INTERNATIONAL SEMINAR
LONG TUNNELS

Safety, ventilation and climate in long rail tunnels

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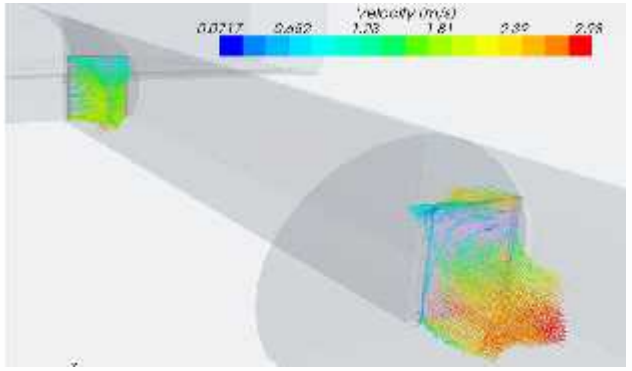
17, 18 y 19 de Octubre 2012
Santiago, Chile

Safety, ventilation and climate in rail tunnels

1. TSI-SRT
2. Safety concept
3. Structural Measures
4. Technical Measures / Ventilation
5. Organisational Measures
6. Aerodynamic / Dust
7. Climate
8. Summary



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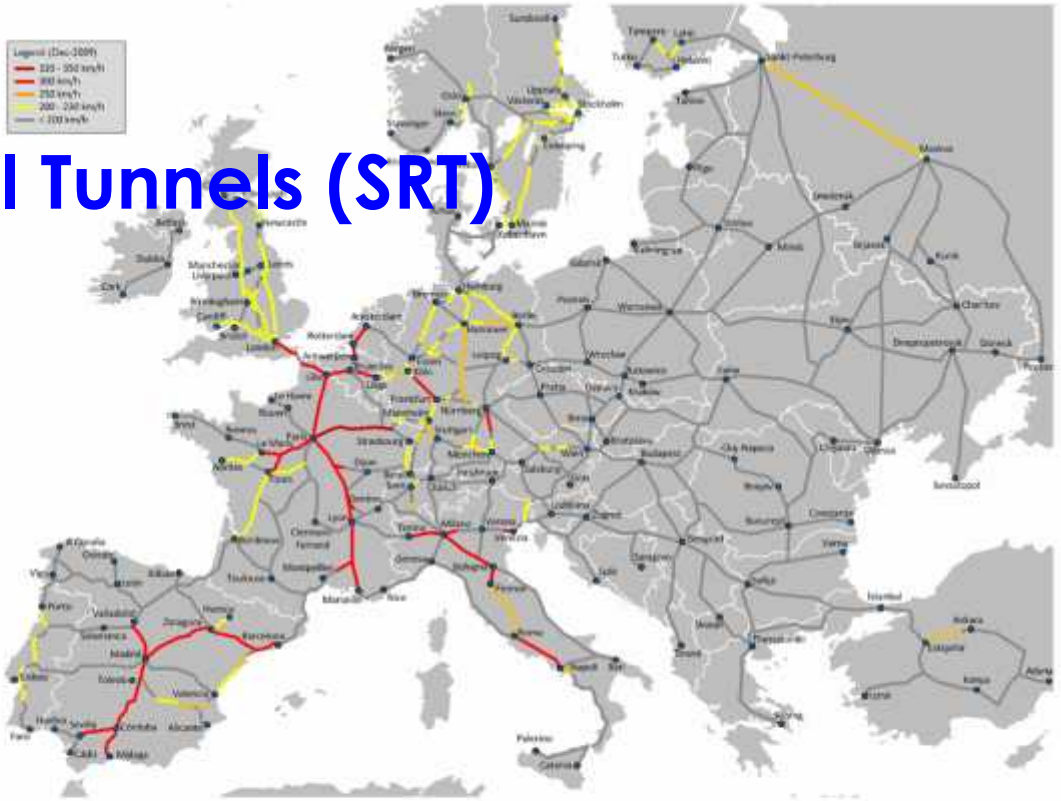
1. Technical Specification Interoperability (TSI) for High-Speed (HS) and Conventional Rail System (CR)

Safety in Rail Tunnels (SRT)

- Rolling Stock
- Infrastructure
- Signalling
- Maintenance
- Energy, etc.
- ...
- ...



Safety hierarchy according to TSI SRT

Safety concepts according to the TSI SRT always build on a four-stage approach that minimizes the risk to persons as well as the risk to physical assets and operations

1. Prevention
2. Mitigation of Impact of Accidents
3. Facilitation of self-rescue
4. Faciliation of Intervention

No fire fighting !

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Safety Concept

Starting Point:

Technical analysis of safety including construction and operating concept to identify any dangers as well as determine the level of safety.

Involve at a very early stage:

- future operator (usually part of railway structure, but organisationally separate from track division)
- responsible national authorities
- local authorities
- emergency services (fire, rescue, etc.)

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Safety Concept / Measures

Depending on the operating concept, dangers and safety targets, the action required will vary for each railway tunnel in each of the four areas named above.

structural, technical or **organizational** measures have to form a convincing safety concept that attains a defined level of safety.

Some of them are individual for each tunnel

e.g. location of hot-boxes, emergency management in the case of an incident, etc.

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Typical Structural Measures

The necessity for design of structural measures depends mainly on the tunnel's operating concept. For tunnels devoted for passenger transportation escape routes and emergency exits are central components.

On European railways, a distance in tunnels between emergency exits of 500 meters and escape routes on both sides with a width of 1.2 m have become common.

Emergency exits must lead to a safe area that ensures passengers survive until the emergency / rescue services arrive.

Emergency exits lead directly outside, into the non-incident bore / a safety tunnel or an emergency station.

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TSI SRT Typical Technical Measures

- ventilation
- signs for escape routes and emergency exits (signs approx. 25 m to 50 m)
- hand rail
- emergency lighting (often hand rail integrated)
- communication (loudspeaker, radio)
- power outlets, earthing devices, etc.
- water for fire fighting - challenging: quickly available with a certain pressure and water volume
- equipment of emergency stations
- …

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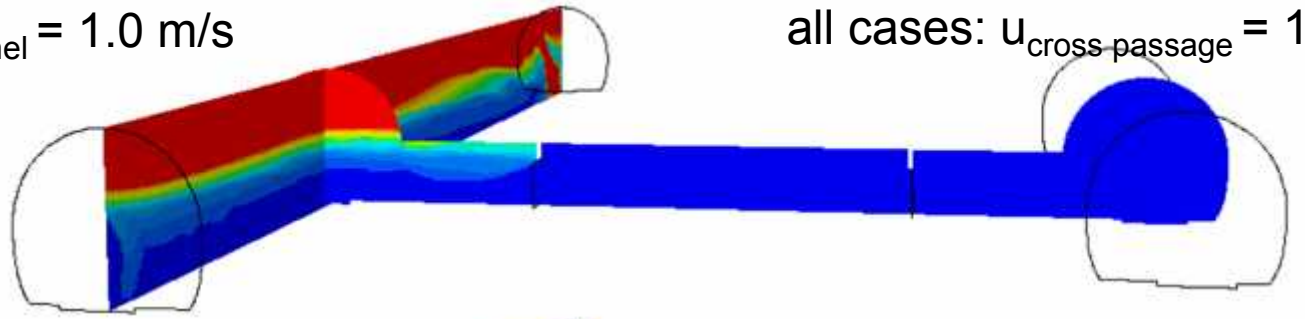
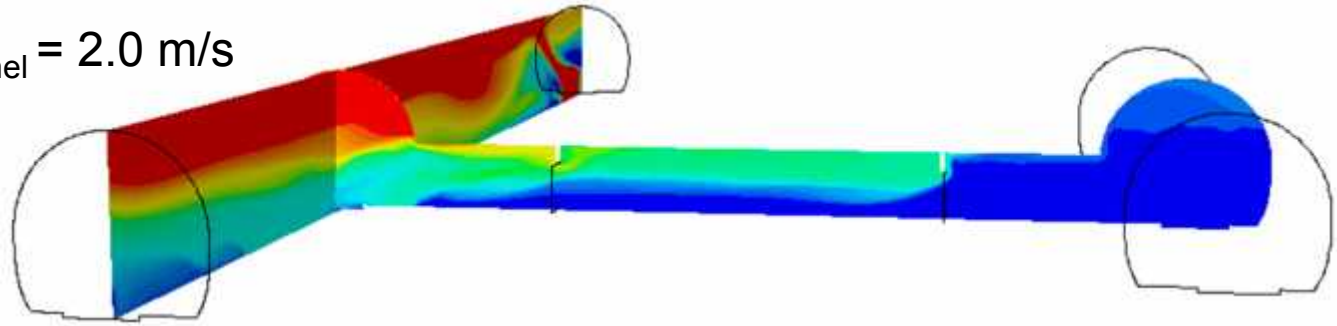
Structural / Technical Measures - cross-passage

u_{tunnel} = 1.0 m/s

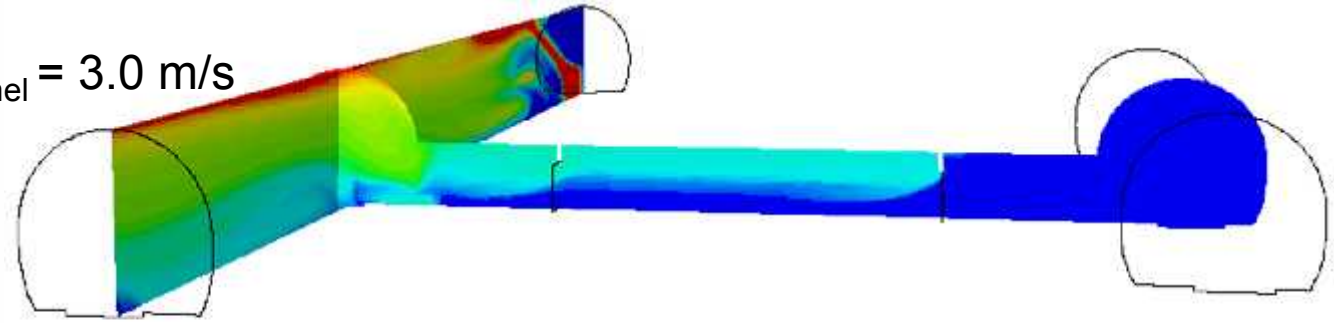
all cases: $u_{cross\ passage}$ = 1.0 m/s

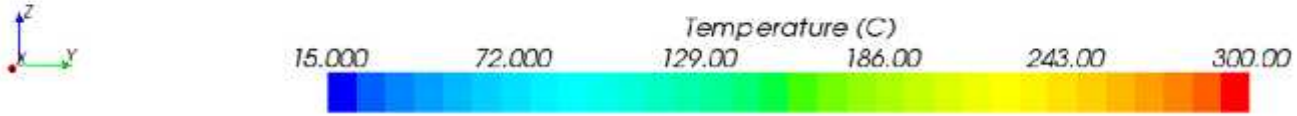


u_{tunnel} = 2.0 m/s



u_{tunnel} = 3.0 m/s





Emergency Stop

- TSI SRT "appropriate provisions must be laid down to take account of the particular safety conditions in very long tunnels"

- passenger trains should maintain its movement capability for 15 minutes, so that in the case of a train fire inside a tunnel, the train is expected to reach the tunnel portal. Assuming a train speed of 80 km/h → emergency stop in tunnels > 20 km
- Loetschberg Base Tunnel
- Gotthard Base Tunnel
- Lyon Turin Base Tunnel
- Brenner Base tunnel, etc.

- BUT …Zimmerberg Base Tunnel, Channel Tunnel, Hirschengrabentunnel, …

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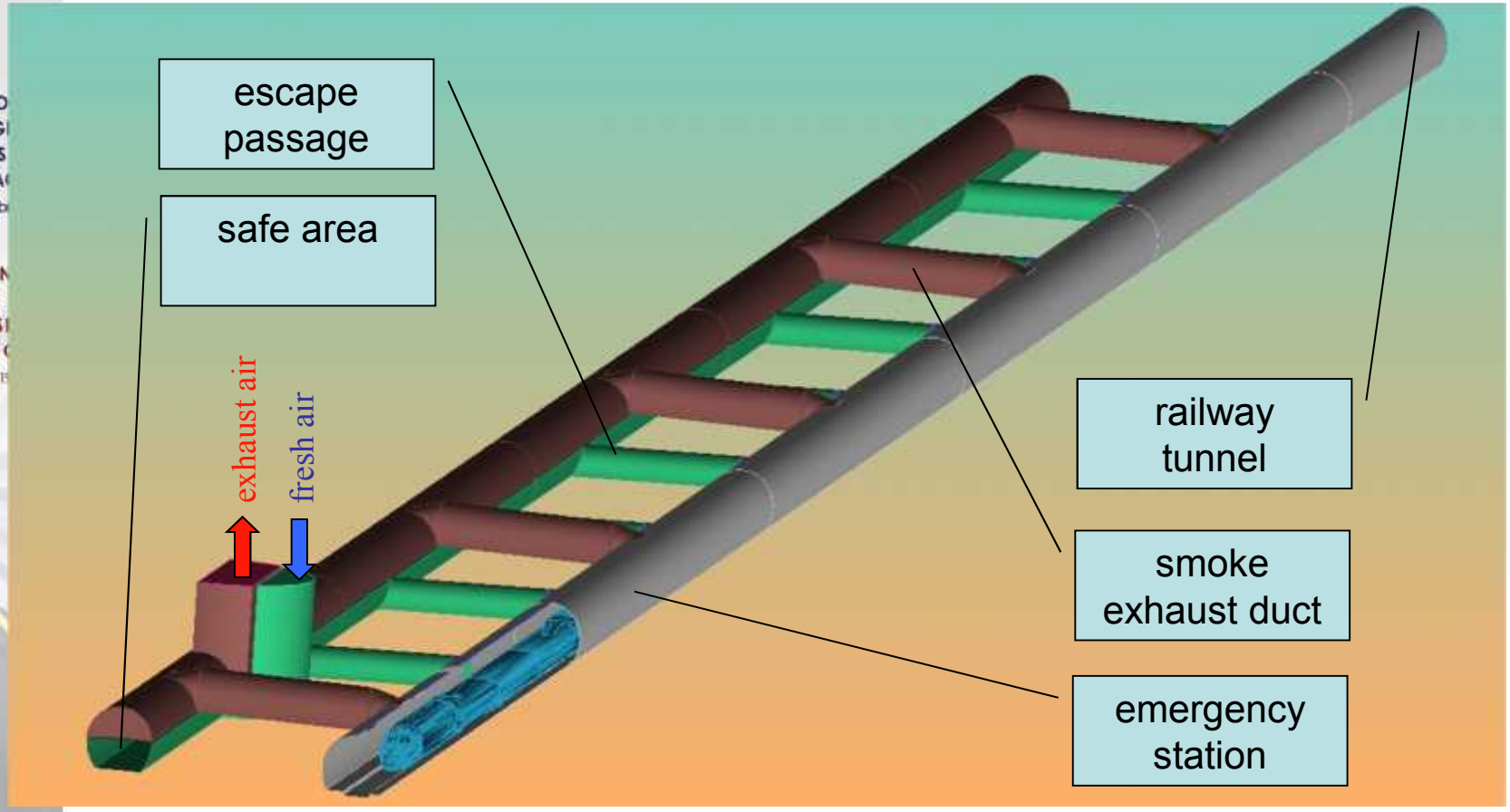
Typical Emergency Stop



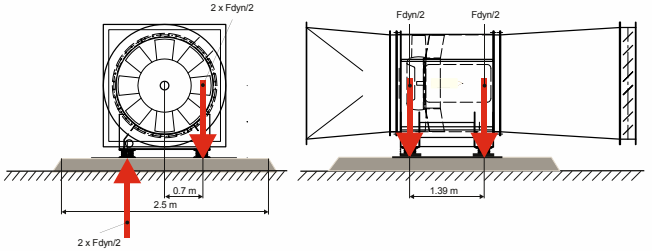
Emergency stop

- tunnel ventilation / no "smoke management"
- safe areas, good evacuation / rescue conditions
- potentially good fire fighting conditions
- sprinkler / water mist systems → complex some aspects

- systems may help rescue services
- guarantees the protection of tunnel structure
- maintenance / tests during operation ?
- automatic detection / start difficult (false alarms buoyancy and piston effect) ?
- reaction of water with transport goods / chemicals, etc. ?
- reduced visibility, hot steam, destroyed stratification ?
- who decides to start / on which information ?
- distribution of burning liquids, etc. ?

Often: Sprinkler / water mist systems are not required with regard to the safety targets / goals

Ventilation



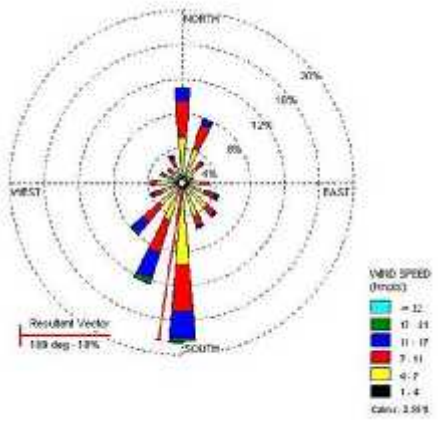
If ventilation is available
- normal operation mode
  climate control
- emergency operation mode
  hot incident / train fire
- maintenance mode / high fresh air demand!
  dilution of exhaust gases from diesel engines
- congested mode

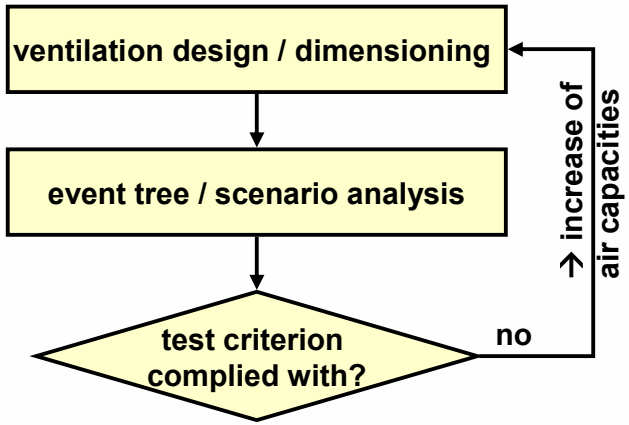
Layout / dimensioning of ventilation system with
- 1D methods (concepts, boundary limits, etc.)
- verification if safety targets are met with 3D analysis

Layout - Dimensioning of ventilation system

Benefit of event tree / scenario analysis:
- analysis of a huge range of possible scenarios
- knowledge of probabilities of certain situations

two incidents





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TSI SRT Typical Organizational Measures

- specific and combined planning of rescue forces
- process of operators (track closure, disconnecting catenary system, etc.)
- shared command of rescue services and expert representatives
- organization with local authorities
- use / organization of access routes to the tunnel / portals
- continuously teaching and practicing
- communication with press, etc.

→ tunnel safety documentation

- general part as technical description of tunnel
- incident part with plans and checklists identical for every related person

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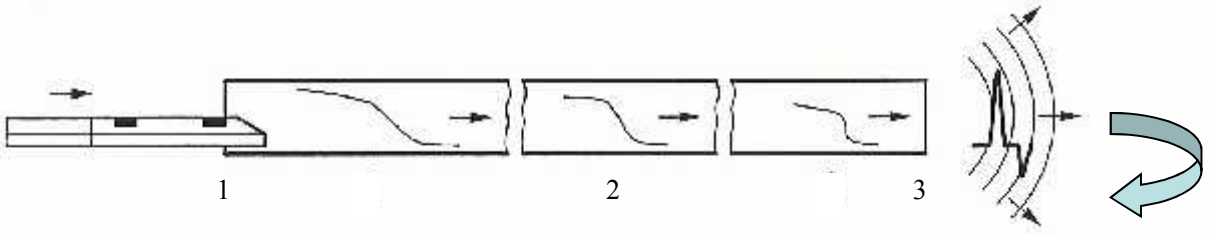
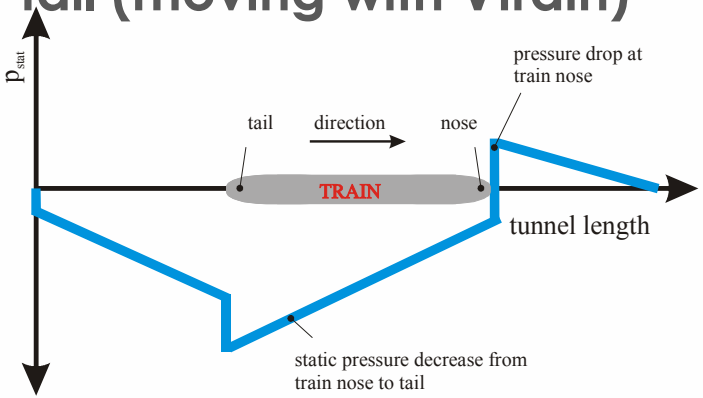
Aerodynamics and safety

pressure waves at train entrance / exit



reflection at tunnel portal ⇨ negative pressure pulse

- **pressure profile in a tunnel during a train passage ⇨ pressure difference between train nose and train tail (moving with Vtrain)**



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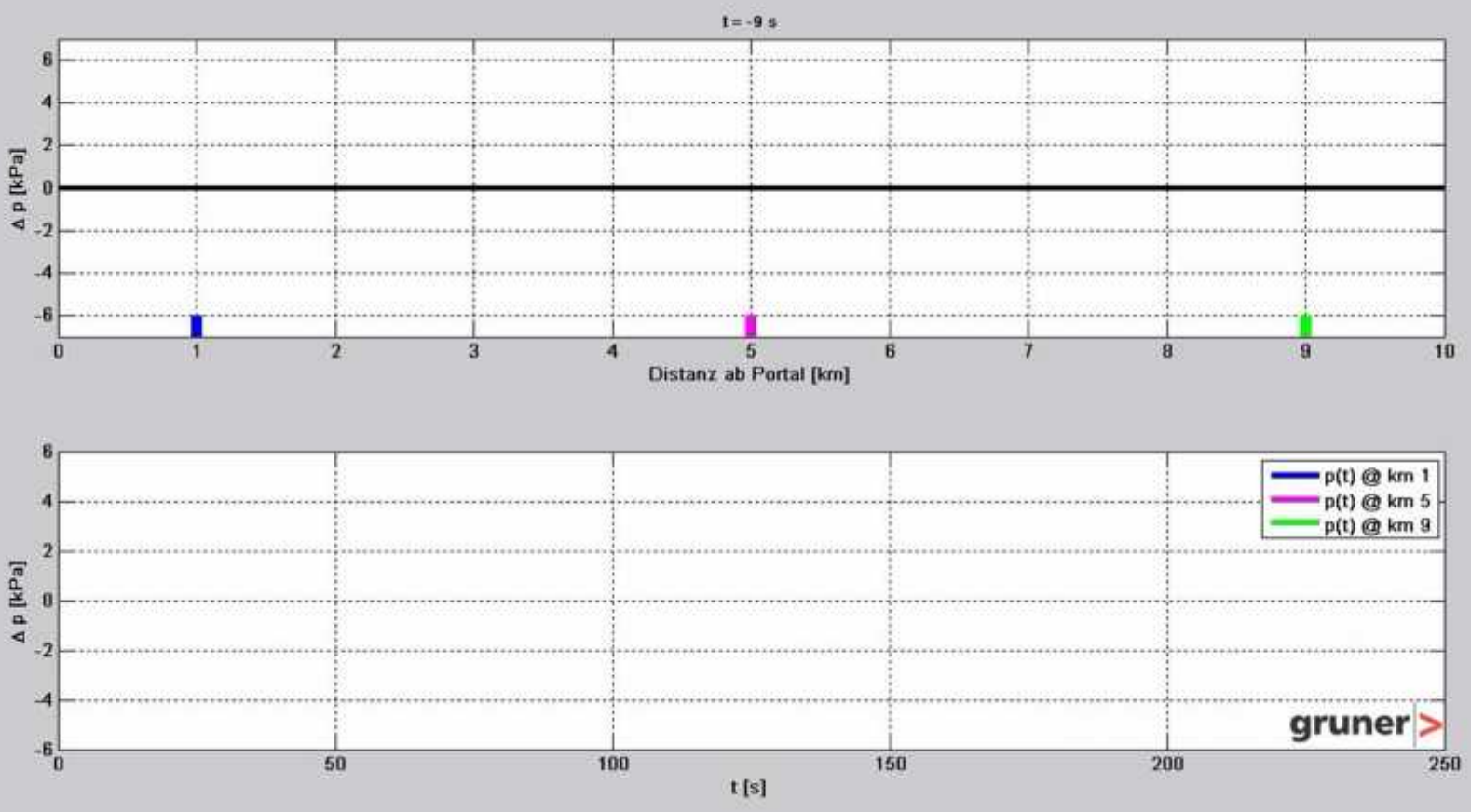
Aerodynamics and safety



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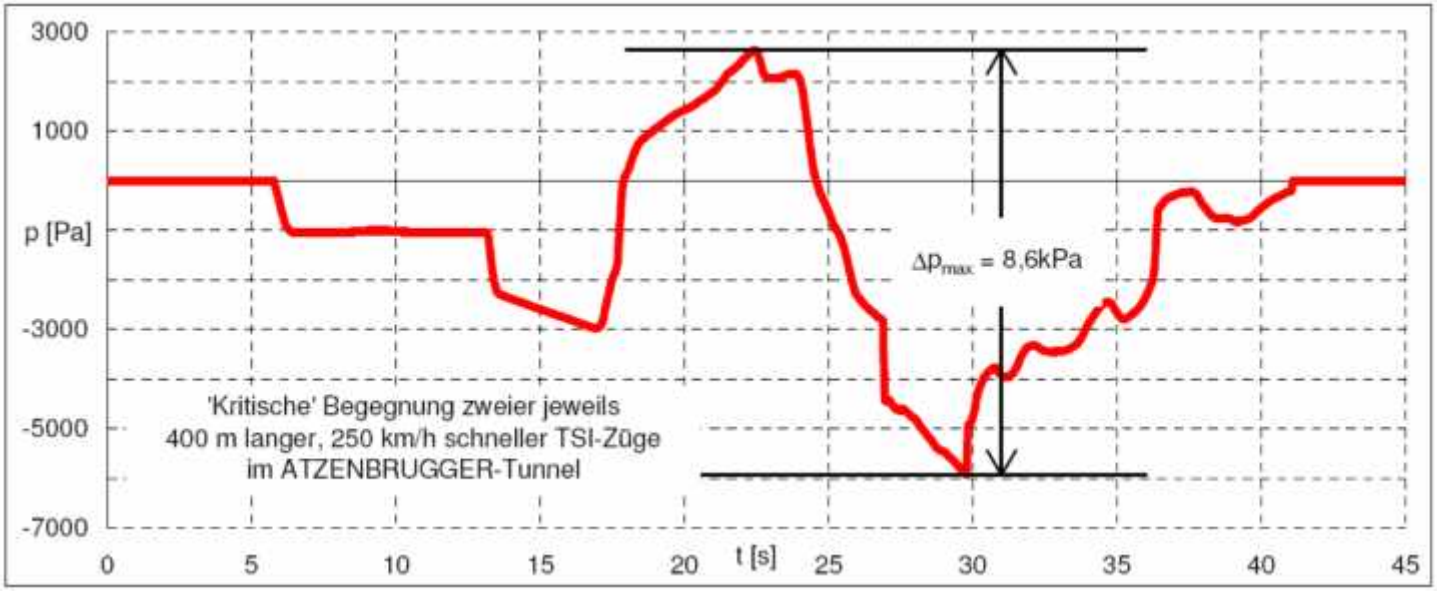
Aerodynamics and safety
TSI-safety criterion

- **TSI: Pressure variation must not exceed a Maximum pressure of 10 kPa within the entire passage through a tunnel**



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SEMINARIO INTERNACIONAL TUNELES DE GRAN LONGITUD: DESAFIOS PARA EL DISEÑO CONSTRUCCIÓN Y OPERACIÓN
Santiago, Chile 17,18 y 19 de Octubre 2012

INTERNATIONAL SEMINAR LONG TUNNELS CHALLENGES POR DESIGN AND OPERATION
Santiago, Chile, October 17,18 and 19 2012

Aerodynamics and safety

- impact on the rolling stock
- pressure forces on trains ⇨ special attention in mixed traffic situations
- pressure forces on installations inside the tunnel
  - doors in cross passages / escape exits
  - technical cabinets
  - covers of cable canals etc.

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Rail Dust

- health of workers
- functionality / life cycle of electronics / cabinets
- cleaning / maintenance costs (twice a year ?)

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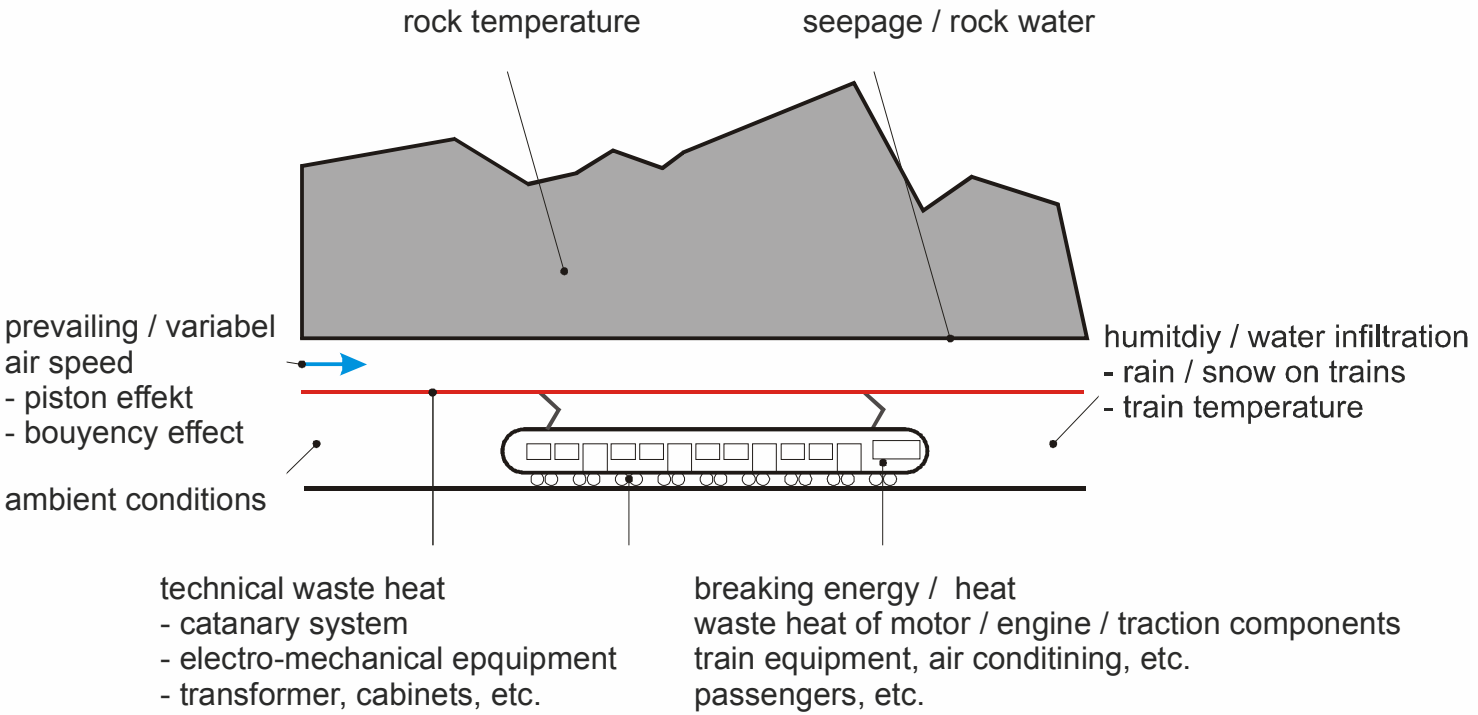
Climate I



- **safety equipment in technical rooms works up to approx. 28 to 35 °C**
- **air conditioning in trains work up to approx. 40 °C**
- **Lack of passenger comfort and health risks during high temperatures in the rail coaches**

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Climate II

- icing / danger from frost
- major safety aspects:
  - ice on egress path
  - ice falling down from tunnel sealing

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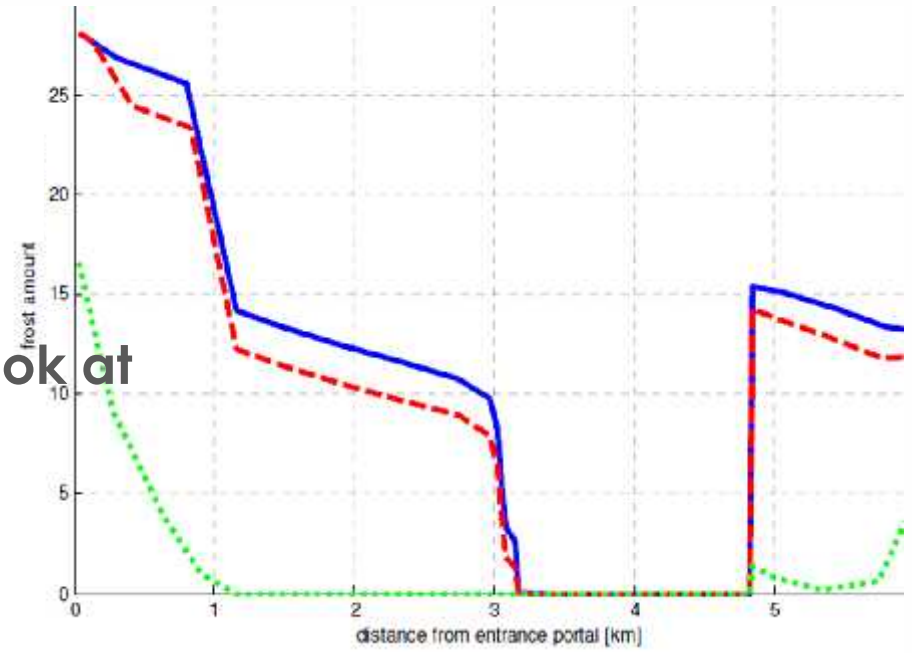
Climate III

climate prediction

- right parameters
- right models
- right numbers to look at
  e.g. AFI
  Air Freezing Index



climate control by

- tunnel sealing
- isolation between rock and lining
- active / passive ventilation measure
- partly recirculation
- heating / cooling devices for underground stations
- tunnel doors during nights, etc.

Summary

Information about TSI-SRT

- priorities: prevent, mitigation, evacuation, rescue
- structural, technical or organizational measures to comply with safety targets
- ventilation as part of technical measures

Aerodynamic has impact on tunnel and passengers safety.

Climate has an impact on the tunnel / passengers for both cases: too hot / too cold

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Thank you

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