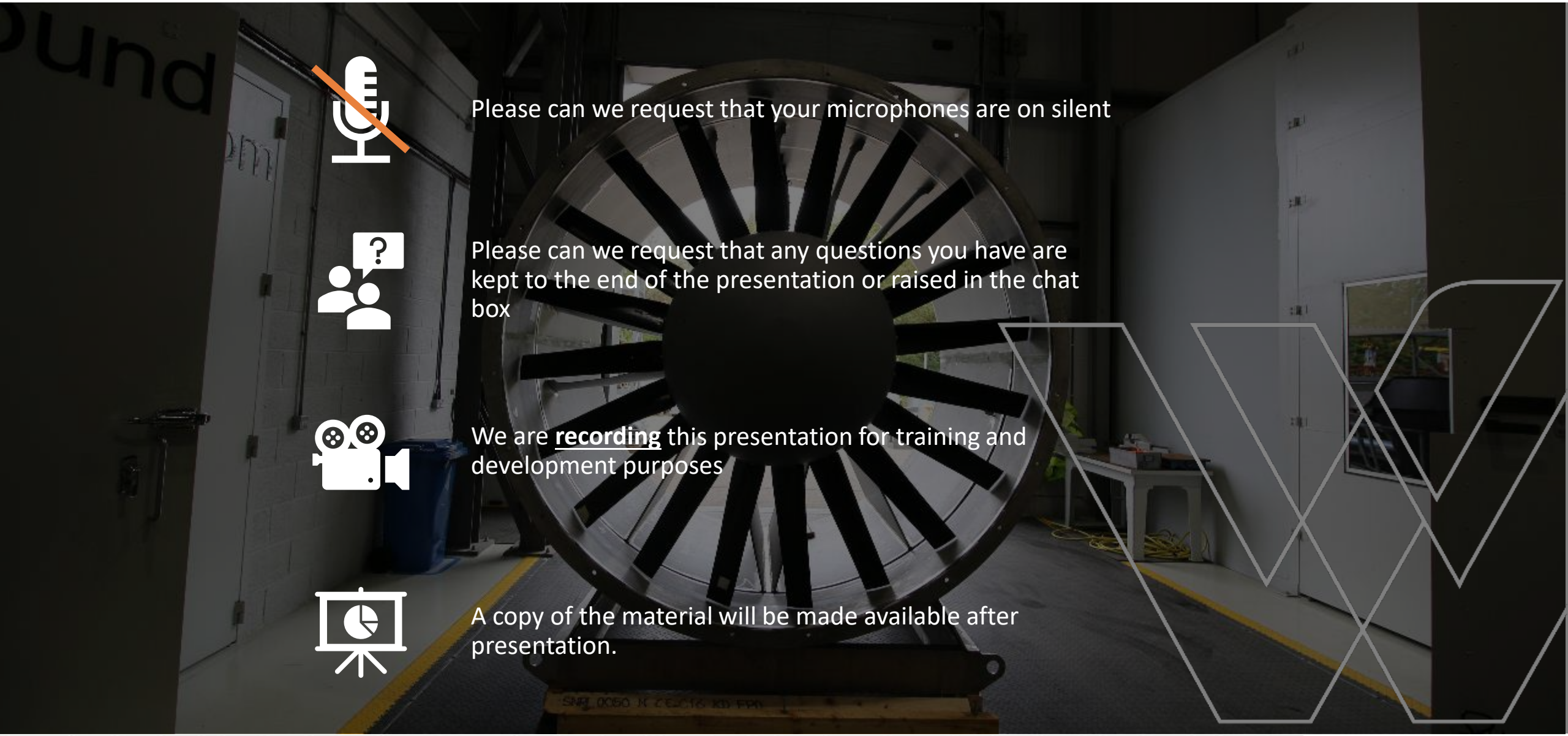
Webinar Guidance



Please can we request that your microphones are on silent

Please can we request that any questions you have are kept to the end of the presentation or raised in the chat box

We are **recording** this presentation for training and development purposes

A copy of the material will be made available after presentation.

Topics covered in this session

Metros, Rail and Road Tunnels

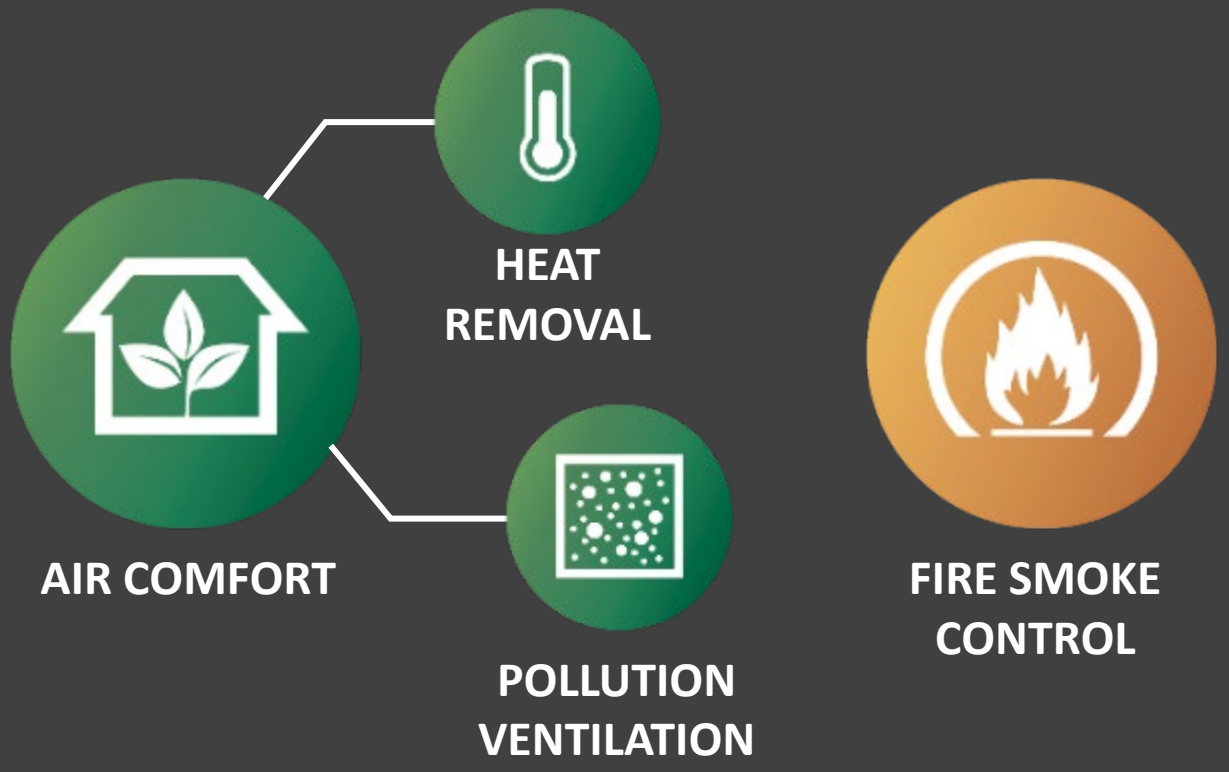
- Why ventilate
- What determines the ventilation rate - Metro & Rail
- Pressure pulse, blade stress
- Mitigation
- Equipment and plantroom layout
- Road Tunnel ventilation methods
- What determines the ventilation rate – Roads
- Product range
- Routine tests and FAT’s

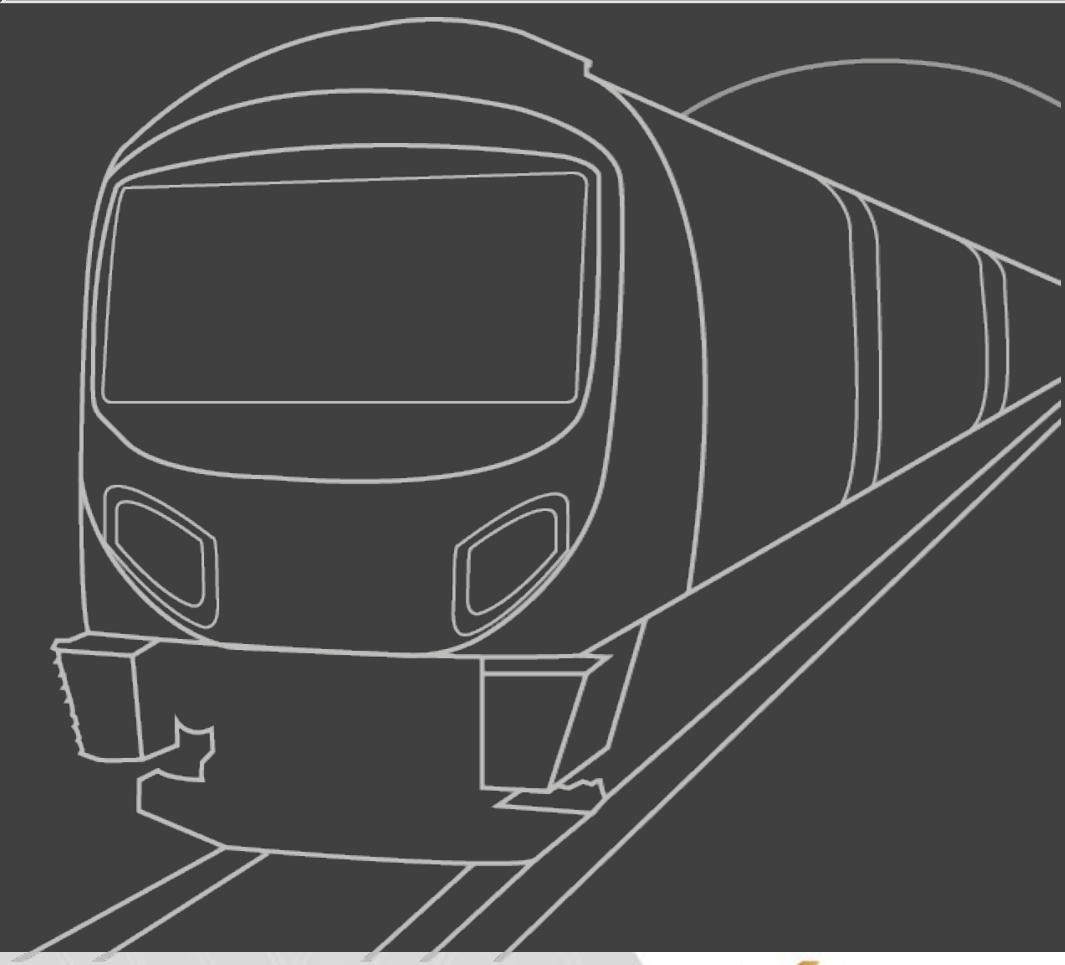
METRO & RAIL VENTILATION

ROAD VENTILATION

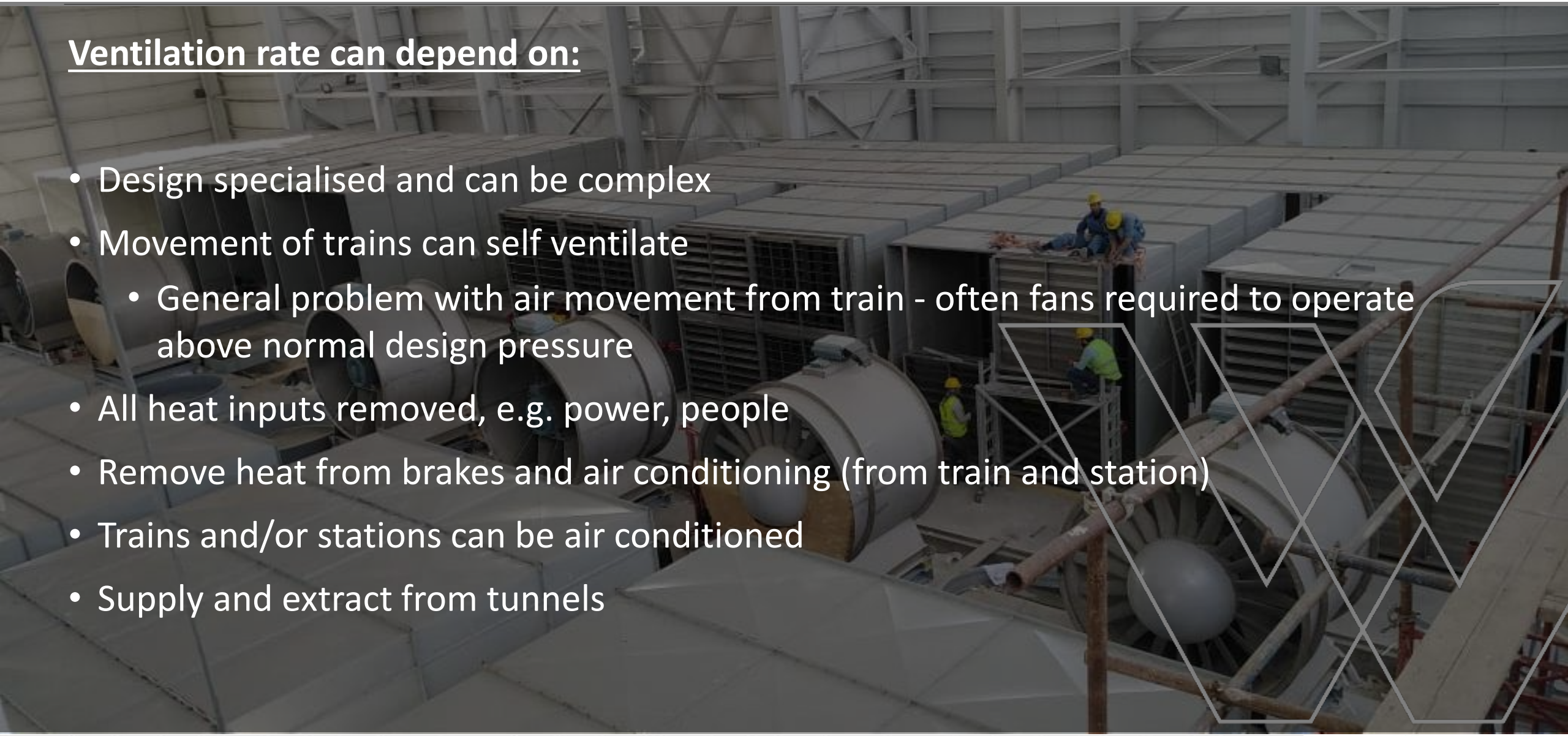
- SAFEGUARD PEOPLE IN TUNNELS
- VENTILATE TUNNELS & PLANT ROOMS

Solutions must adhere to strict regulations and conform to energy efficiency requirements



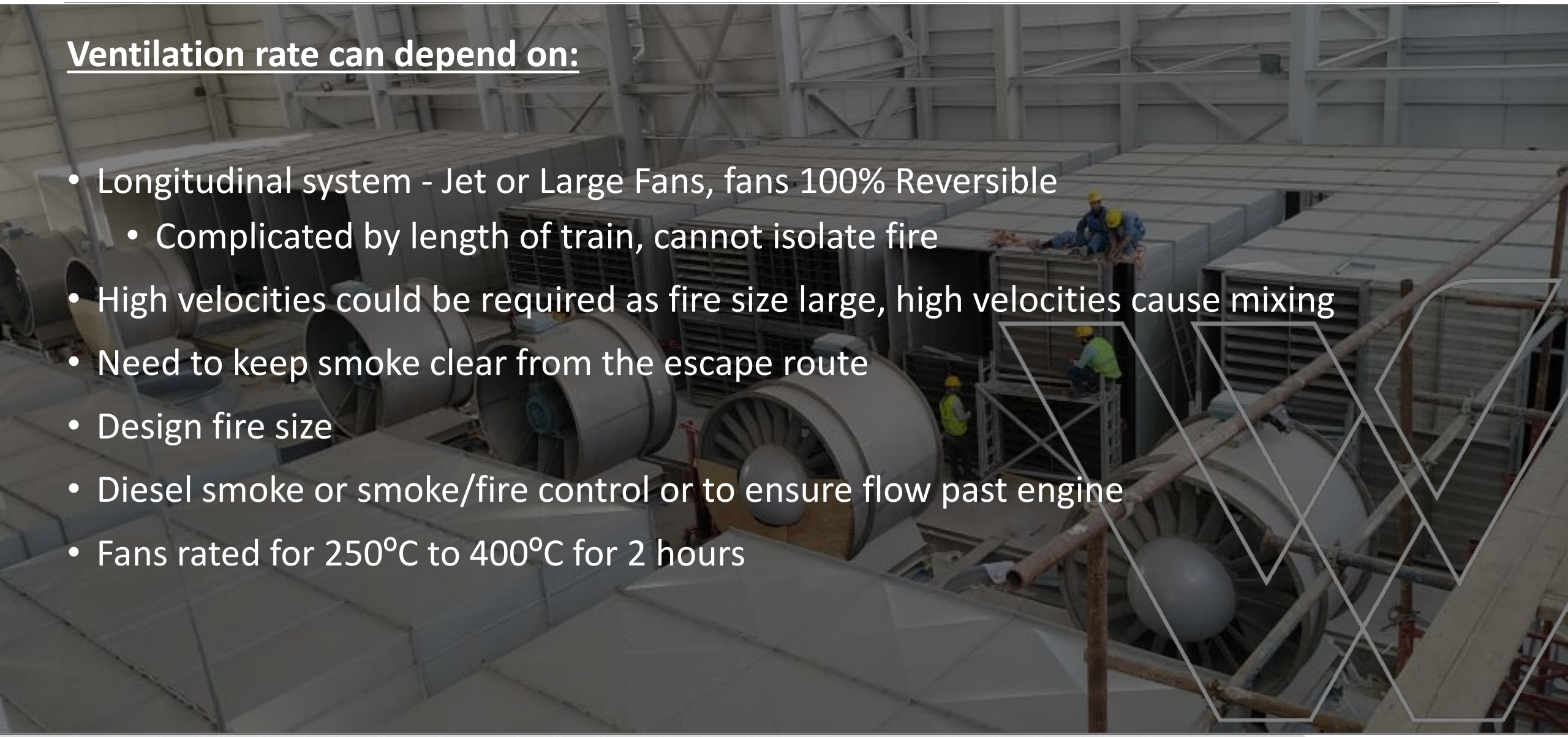


Woods AIR MOVEMENT



Ventilation rate can depend on:

- Design specialised and can be complex
- Movement of trains can self ventilate
  - General problem with air movement from train - often fans required to operate above normal design pressure
- All heat inputs removed, e.g. power, people
- Remove heat from brakes and air conditioning (from train and station)
- Trains and/or stations can be air conditioned
- Supply and extract from tunnels



Ventilation rate can depend on:

- Longitudinal system - Jet or Large Fans, fans 100% Reversible
  - Complicated by length of train, cannot isolate fire
- High velocities could be required as fire size large, high velocities cause mixing
- Need to keep smoke clear from the escape route
- Design fire size
- Diesel smoke or smoke/fire control or to ensure flow past engine
- Fans rated for 250°C to 400°C for 2 hours

- Variations in system resistance caused by pressure changes associated with the movement of trains through the tunnel system

- A typical value for Pressure Pulse is 300Pa, but when platforms have screen doors and/or tight clearances this Pressure Pulse can reach up to +/- 700Pa

  - India = 300 Pa
  - Dubai = 500 Pa
  - Singapore = 700Pa

- Integrated Solutions for operating fans under these challenging conditions

- Variations ir
  associated v
- A typical val
  screen door
  to +/- 700Pa
  - India = 3
  - Dubai =
  - Singapo
- Use Fan Inte
  conditions.

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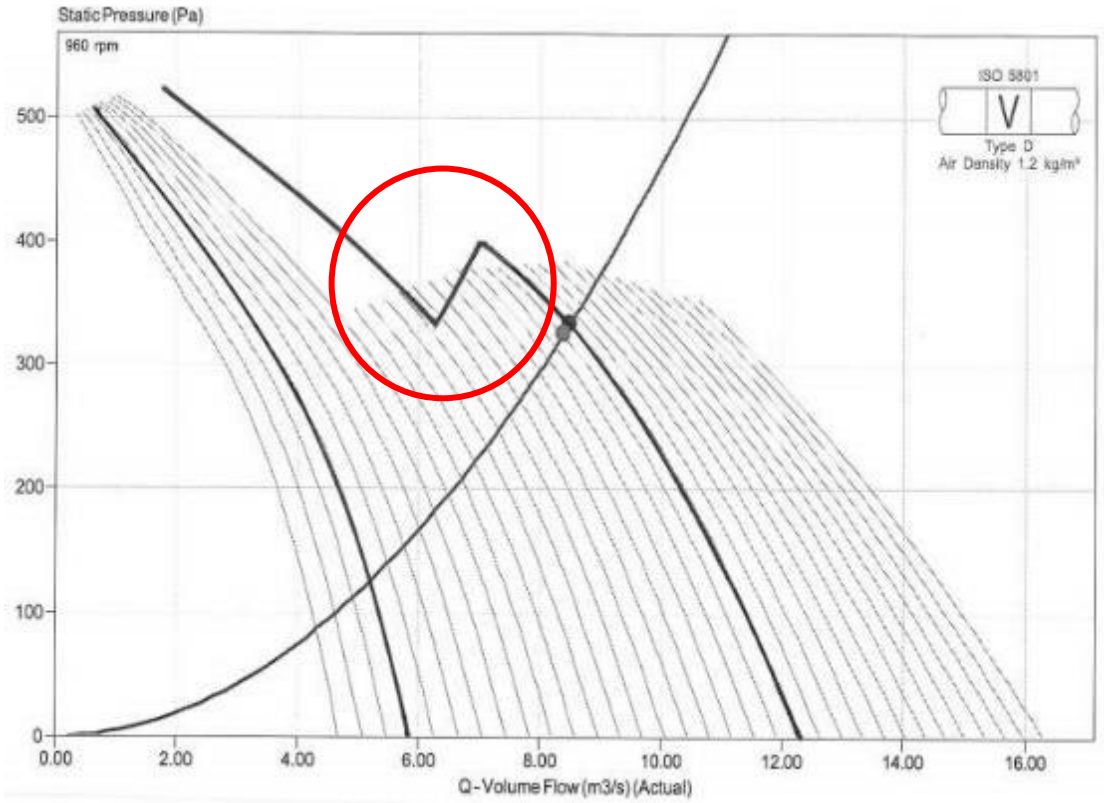
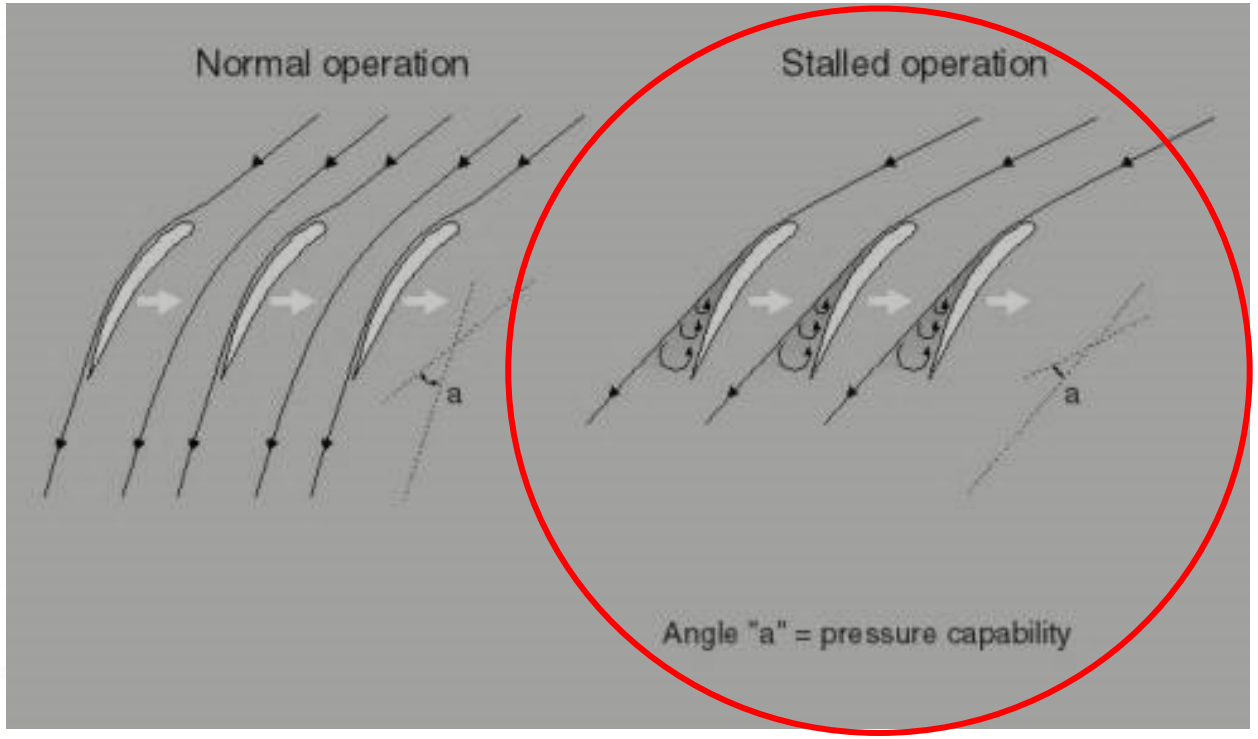
  - India = 300 Pa
  - Dubai = 500 Pa
  - Singapore = 700Pa

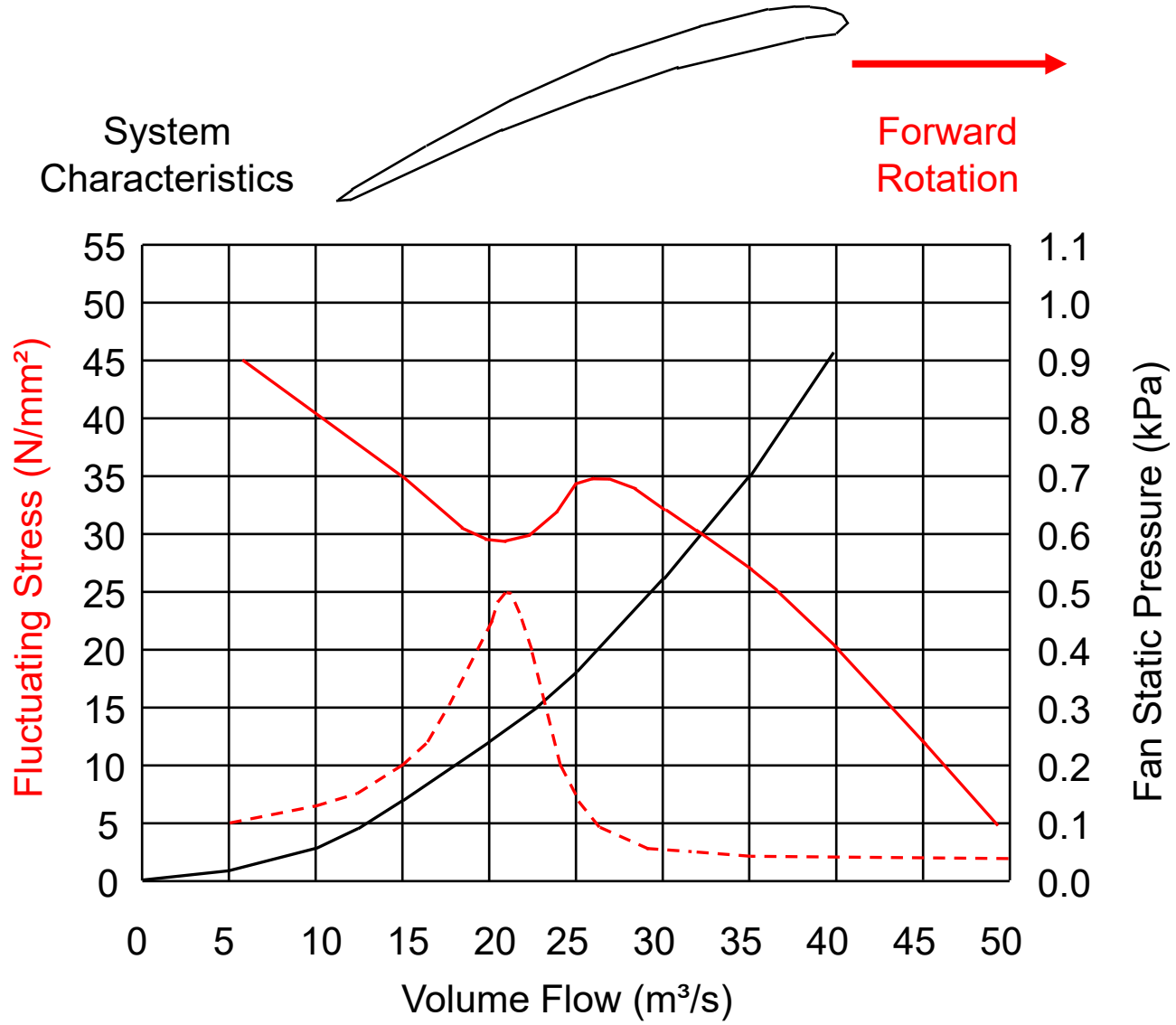
- Integrated Solutions for operating fans under these challenging conditions

1. High pressure pulses may cause the fan to exceed the optimum operating point and enter stall

2. In this area, high turbulences bring low efficiency, high noise level and increased fluctuating stresses that will eventually lead to impeller blade failure

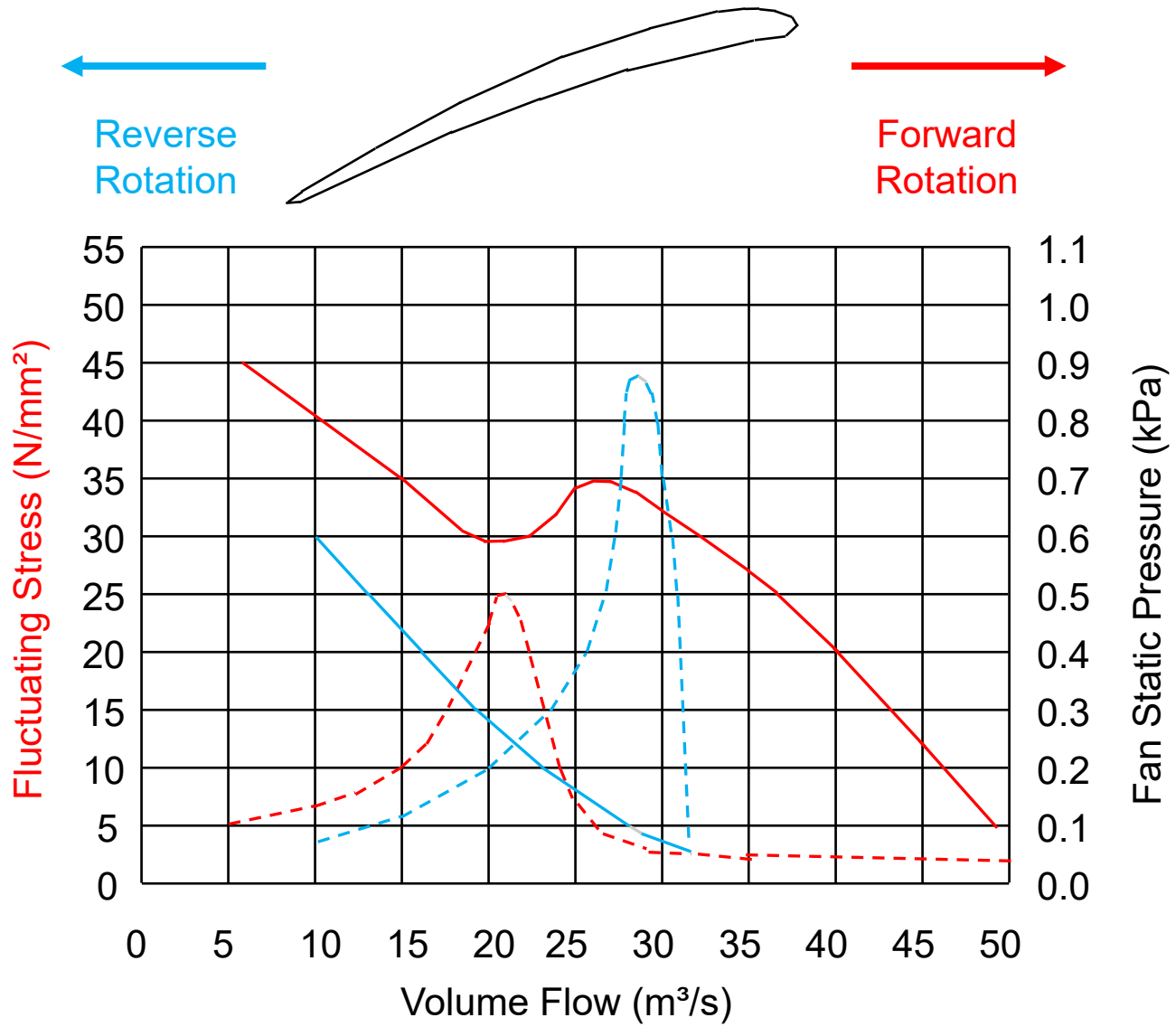






1. Axial fans should never be run in stall conditions for prolonged duration – or repetitively – even in forward only operation

2. In this area, fluctuating stresses will exceed material properties that will eventually lead to impeller blade failure

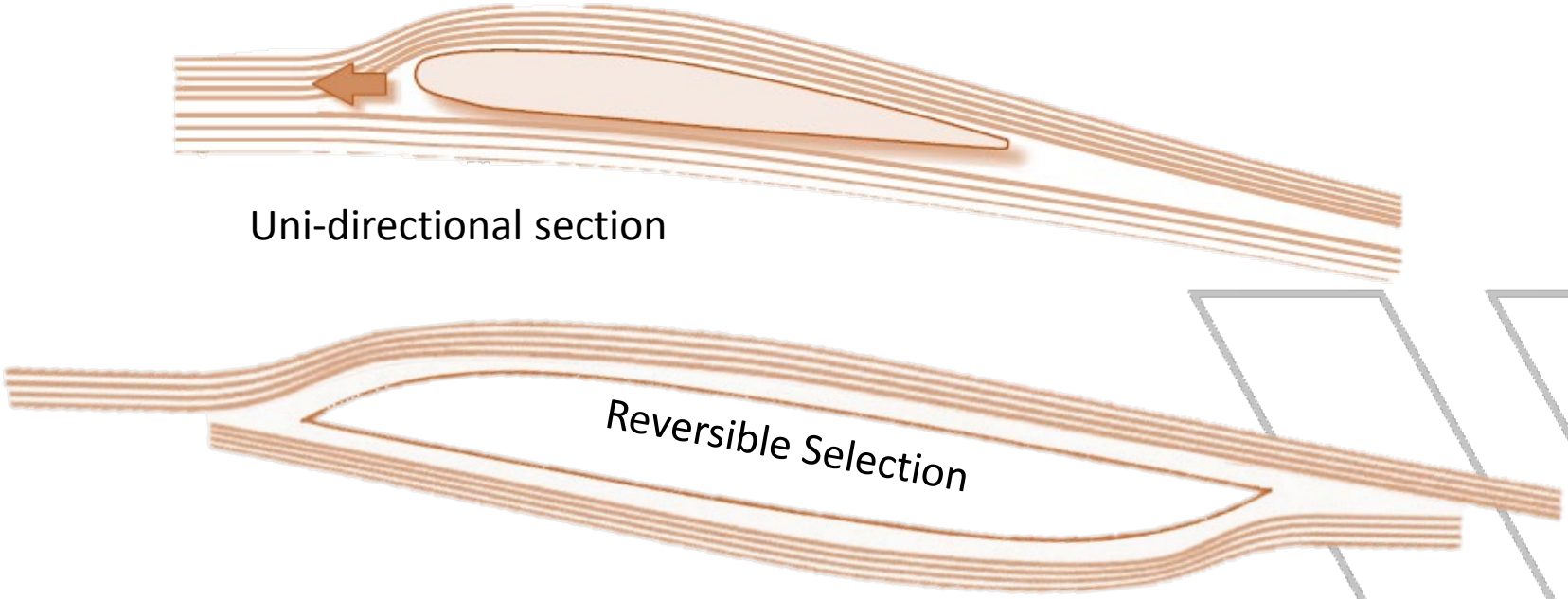


1. Unidirectional axial fans, when operated in reverse will immediately stall and in certain cases fluctuating stresses will exceed material properties that will eventually lead to impeller blade failure.

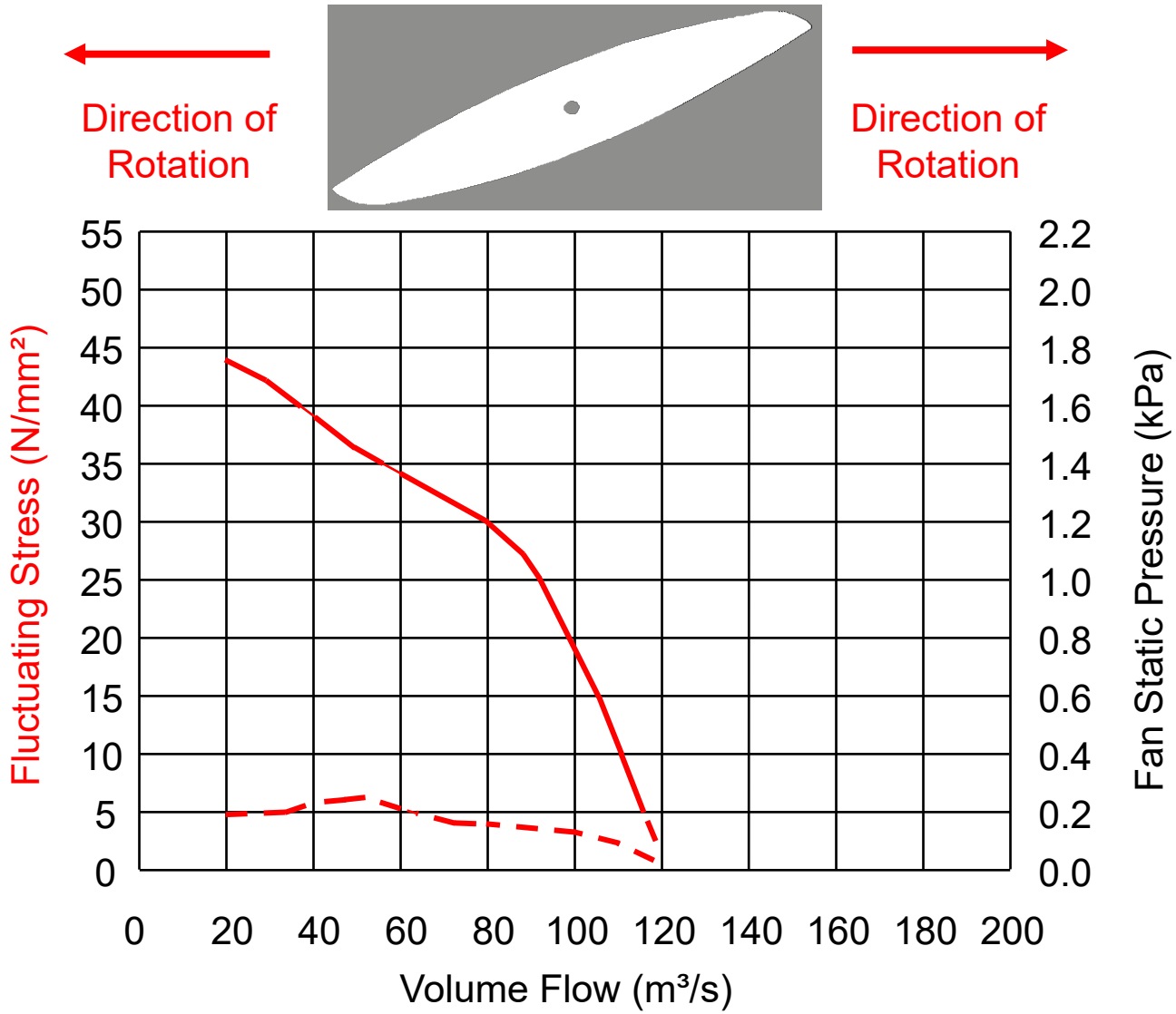
2. For reversing applications – use an alternative aerodynamic section to overcome this problem.

3. Aerodynamic sections that are mechanically safe – are aerodynamically less efficient.

Unidirectional versus Truly Reversible impeller blades



100% reversible fans are designed for maximum performance and efficiency and so have truly symmetrical reversible blade sections. They give the same performance in both the forwards and reverse direction. However, a truly symmetrical section is **less efficient overall c/w a unidirectional section – and this is further reduced when required to operate in an emergency condition/temperature**.



1. Truly reversible aerodynamic sections overcome the mechanical disadvantages of unidirectional sections running in reverse.

2. The compromise in aerodynamic efficiency is presently accepted (but difficult to achieve combined overall efficiency targets in some instances (air-to-gas)).

3. Especially with cumulative need for HT (emergency ventilation) at 250 / 300 and 400°C

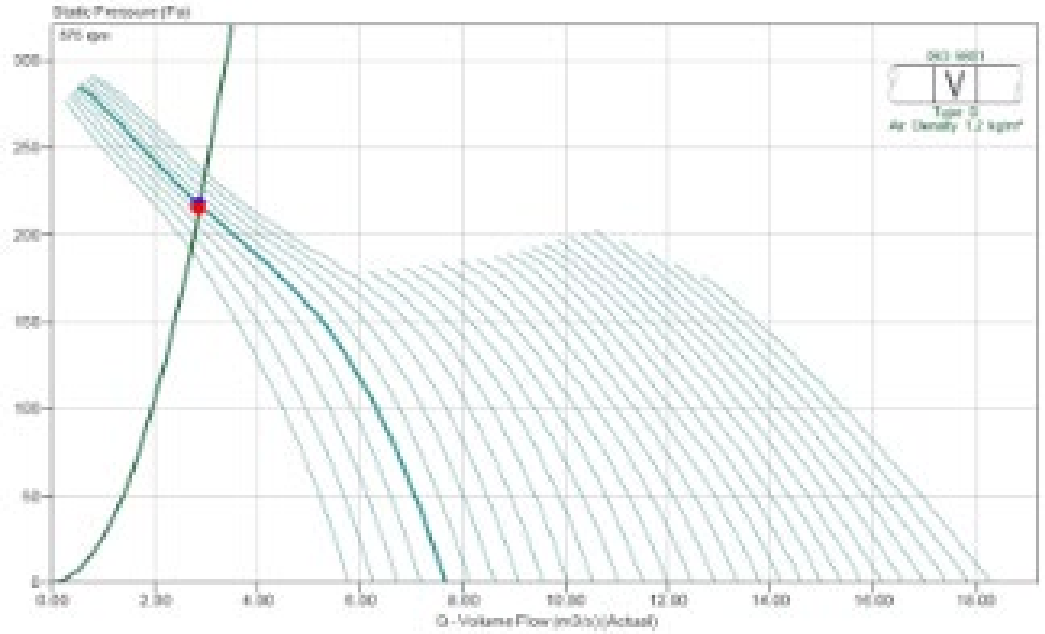
Impact of Reversible fans on power/efficiency

Fan Duty	50 m³/sec @ 1800 Pa (total)		
Fan Description	**Temperature category**	**Power**	**Fan Total Efficiency**
Unidirectional	Ambient	100%	79%
Reversible		110%	73%

- General rule of thumb is that you should expect a reduction of around 5% in efficiency between a optimised unidirectional section and corresponding reversible option.
- This may be improved using IMI configurations that have interstitial guide-vanes that can increase efficiency in both directions.
- The most efficient systems will be a duplicate of uni-directional installations. This will become more common as efficiency targets increase for “normal” operation.

Tunnel Ventilation

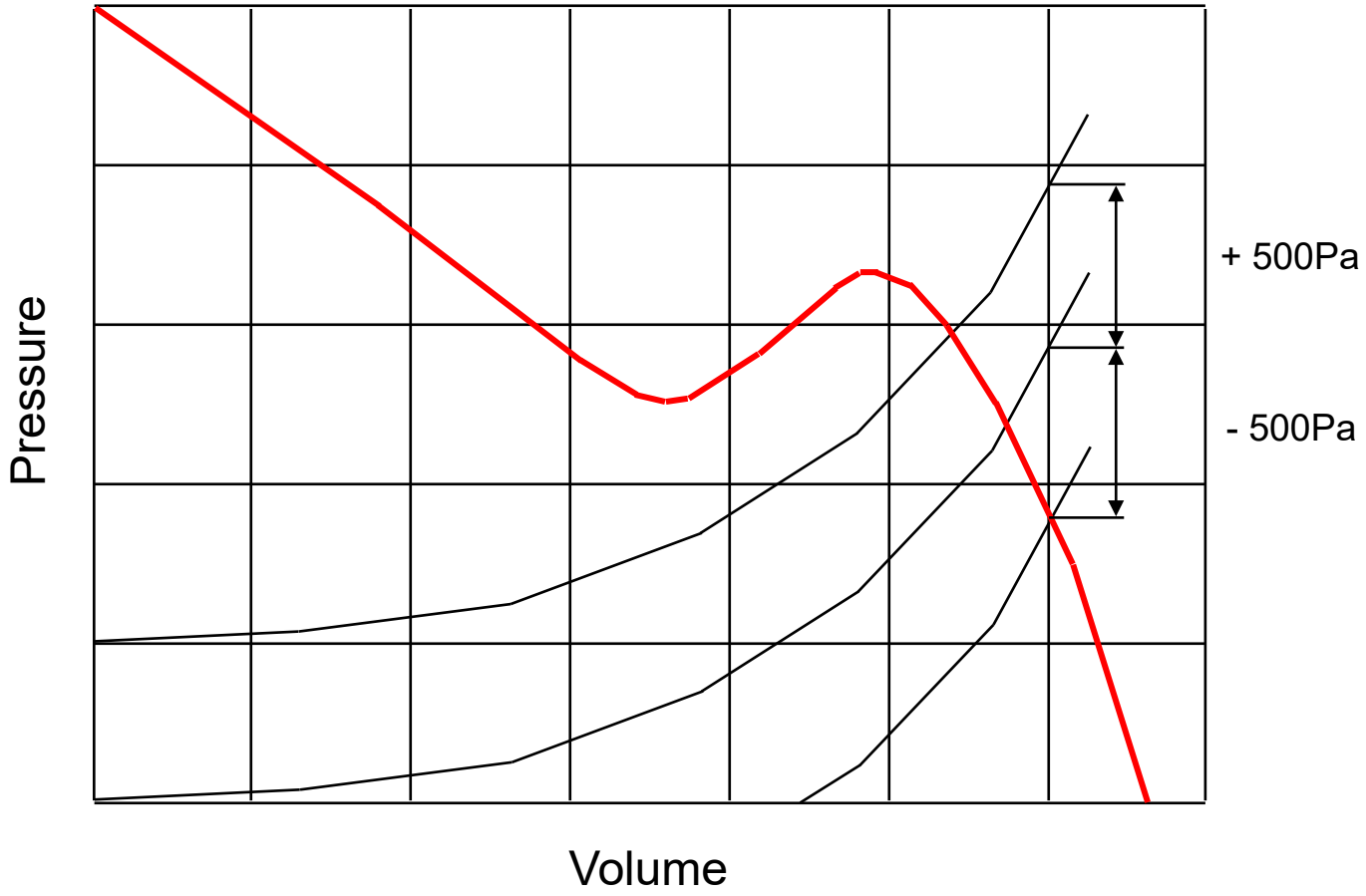
Standard Fan with Pressure Pulse and low Tip Pitch



- Choose a fan with a non-stalling pitch angle
- Normally lower than 16 degree tip pitch angle
- Lower operating efficiency

Tunnel Ventilation

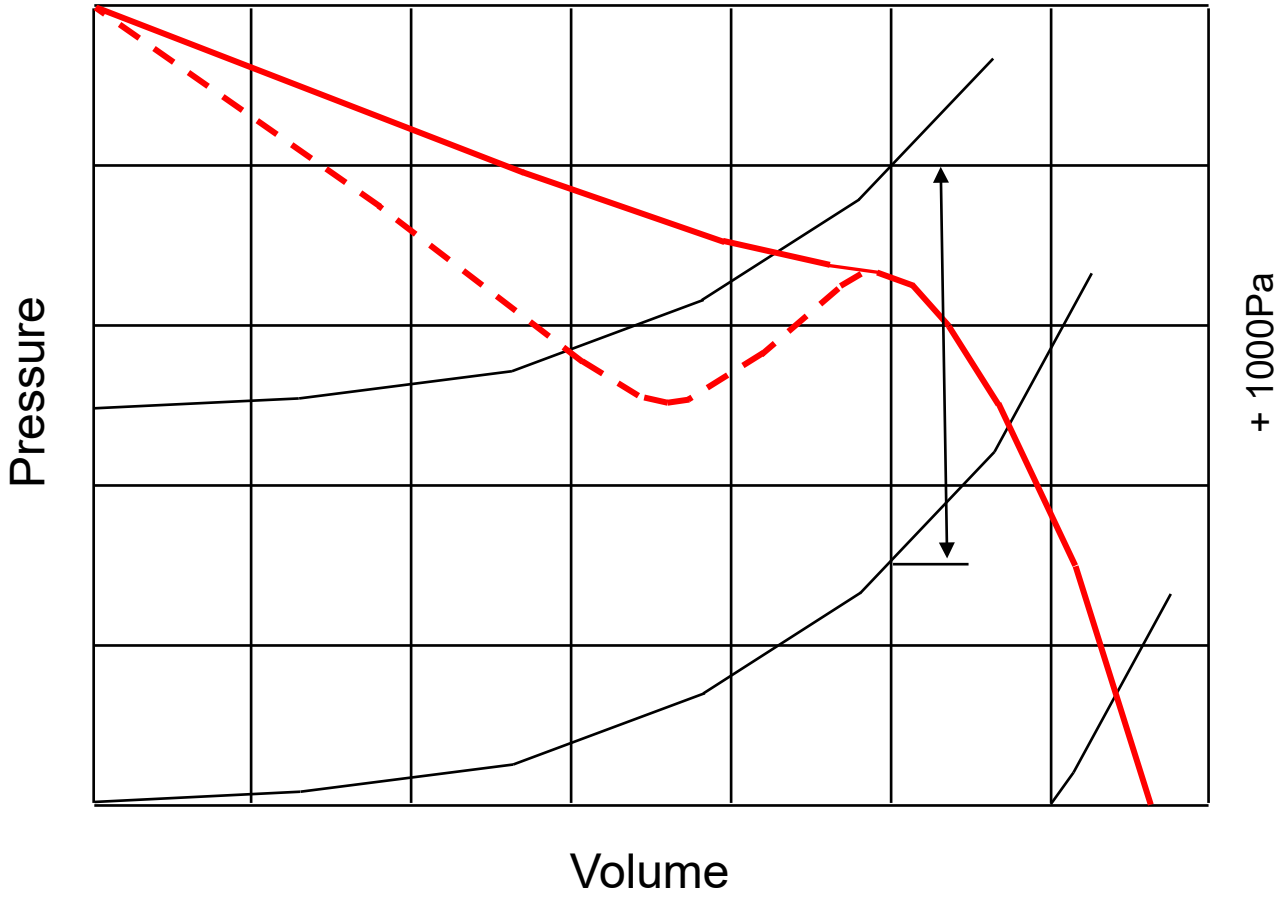
Standard Fan with Pressure Pulse

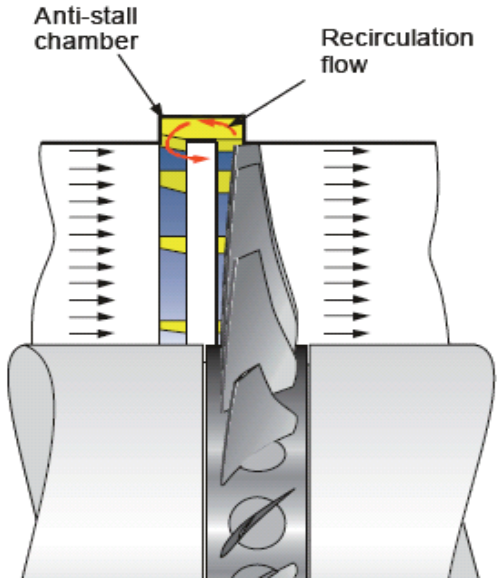


- Ideal situation where the main operating point and both positive and negative points fall within the stable performance curve.
- Will be the most efficient solution – although normally a smaller, lower cost option can be offered for the main operating point…..
- …….rarely are we so lucky…..

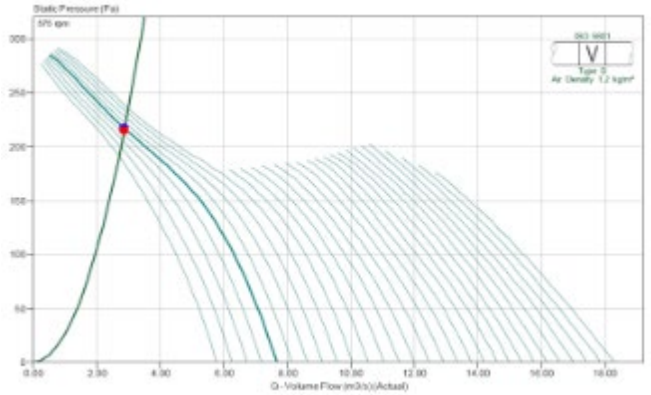
Tunnel Ventilation

Anti-Stall Fan with Pressure Pulse



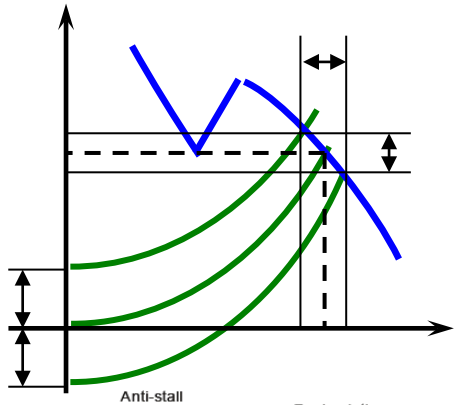


- An Anti-Stall device will divert turbulent air streams and return them to the direction of the main air flow.
- An Anti-Stall Fan will ensure stable operation under all operating conditions
- **Less effective for reversible options** – reduces fan efficiency too much

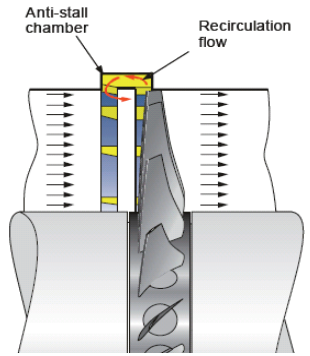


Options for managing Pressure Pulse impact:

1. Choose a fan with a non-stalling pitch angle
    - Normally lower than 16 degree tip pitch angle



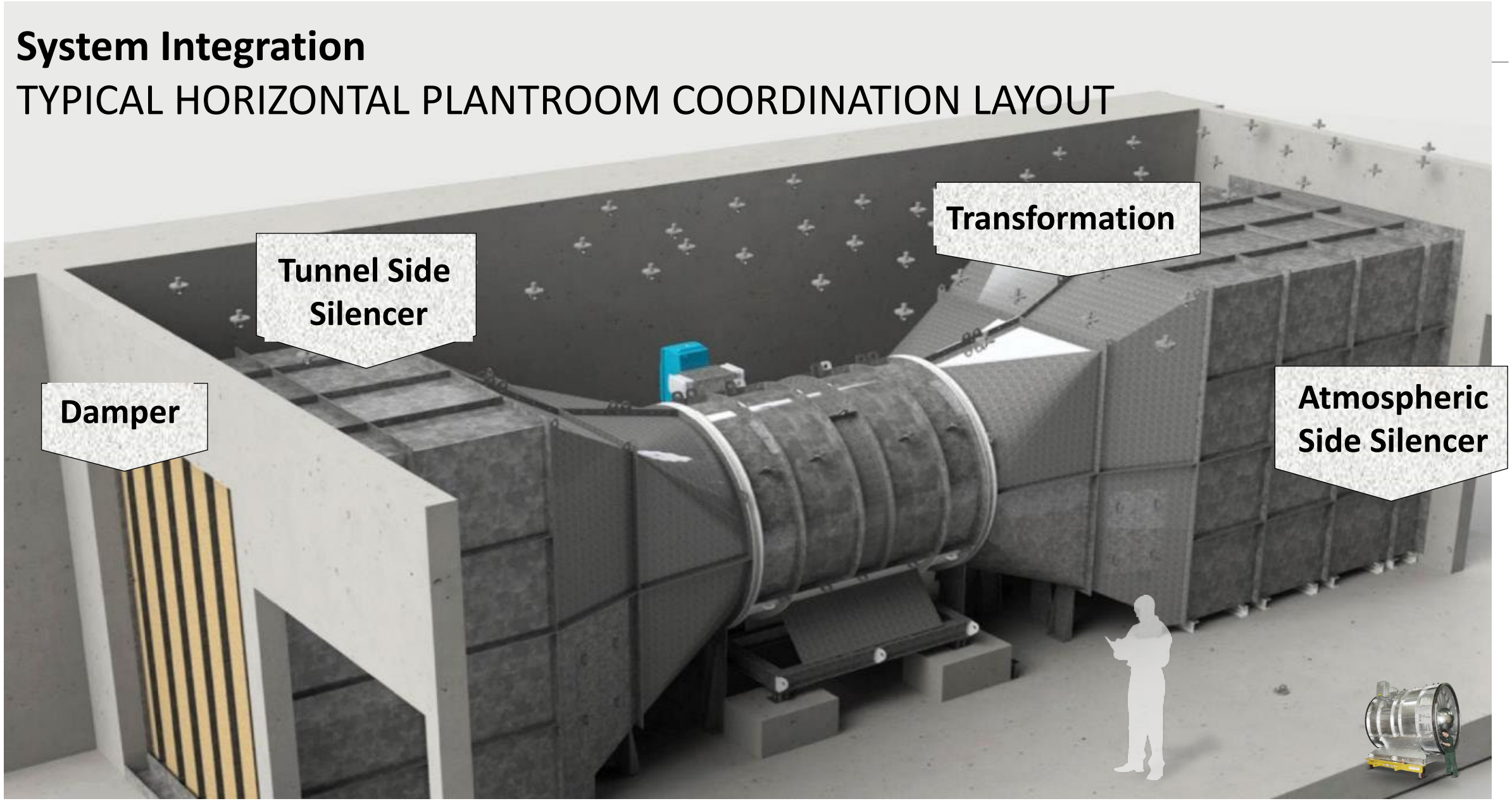
2. Choose a fan with enough reserve pressure to accommodate pulse
    - May be low efficiency normal operating point



3. Use a fan fitted with an anti-stall device
    - Lowers efficiency – particularly for truly reversible fans

System Integration

TYPICAL HORIZONTAL PLANTROOM COORDINATION LAYOUT

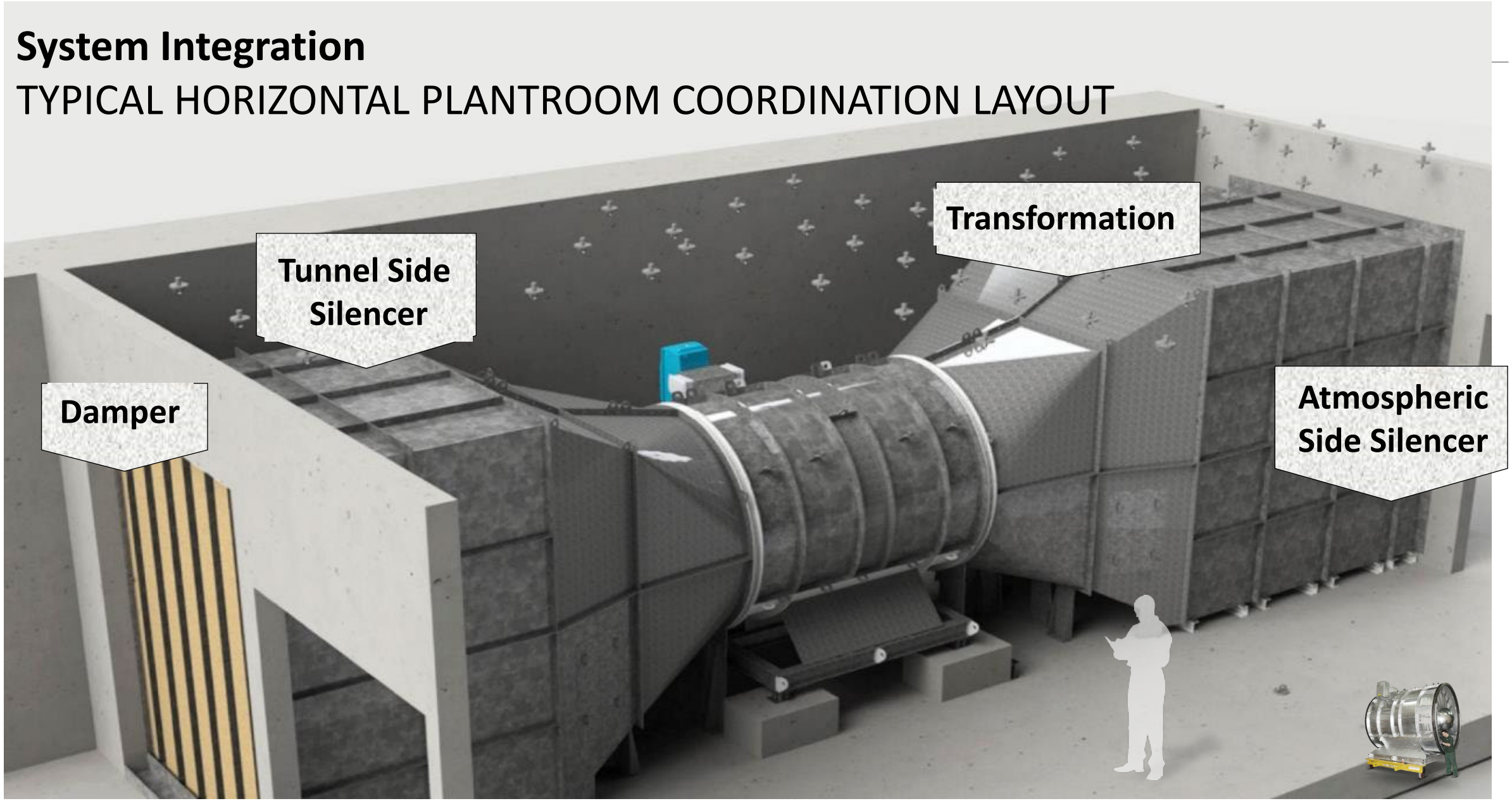


System Integration

TYPICAL HORIZONTAL [illegible] YOUT

System Integration

TYPICAL HORIZONTAL PLANTROOM COORDINATION LAYOUT



TRANSITION DUCT PIECES

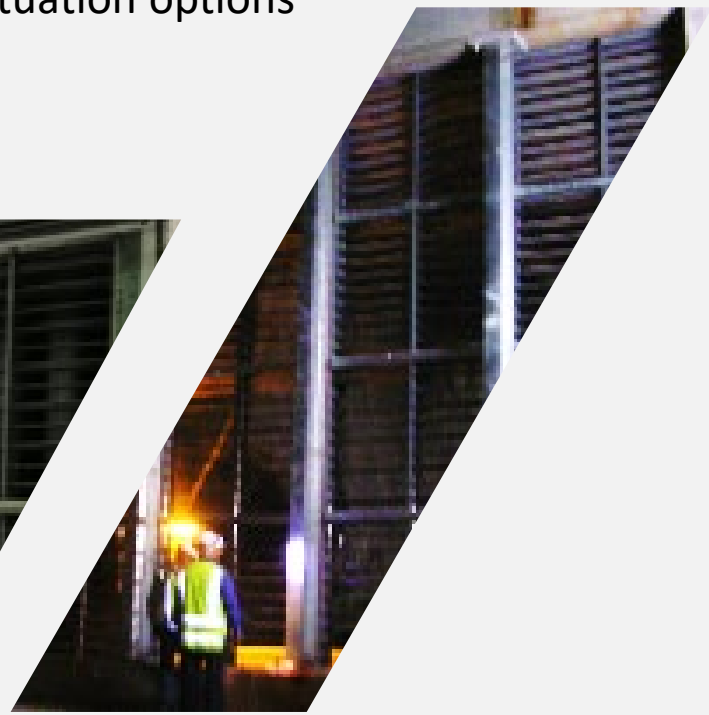
- Hot Dip Galvanized and Painted Finish for C5 environment protection
- Pre-Assembly prior to shipment

SPLITTER SILENCERS

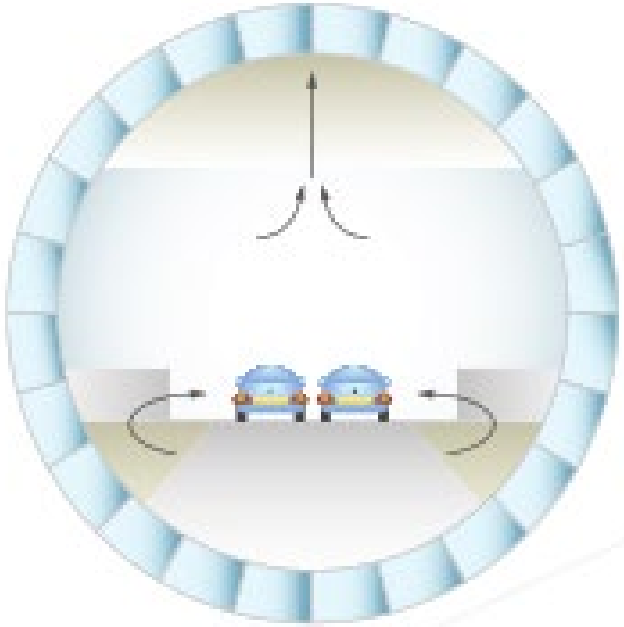
- Suitable for High Temperature operation up to over 400°C for 2 hours
- Modular design to improve installation
- Bespoke selections for each site/installation requirement
- Material options – Pre-Galvanised, Painted or Stainless Steel 304 or 316L

TUNNEL DAMPERS

- Fire Rated
- Operational for 2 hours up to 400°C.
- Suitable for up to 6 kPa pressure
- Low leakage/high-speed actuation options
- Low pressure drop



ROAD TUNNELS

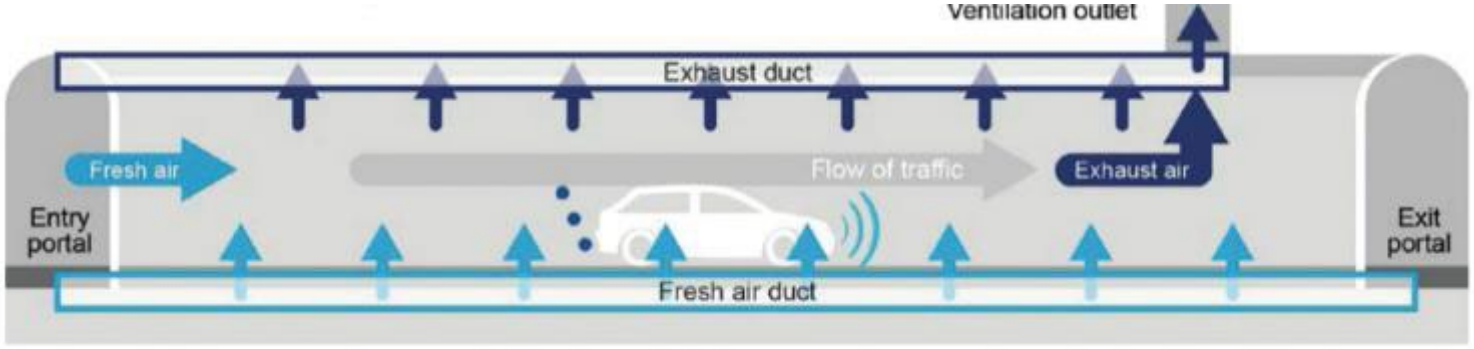


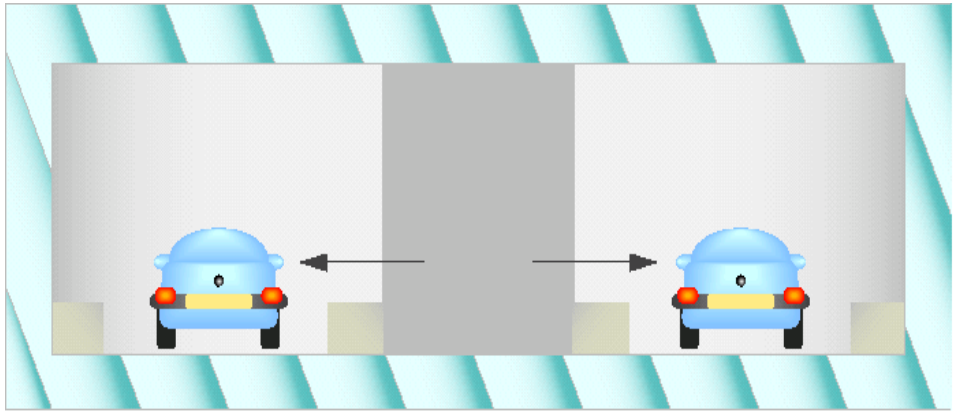
Fully Transverse Systems

- Technically most exact – Uniform supply and pollution exhaust
- Fully Transverse not affected by variations in wind pressure or vehicle piston effect
- The hot polluted air rises and is extracted at a high level normally through a ducted system above the roadway.
- The system requires extensive ducting
- **Used for bi-directional traffic flow**
- High civil and construction costs
- Dampers along length of tunnel to facilitate smoke clearance
- Maintenance normal operating hours without impacting tunnel operation

Fan Types Employed

- Smoke Extract High Temperature Axial Fans
- Inlet Axial Fans
- Unidirectional



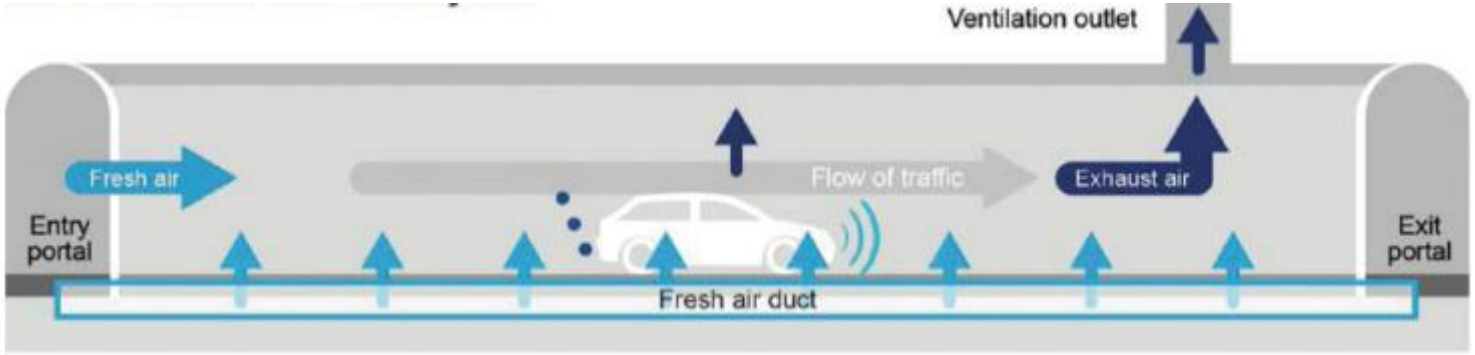


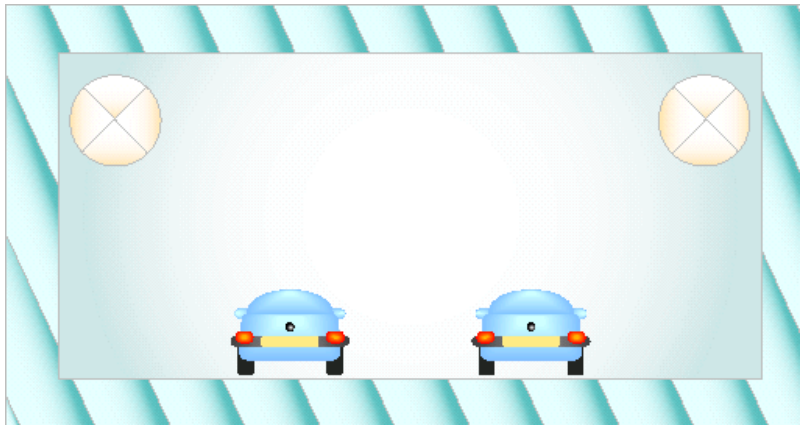
Semi Transverse Systems

- Semi Transverse systems rely on longitudinal air movement along the tunnel
- Semi Transverse utilises the variation in wind pressure and vehicle piston effect
- System requires ducting
- High Civil and Construction costs
- Uni-directional fans, operational sequencing with VSD
- Maintenance normal operating hours without impacting tunnel operation

Fan Types Employed

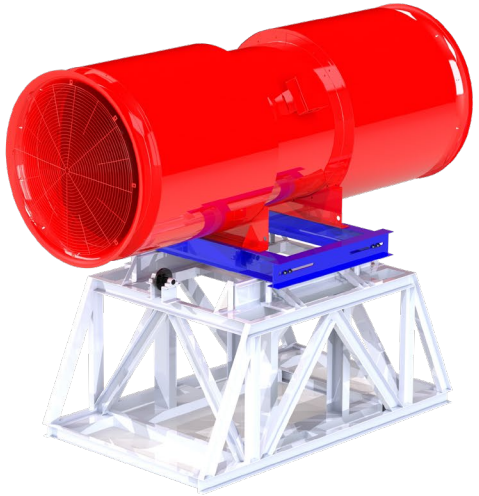
- Smoke Extract High Temperature Axial Fans
- Inlet Axial Fans
- Unidirectional



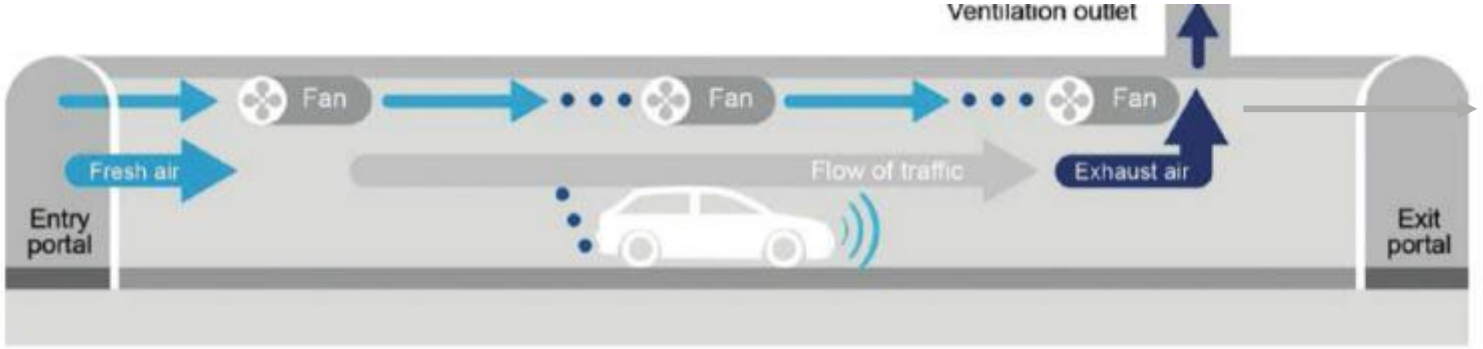


Longitudinal Systems

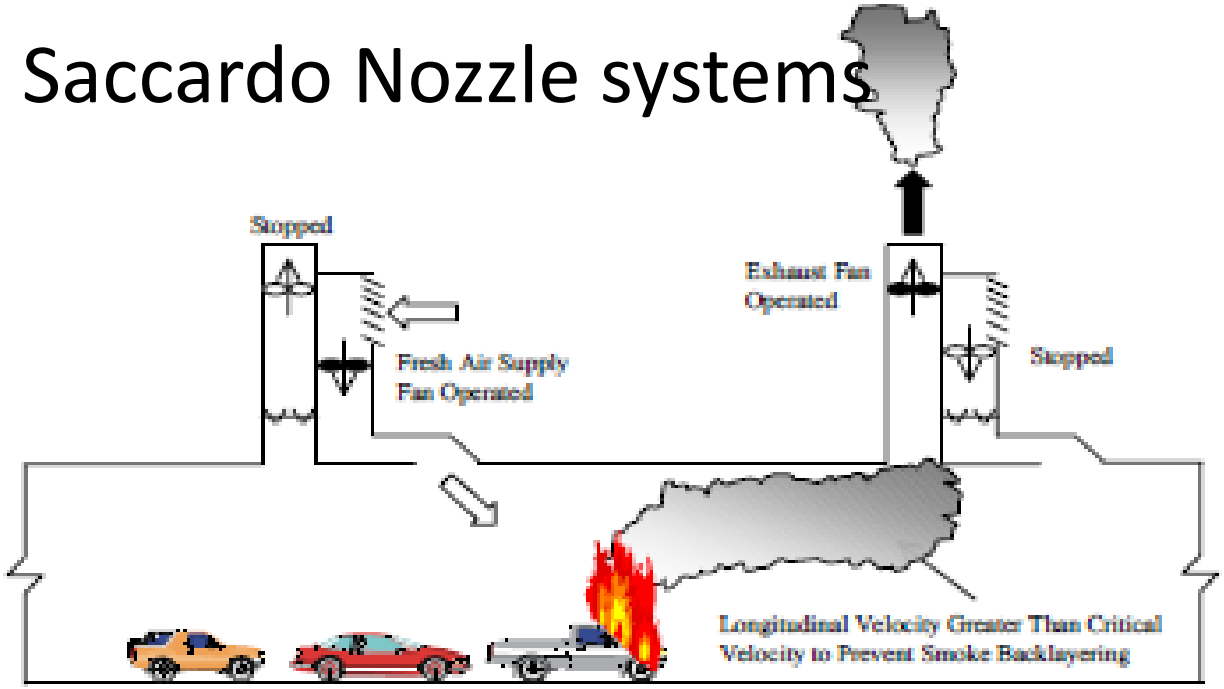
- Induce flow by high velocity Jet
- Jet Fans at high level
- Most economical solution
- Ease of installation and operation
- Operational sequencing of fans reduces need for VSD
- No dampers required
- Maintenance – requires temporary disruption of tunnel use
- Fans directly above fire location, **fully immersed**

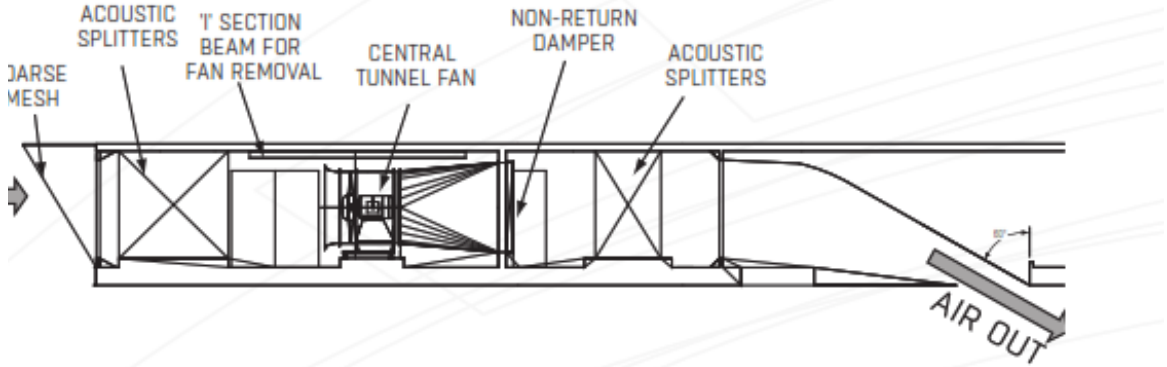


High Temperature
Reversible Jet Fans



Saccardo Nozzle systems





Considerations

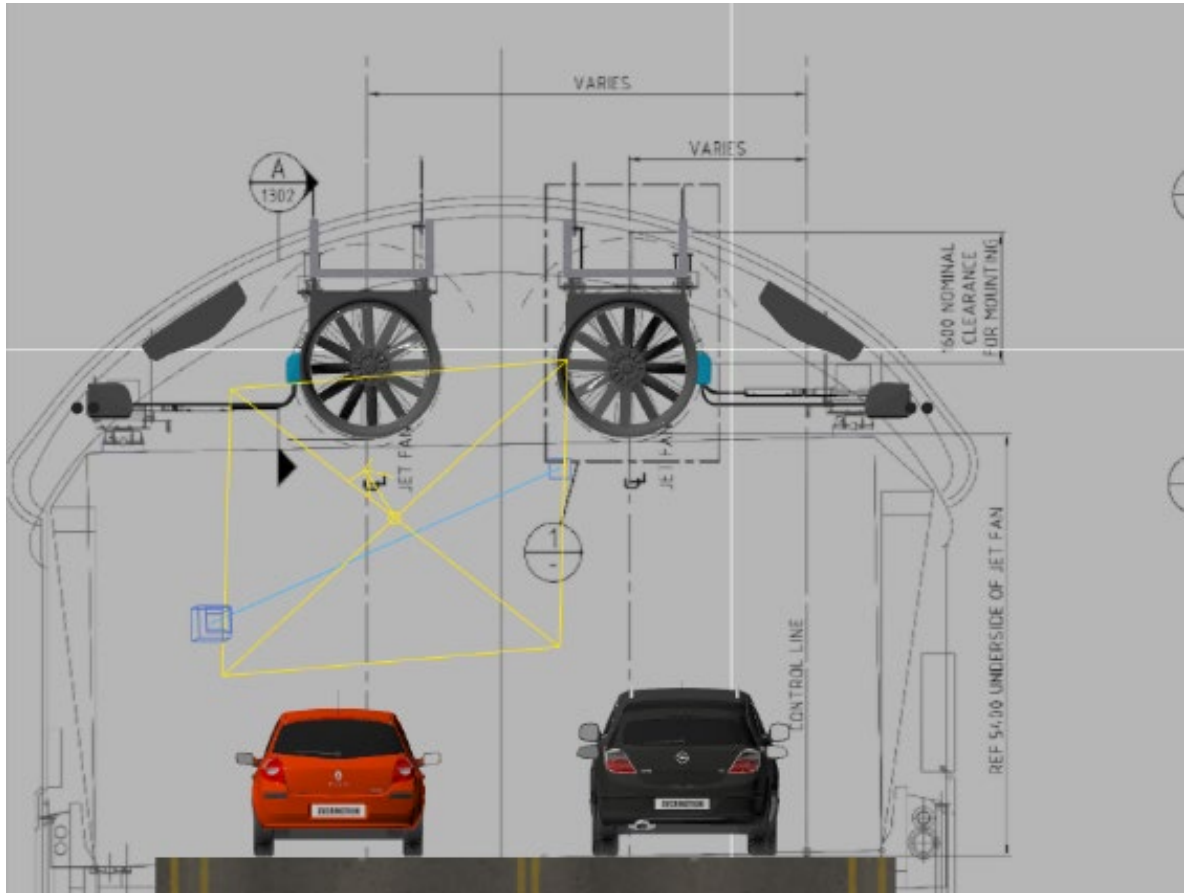
- Reduced tunnel height
- Maintenance normal operating hours without impacting tunnel operation
- Noise level in tunnel is decreased
- Lower number of fans reduced cabling and controls

- Reduced running cost
- Low running costs uses traffic piston effect
- Fans portal mounted - land issues
- Cost of ducting

Tunnel Ventilation

Fan Selection - Longitudinal

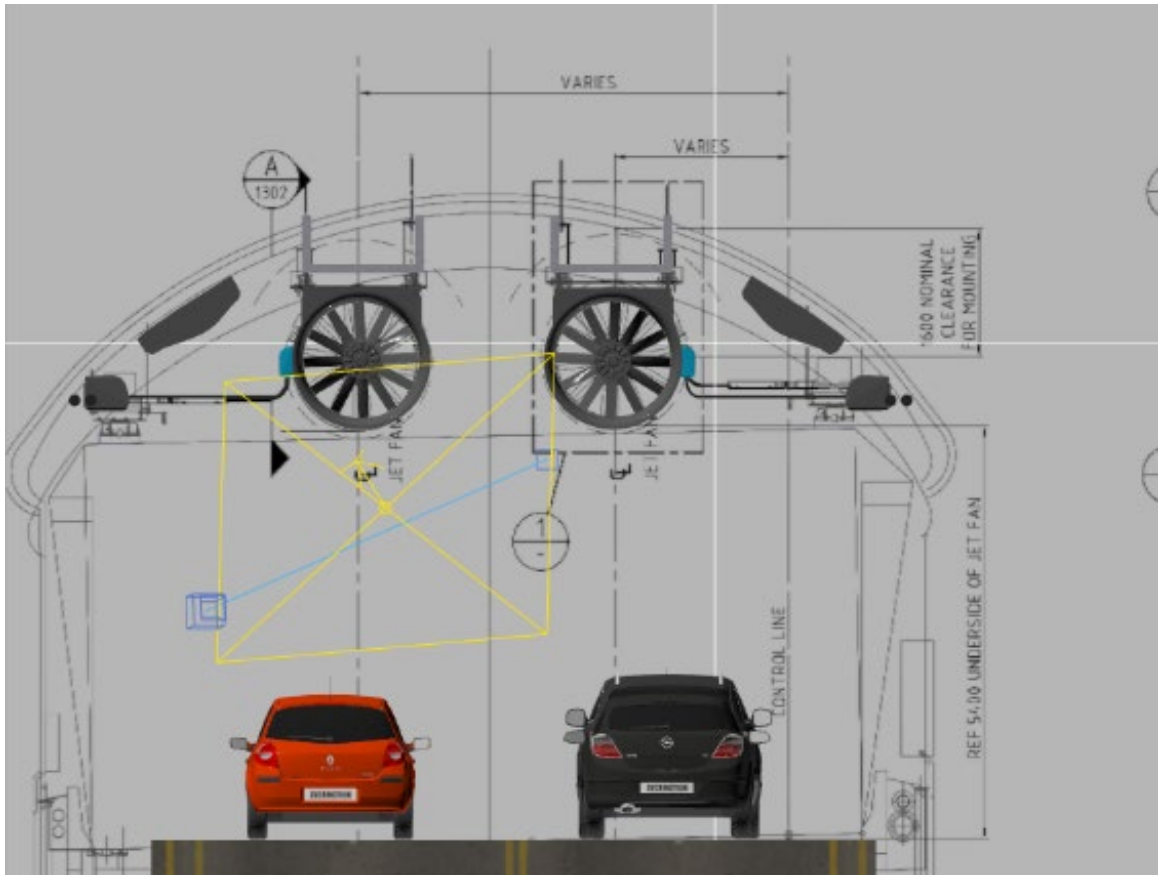
- Ventilation rate to dilute pollutants or for fire size.
- Extra for recirculation at inlet or if semi-polluted at inlet
- Special system resistance calculations.
- Usually multiple installations of fans along tunnel.
- Fans normally high temperature – 250 up to 400^{o}C for 2 hour.
- Silencing to 85dBA (NR80) in tunnel (communication).
- Environmental levels near discharge and portal.
- Low speed could be used for night.



Tunnel Ventilation

Fan Selection - Longitudinal

- Multiple levels of ventilation.
- Fan control by CO, NoX, visibility, smoke monitor, manual or automatic.
- Fans assisted by vehicles, helped or hindered by wind.
- Unidirectional if wind unimportant.
- Reversible if exposed.
- Exhaust from fan with traffic until prevailing higher wind, then against.



PERFORMANCE PARAMETERS – TVF – METRO/RAIL

Large axial fans (1600 mm – 3150 mm diameter)

1. Pressure Pulse
2. Unidirectional versus Truly Reversible
3. Speed Control

High temperature requirements – impact on performance (200°C, 300°C or 400°C for up to 2 hours).

Test requirements – and Efficiency Compliance (ErP versus FEI).

PERFORMANCE PARAMETERS – TBF (JET FANS) – ROAD

Jet fans (500 mm to 1600mm diameter)

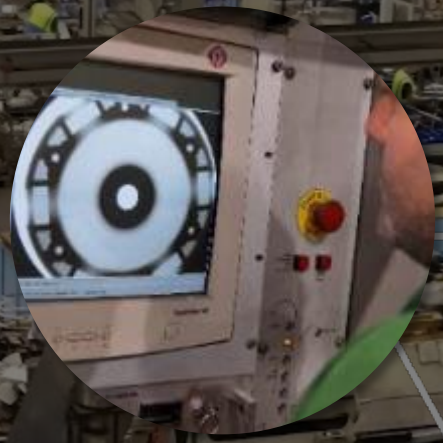
1. Unidirectional versus Truly Reversible

Test requirements – and Efficiency Compliance (ISO). Tunnel simulation tests. High temperature requirements – impact on performance (200°C, 300°C or 400°C for up to 2 hours).

ROUTINE QUALITY TESTING

100% X-Ray
ALL aluminium moving parts
Archived for specific projects

Balance ISO1940
Vibration BS848 pt 7
ISO14694

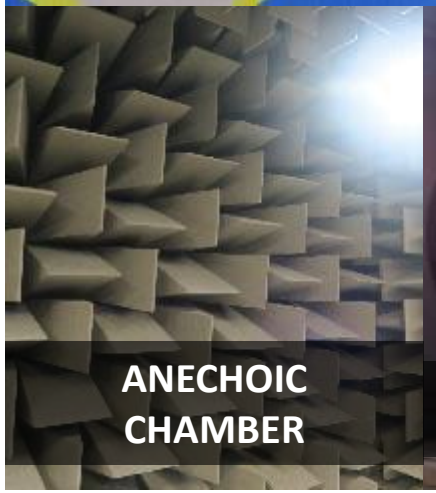


X-Ray ASTM E155

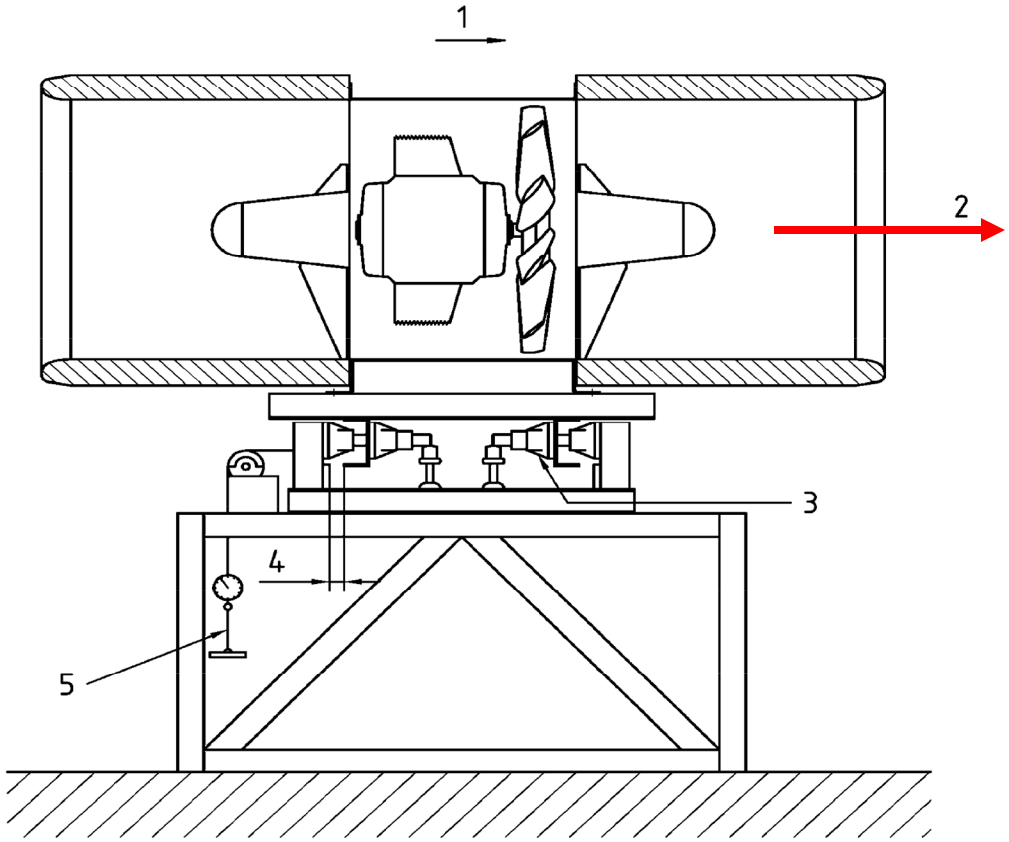
Impeller Strain Gauge Test
Over speed 125% for 15 mins

Insist on Certified Laboratory standards and conditions for FAT requirements – typically:

- ISO, AMCA, EN, BS, IEC
- Specific Aerodynamic Testing:
  - ISO 5801:2017 Code D (Ducted)
  - ISO 13348 Tolerances AN2/3
- Acoustic Testing
- Semi Reverberant Area ISO 5136
- Vibration Testing: G6.3 and better
- Thrust and Acoustic Testing to ISO 13350



ISO13350:2015 (AMCA 250) – Thrust Measurement Procedure



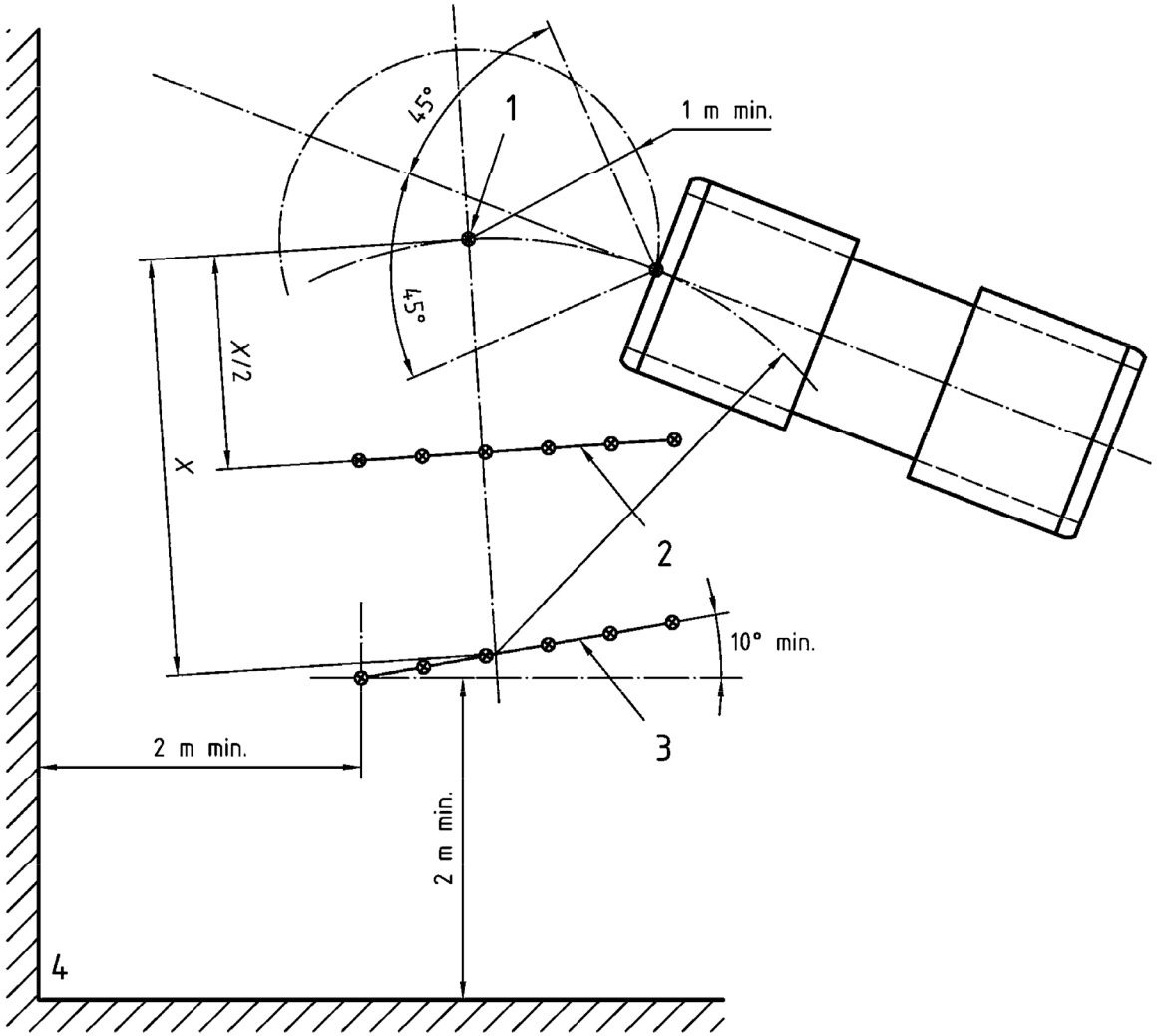
Key

1 direction of fan movement
2 air flow
3 bearings
4 fan movement possible
5 thrust gauge (measurement in kg direct off gauge + mass of gauge in suspension = thrust)

The fan should be accurately levelled prior to testing.

1. Only method to measure **actual** thrust in direction of fan axis.
2. Fans with deflectors (or slanted inlet/outlet) should still declare actual thrust in-line with fan axis.
3. Tunnel designers use whatever installation effect appropriate to each tunnel – based on many criteria:
    1. Distance to tunnel surface (roof, wall or both)
    2. Obstructions in tunnel (signage etc.)

ISO13350:2015 (AMCA 250) – Noise Measurement Procedure



1. Based on ISO 13347 – substitution method in a qualified environment
2. Requires a large test space (or free-field).
3. Sound Power level of inlet and outlet measured (and combined if necessary).
4. Sound Power inclusive of attenuation of silencers or accessories (guards; deflectors etc.).

Topics covered in this session

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- Why ventilate
- What determines the ventilation rate - Metro & Rail
- Pressure pulse, blade stress
- Mitigation
- Equipment and plantroom layout
- Road Tunnel ventilation methods
- What determines the ventilation rate – Roads
- Product range
- Routine tests and FAT’s

THANK YOU

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