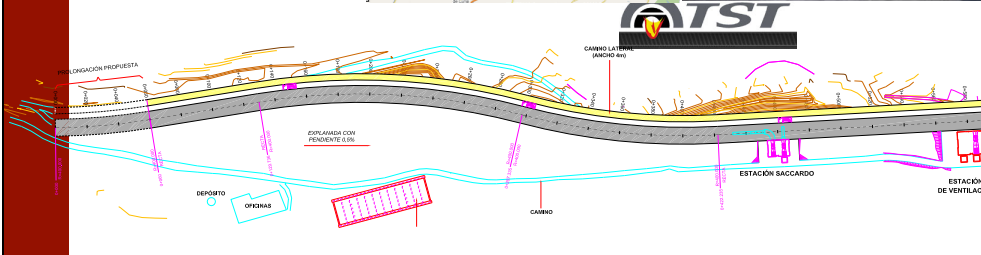
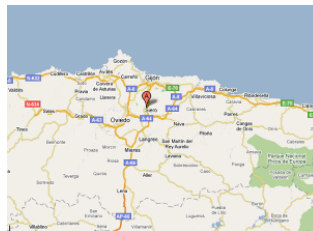


**San Pedro des Anes**

Next City: Oviedo; Gijón

Airport: Asturias (OVD)

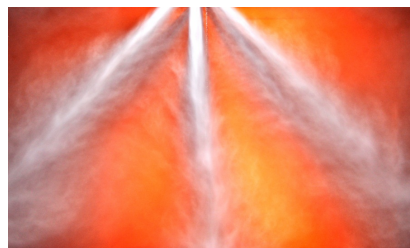
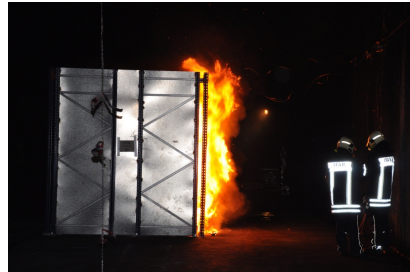
Length: 600 m





## Full Scale Fire Test Program

- HGV Fire tests with Longitudinal and Semi-transversal Ventilation
- 30, 50 and 100 MW Pool Fire tests with various ventilation conditions
- Study of the influence of FFFS on ventilation and vice versa



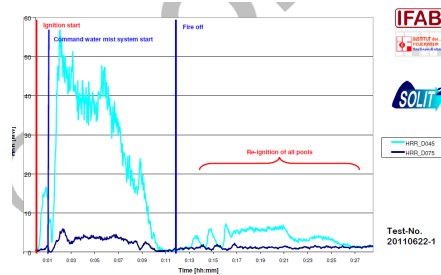
## Full Scale Fire Test Program

- Interaction with the Fire Brigades Approach
- Cooperation with the Hamburg and Elbtunnel Fire Brigade
- Workshop with life fire test in the tunnel

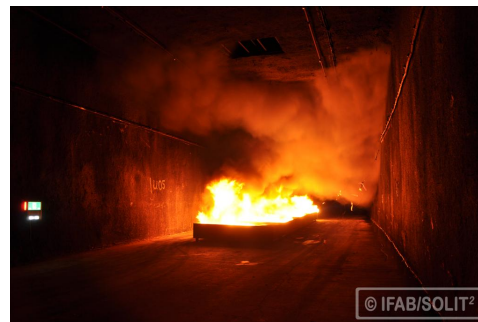
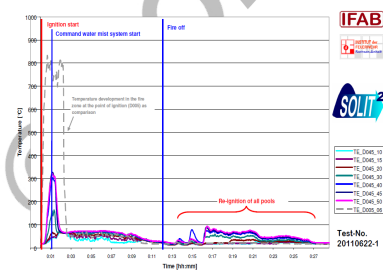




## SOLIT<sup>2</sup> Class B Fires

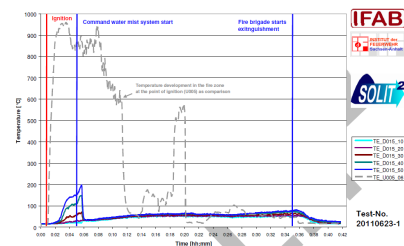
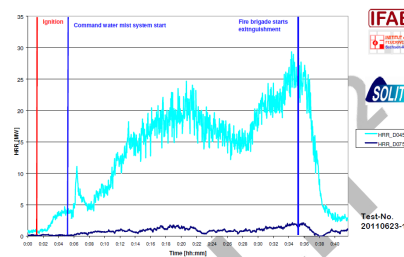


- Class B fires with 30, 60 and 100 MW
- Diesel
- Fires were extinguished



## SOLIT<sup>2</sup> Class A Fires

- Potential fire load up to 180 MW
- Covered and uncovered
- Target objects at downstream



Compensation means to achieve the same level of safety by other measures.

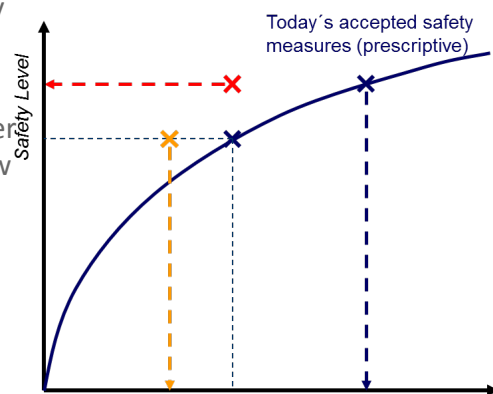
Compensation requires a proof of equal level of safety

Compensation requires equal reliability

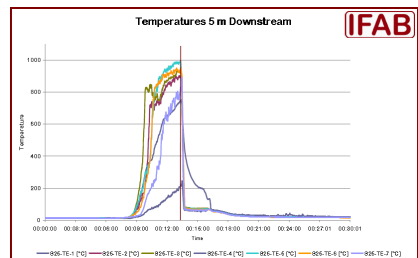
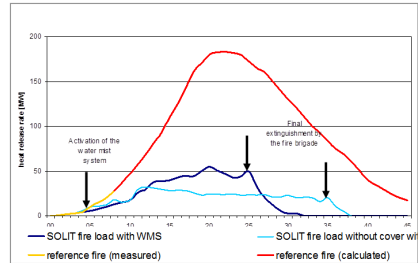
Compensation should be based on LCC evaluation

Compensation requires a holistic performance based tunnel safety concept

- Design fires for tunnel safety systems are usually increased to 100 MW (at least)
- New design fires and other data for upgrade and new projects
- Space & Power
- Costs
- Design



- For FFFS water mist systems are considered
- HRR will be limited by FFFS
- Smoke production rate will be limited
- Cooling effect will reduce the smoke volume
- Further effects for people, fire brigade and structures







## Wirkungsweise: Sichtweite

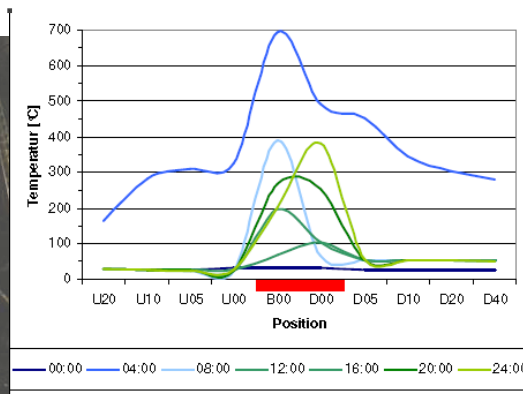
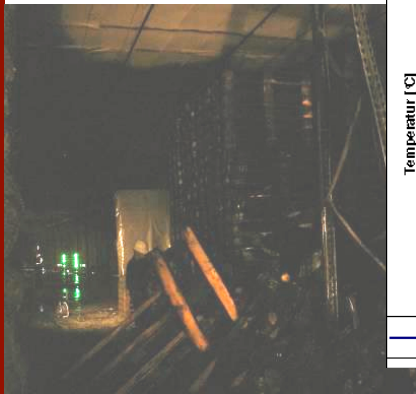
- Still good visibility through water mist
- Increased capacity of the smoke extraction or longitudinal ventilation by 70%.
- Further infos: [www.solit.info](http://www.solit.info)



## Rescue Services

- Reality: Fire brigades need up to 30 minutes to reach the place of incident!
- Fire spread (even for Class B truck fires) can be observed within
- Rescues services can not be considered as assistance for the self rescue procedures.
- Timing problem is often ignored and unsolved.
- Some tunnels operate their own fire brigades (such as Elbtunnel (Hamburg), MontBlanc). Costs per year and fire fighter: not less than 200.000 €/man)

- Area of high temperatures is limited
- Time of temperature is limited
- Absolut temperature is limited



- Compensation requires a proof of a equal level of safety
- This includes a similar reliability of the systems (eg. MTBF)
- Holistic tunnel safety concepts require also RAMS (Reliability, Availability, Maintainability and Safety) and LCC (Life Cycle Costs) analyses.
- Hardly used for conventional fire protection systems
- Common usage e.g. for rolling stock, cars, planes, etc.

E.g.: Decision to install a FFFS into New Tyne Crossing was fully based on a economic base.



## SOLIT<sup>2</sup> Workshop

Pre-Announcement:

2nd Conference on Fire Suppression in Tunnels

- Fire Suppression Systems in Tunnels
- Compensation of Safety Measures
- Integration of FFFS

**19.06. – 20.06.2012 in BERLIN**

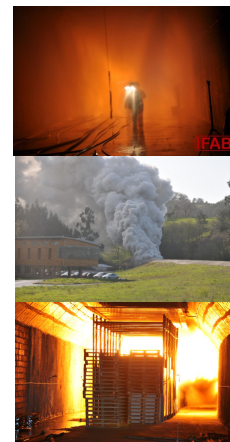
More informations within the next weeks at [www.solit.info](http://www.solit.info)

Or send a short email to [contact@solit.info](mailto:contact@solit.info)

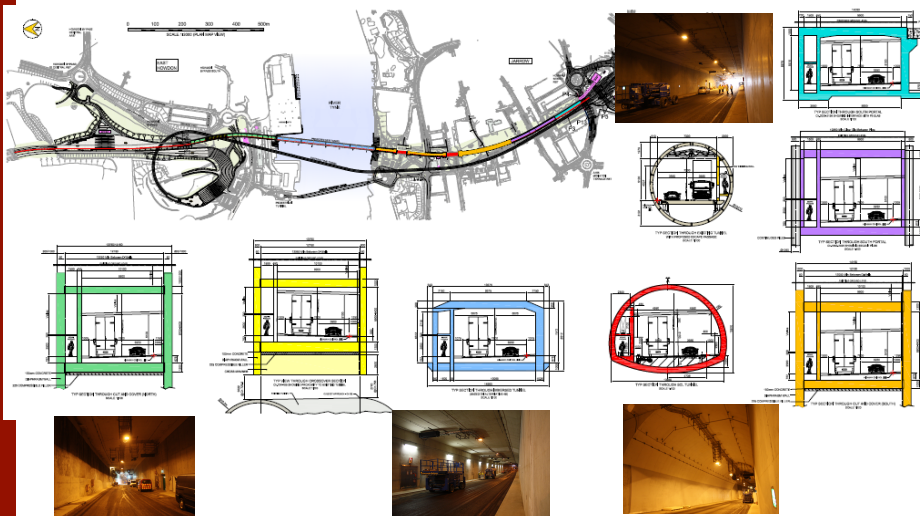
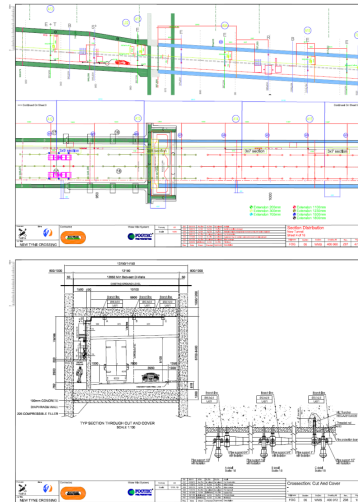


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## Case Study: New Tyne Crossing



- Section length: 25 meters
- Number of sections: 60 (new) + 68 (existing)
- Activation: 3 sections simultaneously
- Total pump capacity: 3250l/min
- Maximum pressure: 140bar
- Design basis: SOLIT fire tests
- Engineering basis: UPTUN Engineer-ring guideline – Report R251



- Mechanical and hydraulical design:
  - Main pipes DN50 and DN100
  - Section pipes (primary) DN17
  - Minimum pipe quality: AISI316 (lifetime / standards)
  - Pipe connections mainly in welding (lifetime / standards)
- Main aspects:
  - Proper hydraulic design (worst case scenario)
  - High level of prefabrication (detailed design)
  - Quality control
  - Testing



- Jockey pump unit with self-cleaning filter for the pre-pressure of wet main pipes
- Booster pump unit (redundant pumps) with main filter
- HP pump sets
  - Each set 600l/min@140bar
  - Follows UPTUN R251 Engineering guidance:
    - Direct coupling, one motor per pump, all pumps have individual safety valve, etc.
- Pump control cabinet
  - Many service / monitoring functions of critical components

