



# *Ventilation of Escape Routes*

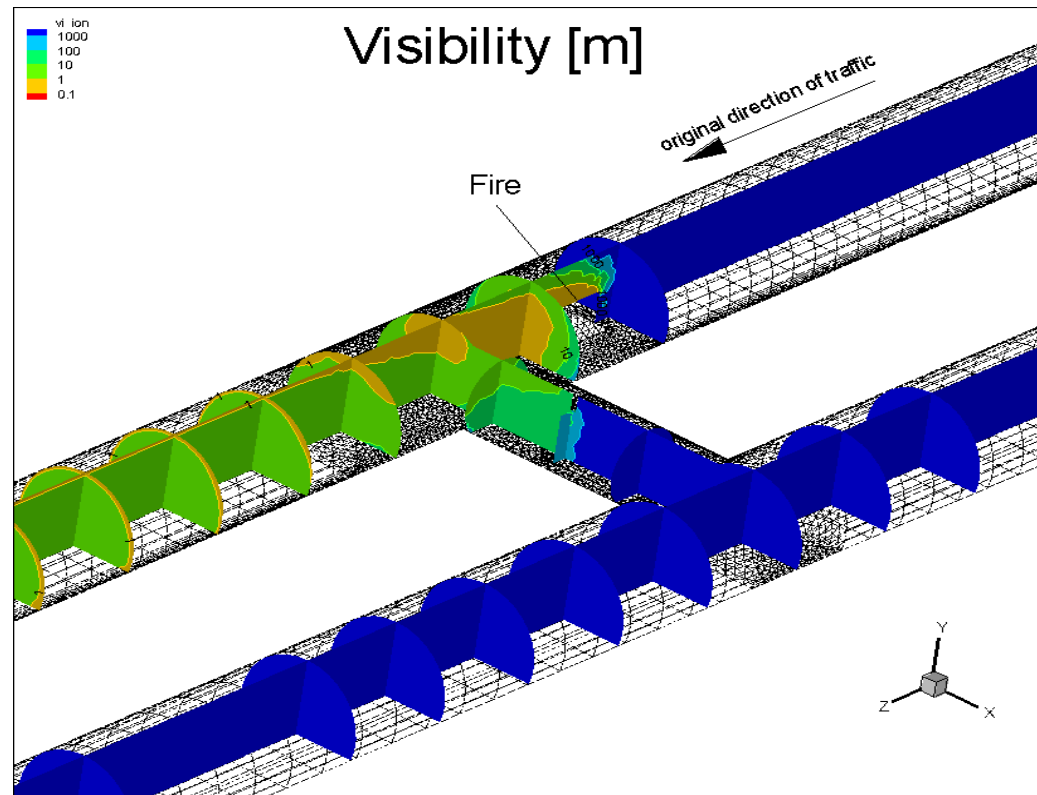


**Demand for escape routes  
in safe, tenable conditions**

# Requirements

**Escape route is pressurised  
while the escape door is closed**

**When escape door is opened, smoke may entry**





# *Requirements*

**air-flow through open doors  
keeps the escape route free of smoke**





# *Requirements*

## **Specifications 1:**

- In emergency operation: airflow  
**Minimal average air velocity through open doors**
- ( In all modes of operation: airflow  
**Minimal pressure difference over closed doors )**  
NFPA 105, NFPA 92A, ...
- In all modes of operation: **enable opening of doors**  
**Maximum pressure difference over closed doors**



# *Requirements*

## **Specifications 2:**

- Required air-flow must build up without delay
- Switch rapidly from permanent to emergency operation
- Redundancy
- Safe state even if the ventilation completely fails
- ( Fresh-air supply for persons and technical equipment )
- In permanent operation:  
energy consumption should be low



# Requirements

**Which minimal average air velocity ?**

- **Empirical formula for critical velocity**

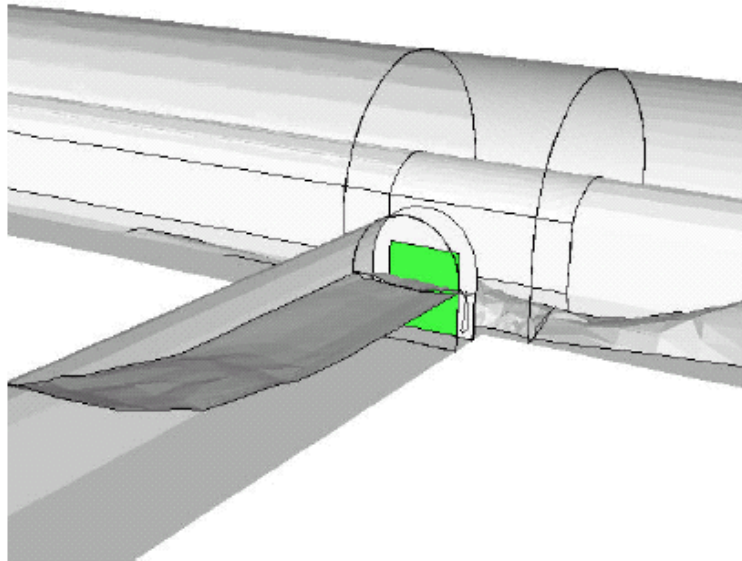
$$v_{critical} = K_1 \cdot K_g \cdot \left[ \frac{g \cdot Z_{tunnel} \cdot \dot{P}_c}{\rho \cdot c_p \cdot A_{tunnel} \cdot T_{g0}} \right]^{\frac{1}{3}} \quad \left[ \frac{m}{s} \right]$$



# *Requirements*

**Which minimal average air velocity ?**

- **CFD Calculations**





# *Requirements*

## **Which minimal average air velocity ?**

### **Constant value**

- High buildings: 1 m/s
- Gotthard Road tunnel (1980):  
1 m/s through 10 successive open doors
- New approach (2000):  
(Swiss Alptransit Rail tunnels,  
new Swiss Road tunnels, Branisko, ...)

2.5 m/s through 1 door

or

1 m/s through 3 successive open doors

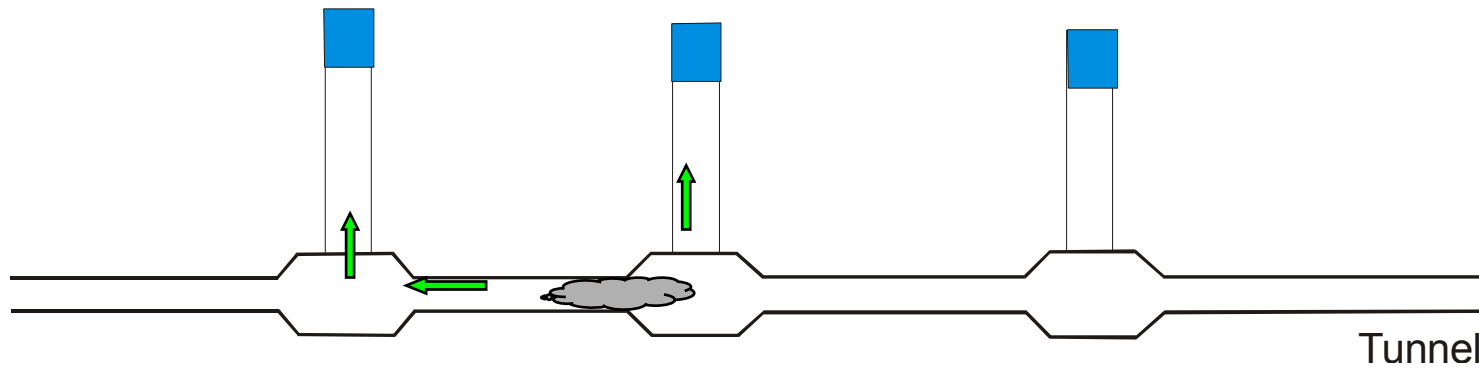
or

1 m/s through any 2 open doors

taking into account all critical cases

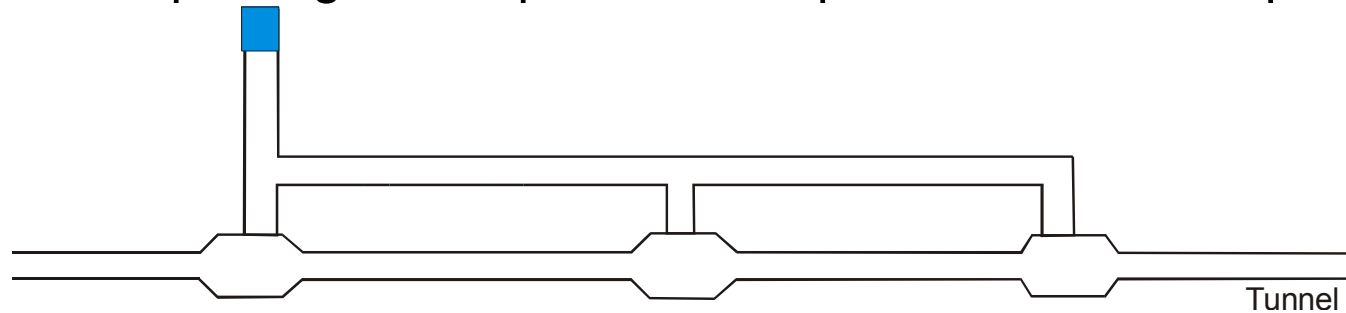
# Concepts

A) Escape ways direct to the outside

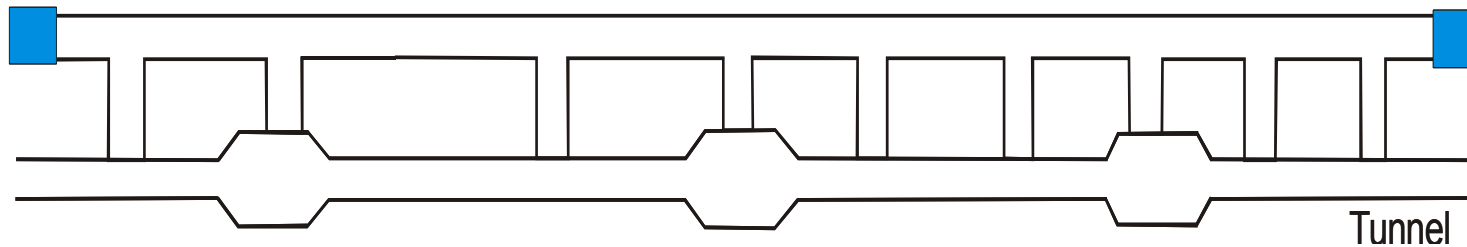


# Concepts

B) Cross passages to a parallel escape tunnel with one portal

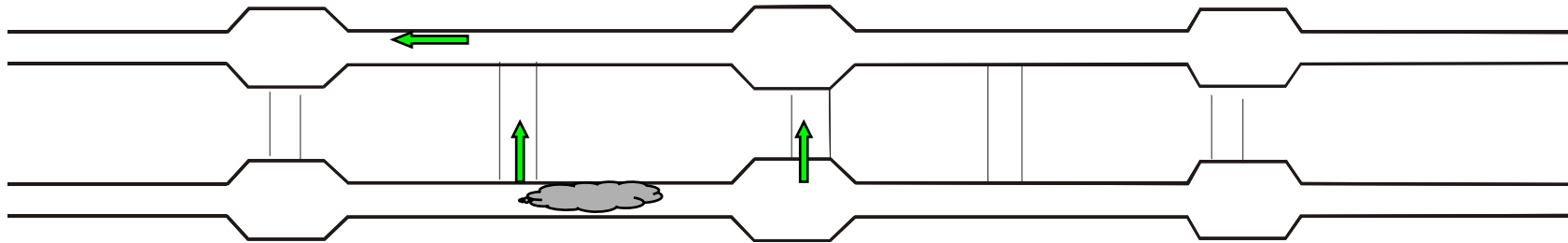


C) Cross passages to a parallel escape tunnel with two portals



# Concepts

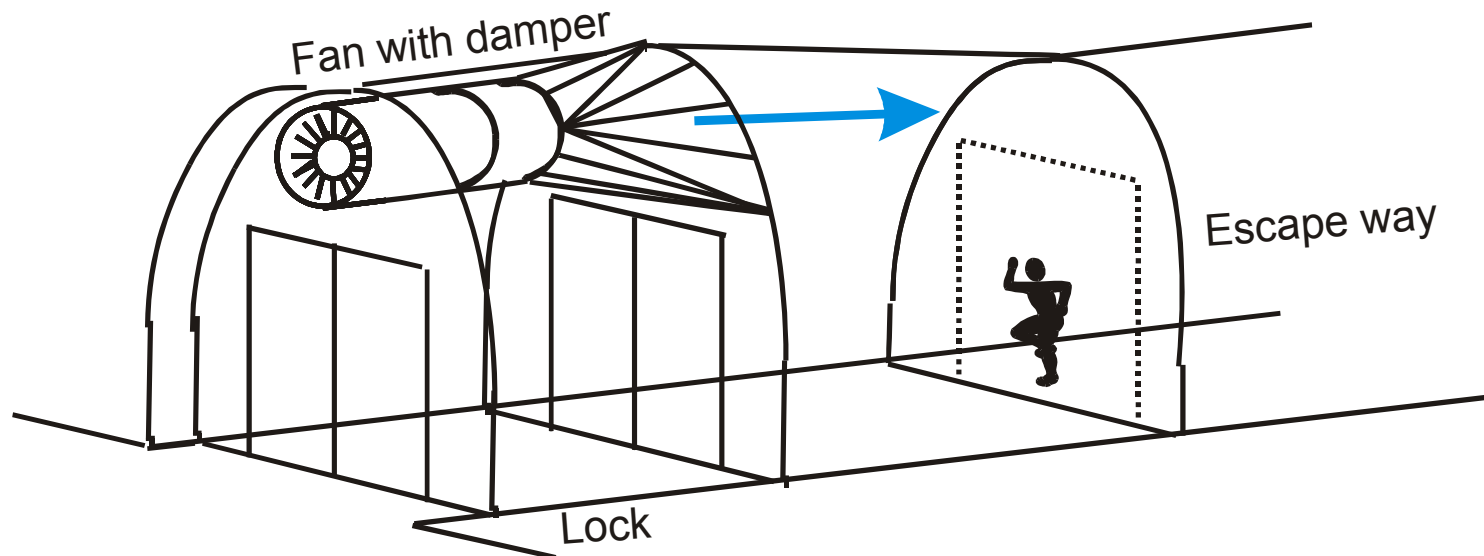
## D) Dual-tube tunnels with cross passages



The escape way is the traffic space of the non-incident tube !

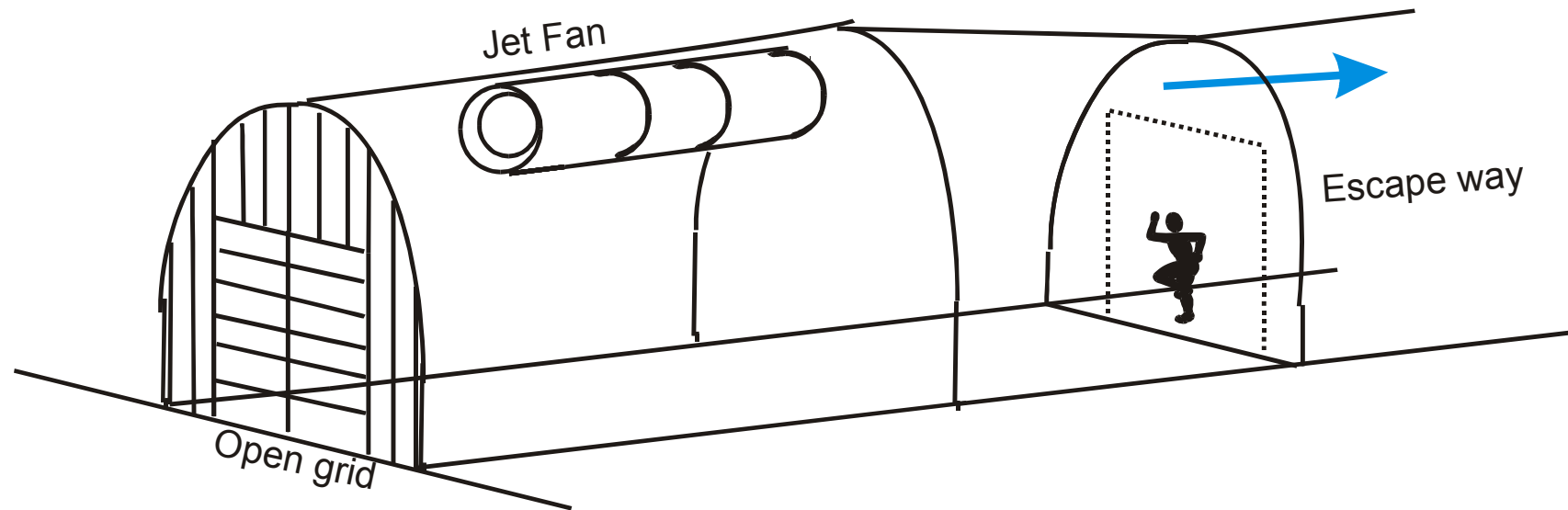
# Concepts

Concept 1: Fans parallel to an air lock



# Concepts

## Concept 2: Jet fans in open tunnel



Suitable for dual-tube tunnels with cross passages

Not recommended for separate escape tunnels

# *Escape doors*

## **Flap doors**

- Force to open the door limits the max. pressure difference
- extra pressure relieve dampers
- sensitive ventilation layout
- pressure fluctuations

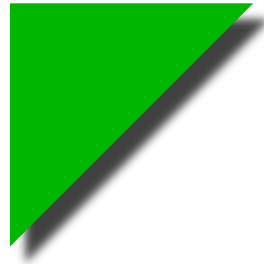


# *Escape doors*

## **Sliding doors**

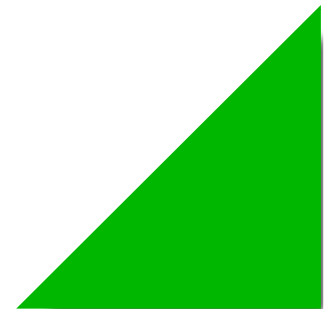
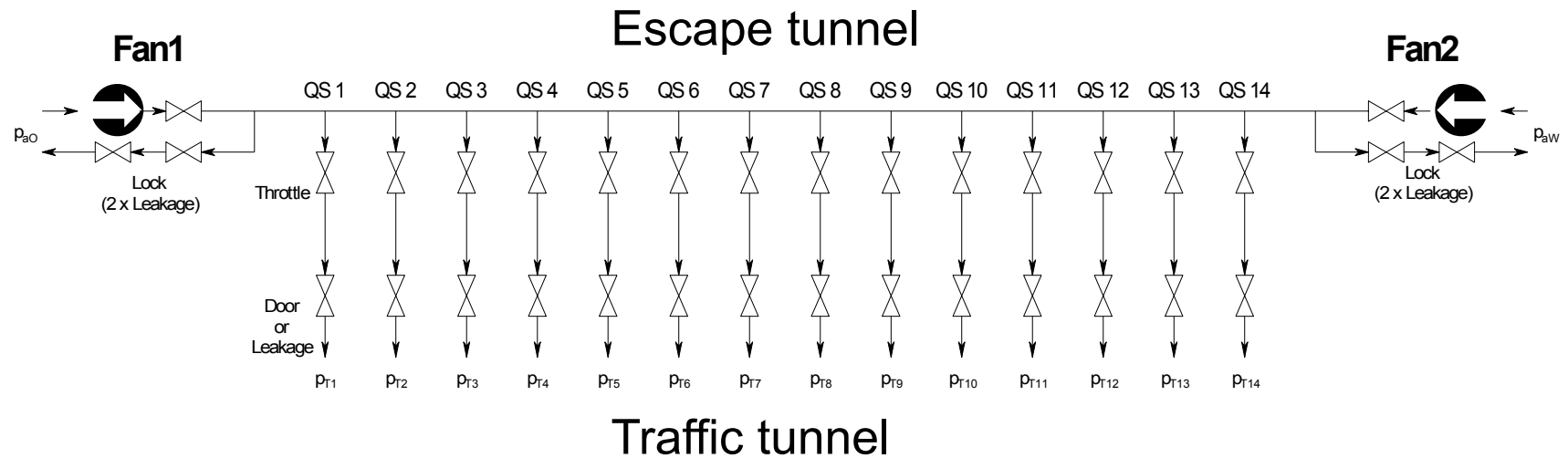
- **recommended !**
- sensitive construction
- must be proven under tunnel conditions





# Layout

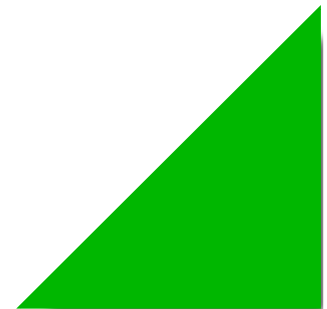
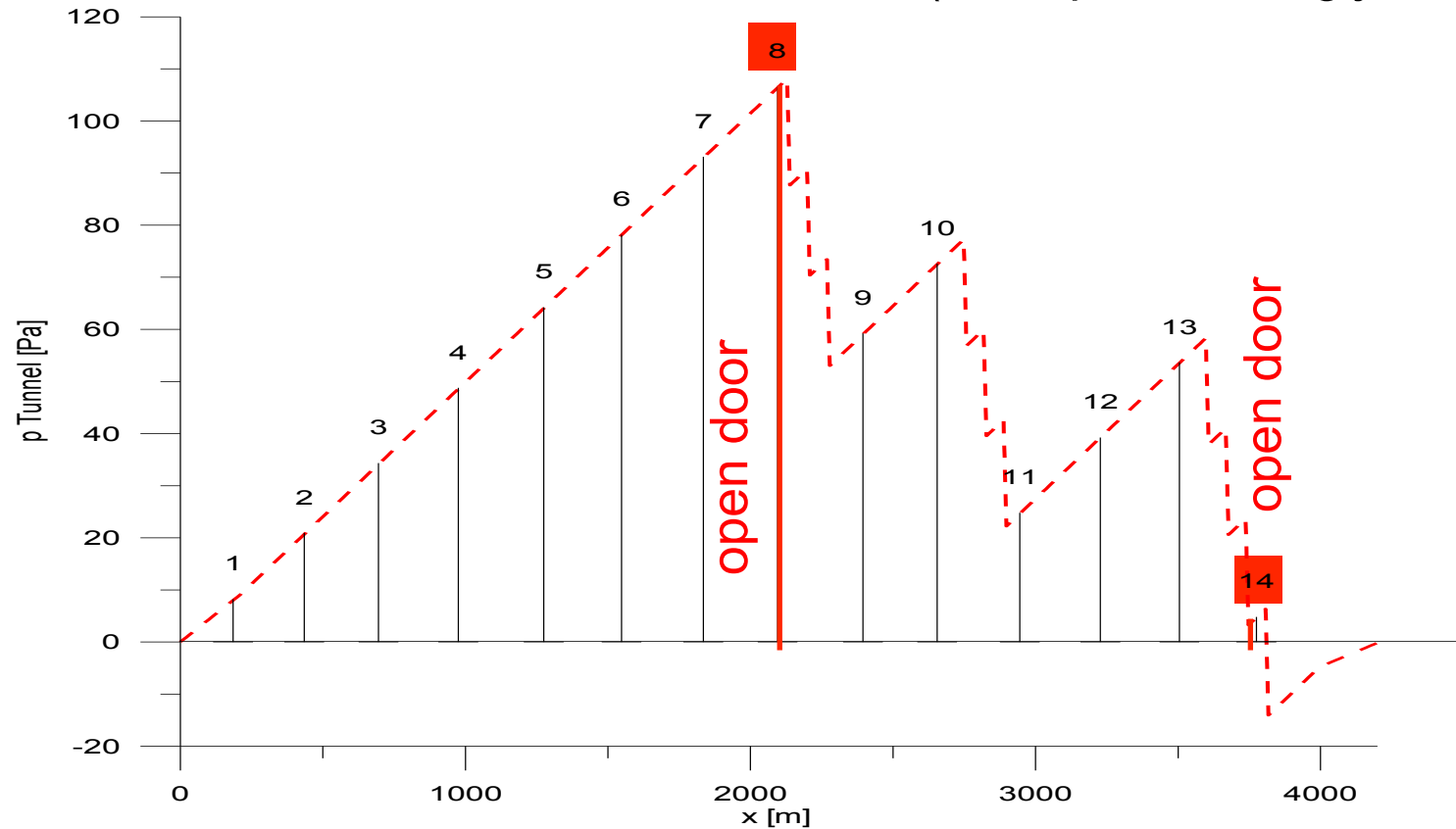
## 1-D model





# Layout

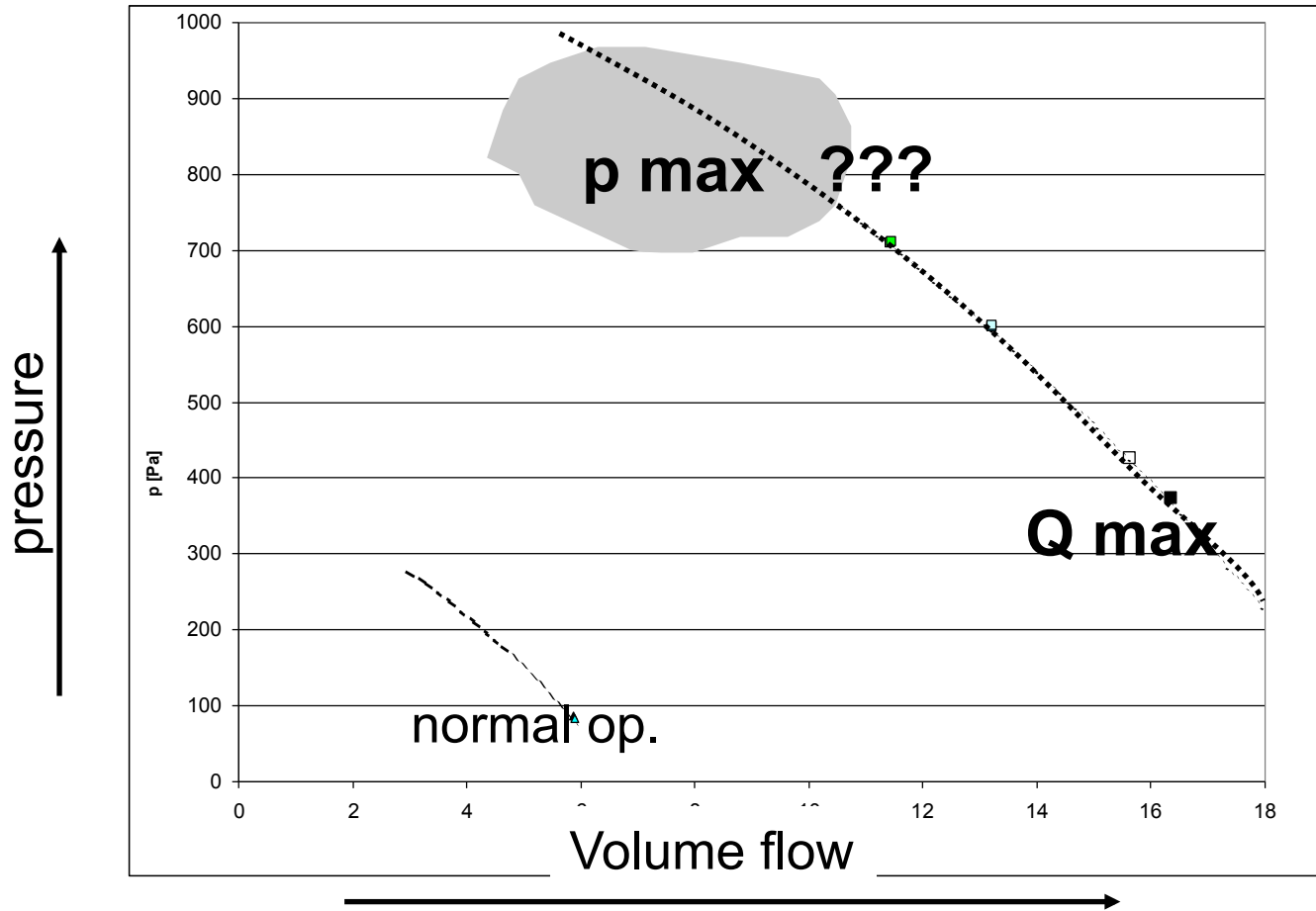
## Pressure in traffic tunnel (example: running jet fans)





# Layout

Layout of fan - stall free characteristic



# *Layout*





# *Aspects*

## **Realisation**

- commissioning – performance test (measuring of air velocity in open doors)
- regular function tests in operation
- maintenance
- repair service / replacement





# Aspects

## Focus on escape way ventilation

Relations	Escape way ventilation	Tunnel ventilation (Smoke extraction)
Safety	guarantees safe conditions in escape ways	improves unsafe conditions in traffic space
Investment	1	: 10 - 50
Installed power	1	: 10 - 100
Engineering	1	: 1