


**International Conference on
Operational Safety of
Underground Facilities**
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**Active and passive fire
protection –
which way should we go ?**

Alfred Haack
 STUVA, Cologne, Germany
 ITA, Lausanne, Switzerland

**General
starting
situation:**

Busy traffic
 tunnels with
 passenger and
 goods transport




Fire Catastrophes - Road

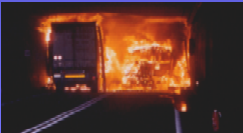
Mt. Blanc Tunnel (F/I)
 24.03.1999
 39 Fatalities



Tauerntunnel (A)
 29.05.1999
 12 Fatalities




Gotthardtunnel (CH)
 24.10.2001
 11 Fatalities



Fire Catastrophes - Rail

Station Koblenz (D)
 07.11.1983
 No injured



Eurotunnel (F / GB)
 18.11.1996
 31 injured



Station Offenbach (D)
 23.11.2001
 No injured



Fire Catastrophes - Metro

Hamburg S-Bahn (D)
 08.04.1980
 3 injured



**London Metro (GB)
(Station Kings Cross)**
 18.11.1987
 31 fatalities



Daegu Metro (South Korea)
 18.02.2003
 196 fatalities



**Active and passive fire
protection –
which way should we go?**

**This question given with the title
concerns technical,
operational, and commercial
matters as well!**

Basic reflection

Using effective measures against fire is not at all a new idea!

Since many decades it is systematically followed in the field of:

- Industrial plants
- Storage facilities
- Warehouse departments
- Public assembly places

with combustible masses more or less lying steadily in the same place

Basic reflection

In contrast the combustible masses in traffic tunnels are moving which makes it more difficult to handle a starting fire.

Basic reflection

Designing any industrial or commercial facility raises immediately the question:

What is the best?

An active or a passive fire protection or a combination of both?

In industrial or commercial facilities usually active fire protection measures are supplemented by passive ones.

Active Fire Protection

Fixed Fire Fighting Systems as:

- Low or high pressure water mist
- Sprinklers
- Deluge systems

Advantages:

- Avoidance of fire spreading
- Improved accessibility of the fire place
- Better protection of infrastructure

Disadvantages:

- Destratification of smoke layer
- More complex equipment
- Reduction of visibility



Fixed Fire Fighting Systems

- do not extinguish large fires
- are often overestimated with regard to their capability

BUT

- slow down the fire development
- reduce or avoid fire jump from car to car
- improve by that conditions for escape
- better protection of infrastructure



Fixed Fire Fighting Systems

Require:

- precise and early detection
- efficient localisation of fire
- activation at right time

Fire Detection

To trace vehicle fire

- fastly
- reliably

Aiming at immediate

- information of tunnel users
- modification of tunnel operation

Basic Requirements to Fixed Fire Fighting Systems

- at any time functionable
- reliable even under the rough conditions of tunnel atmosphere (moist and salty air, dust, soot)
- acceptable investment costs
- low maintenance costs
- Easy to install and to use



Automatic Fire Suppression

Advantages of water based systems:

- Fire and smoke restricted to shorter tunnel section
- Cut down of fire jump from one car to another
- Cooling effect



Automatic Fire Suppression

Problems of water based systems:

- immediately reduced visibility
- destratification of smoke
- no or low efficiency for fires inside vehicles
- in special cases dangerous chemical reactions



Automatic Fire Suppression

Australian experience:

in urban road tunnels with

- manned control center or
- video/automatic incident detection facilitating precise event location

to minimize fire growth

to reduce probability of flashover

Automatic Fire Suppression

Dutch experience:

- no extinction of fire inside vehicle
- immediate reduction of visibility
- large amount of steam if fire > 15 MW
- reduced risk of fire propagation

Automatic Fire Suppression

Japanese experience:

- no fire extinction at all
- cut down of fire jump from one car to another
- cooling effect for tunnel structure
- no immediate activation to keep better escape conditions
- no promotion of sprinklers in tunnels intended

Questions left with Fixed Fire Fighting Systems

- Is there any economic compensation given with the investment for a FFFS – e.g. savings for ventilation?
- What is the mutual impact of various components of safety systems?

Fixed fire suppression systems

- world wide so far not often installed
- intensive global discussion regarding:
 - optimal time of activation
 - cost benefit effects

➔ L-surF Project

L-surF



Design Study for a **L**arge **S**cale
Underground **R**esearch **F**acility on
Safety and Security

2005 – 2008

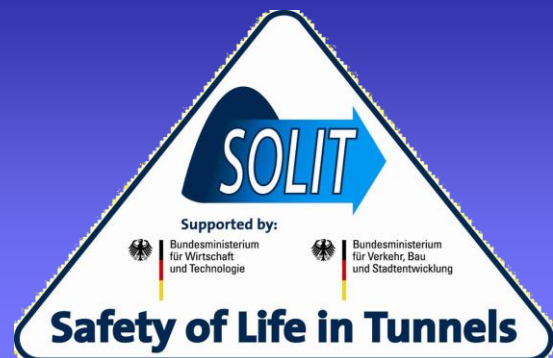
VSH (CH) + 5 partners

- feasibility study to establish a pan-European test facility
- scientific and technological research
- business plan for test programme

www.l-surf.org



Recent German research project



Passive Fire Protection

Structural components of a tunnel as:

- mineral boards or plasters
- fire resistant concrete tunnel lining
- enlarged concrete cover and additional reinforcement layer
- special perforated steel sheet

Advantages:

- no operational maintenance
- no failings

Fire protection of tunnel lining

- mineral cladding / mineral plaster
- large covering and additional reinforcement
- perforated steel plates with foaming coating
- fire resistant concrete

- ➔ Heating up of bars < 300° C
- ➔ Minimization of spalling



Mineral Boards and Plaster (1)

Advantages:

- installation in already existing tunnels
- mostly no maintenance
- no risk of failing in case of fire

Mineral Boards and Plaster (2)

Disadvantages:

- larger excavation cross section
- longer construction time
- risk for absorption of seepage water causing loss of thermal insulation capacity
- risk of local falling down due to increase of dead weight

Mineral Boards and Plaster (3)

Disadvantages:

- risk for corrosion of board fasteners
- no visual access of lining for inspection
- renewal after 25 to 30 years: 3 to 4 times during life cycle of a tunnel
- risk of partial falling down due to sucking and pressure load of fast trucks



Fire resistant Concrete

Special mix required:

- maximum core group of aggregates consisting of basaltic gravel
- quartzite, no chalky aggregates
- addition of 3 kg/m³ Polypropylene fibres
- quality class \geq C 25/30

Fire resistant Concrete

- several years research work by:
 - Hochtief AG (contractor)
 - TU Braunschweig, Germany
 - STUVA, Cologne, Germany
- fire test 1200 C° over 90 minutes
- no severe spalling, locally restricted only
- spalling depth less than 10 mm





Fire resistant Concrete: advantages during **construction**

- omission of fire proof cladding
- smaller excavated cross section
- shorter construction time
- sufficient fire protection already during construction
- simpler assembling of tunnel installations

BUT

- not applicable in existing tunnels

Fire resistant Concrete: advantages during **operation**

- free access for tunnel inspection
- life cycle like for the tunnel
- no problems caused by sucking and pressure loads of fast trucks
- problem-free tunnel cleaning
- no problems with water seepage
- low damage in case of vehicle collision
- nearly no spalling in case of fire

Enlarged concrete cover for structural reinforcement

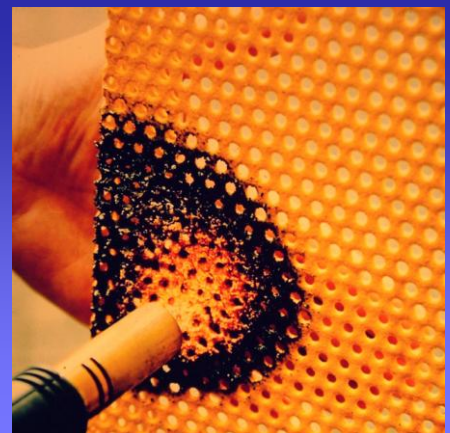
Requires additional layer of steel mat set up towards the fire affected side of the lining to reduce spalling

Disadvantages:

- increase of costs
- thicker lining
- additional working step



Perforated
steel sheet with
foaming coating



Passive Fire Protection

- avoids structural disintegration
- reduces spalling

BUT

- does not prevent fire spreading
- does not cause any cooling effect
- gives no protection for persons and vehicles

Passive Fire Protection

meets only some of the important objectives

BUT

we need a holistic fire safety concept with:

- best chances for a successful escape
- optimum safety for tunnel users
- use of all available technical options

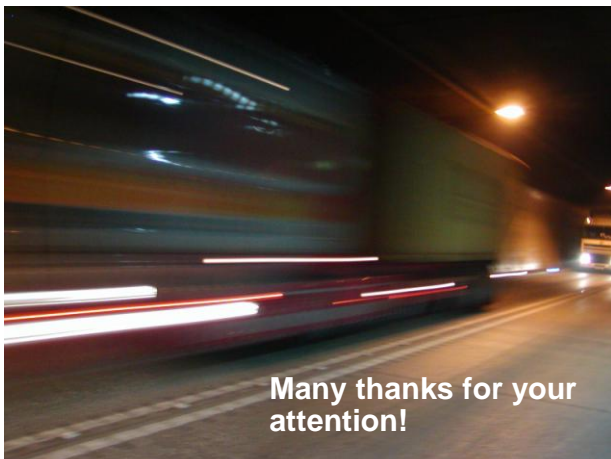
Conclusion

Active and passive fire protection – which way should we go?

We need an efficient and balanced combination of both!

Active fire protection measures can only be complimentary to passive ones as useful component in a holistic fire safety concept!

This has proven to be very effective, useful, and pragmatic in the field of industrial and commercial facilities.



Many thanks for your attention!