



FLÄKT WOODS – AIR MOVEMENT

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# TUNNELS & METRO

## TUNNEL VENTILATION

## DESIGN SOLUTIONS

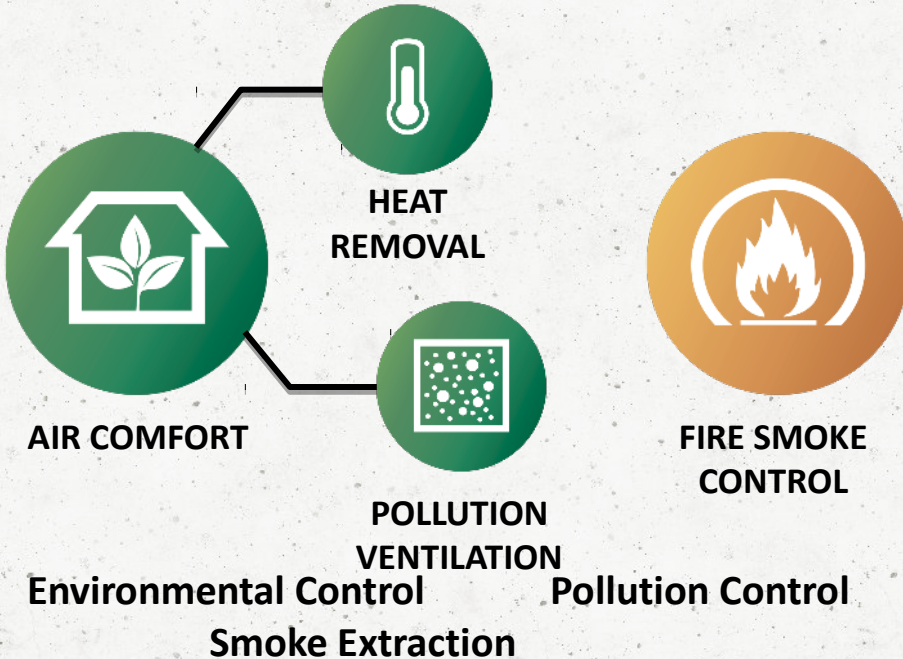
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Benjamin Fair



# THE CHALLENGE

- SAFEGUARD PEOPLE IN TUNNELS
- VENTILATE TUNNELS & PLANT ROOMS



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

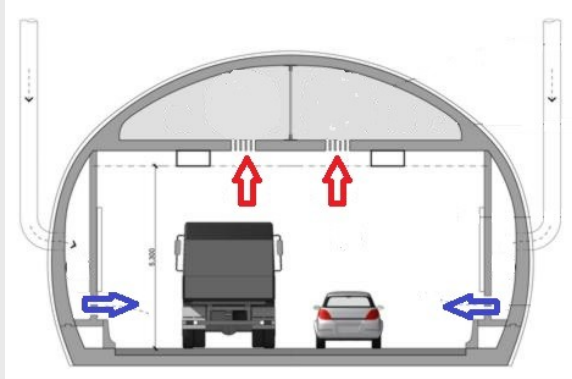


# THE SYSTEMS

- **TRANSVERSE**
- **LONGITUDINAL**

The design of tunnel ventilation systems, broadly, falls into two categories, transverse and longitudinal.

- Large fans are classically used in transverse designs.
- Longitudinal designs classically use a larger number of jet fans suspended from the tunnel ceiling.
- Guide lines for the system sizing and specification characteristics of tunnel ventilation systems was provided by Moret (1999):



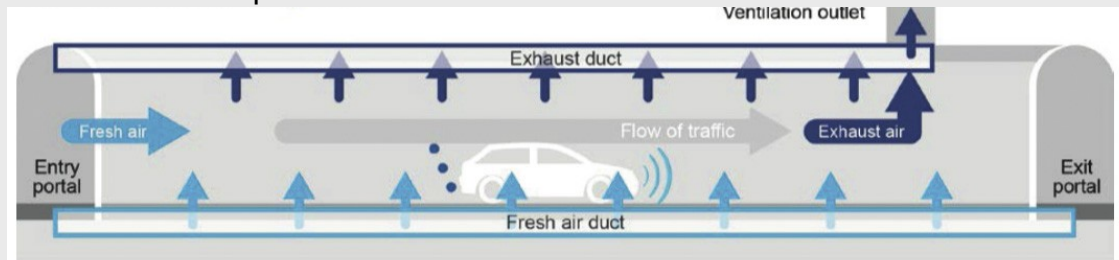
## Fully Transverse Systems

- 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

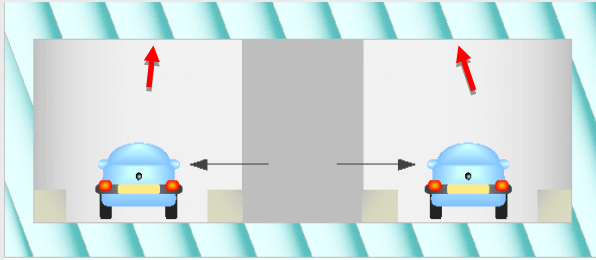
- Smoke Extract High Temperature Axial Fans
- Inlet Axial Fans
- Uni directional





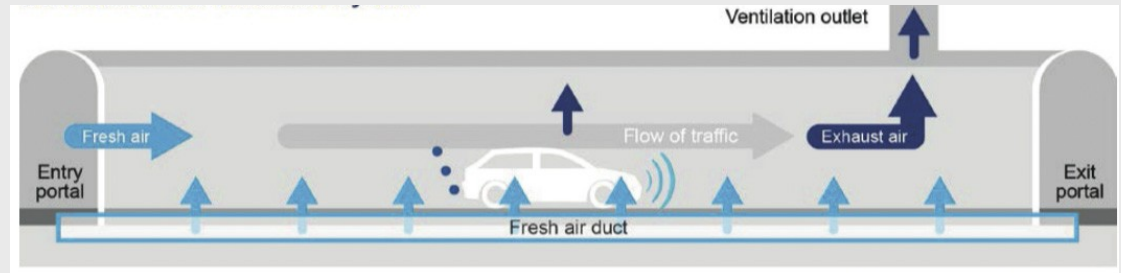
## Semi Transverse Systems

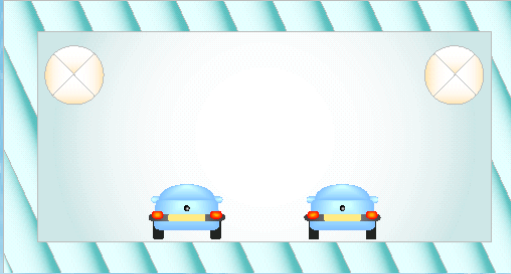
- Semi Transverse systems Rely on longitudinal air movement along the tunnel
- Semi Transverse utilises the variation in wind pressure and vehicle piston effect
- System requires ducting
- High Civil and Construction costs
- Reversible fans, operational sequencing with VSD.
- Maintenance normal operating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



### Fan Types Employed

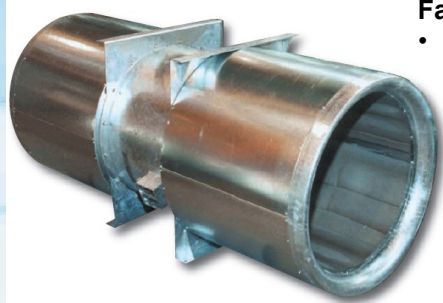
- Smoke Extract
- High Temperature
- Reversible JET Fans
- Inlet Axial Fans





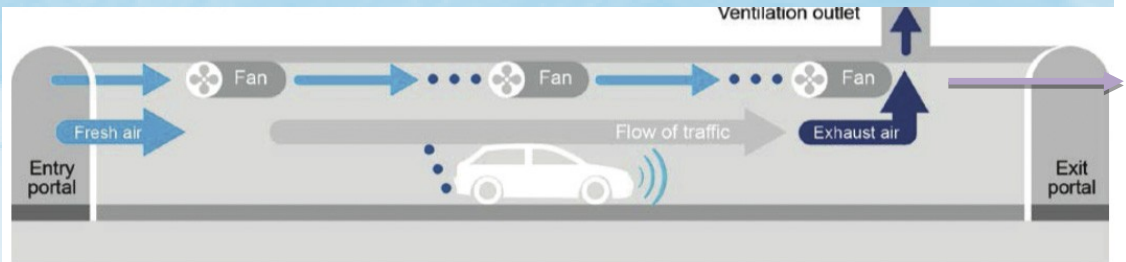
## Longitudinal Systems

- 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.



### Fan Types Employed

- Smoke Extract
- High Temperature
- Reversible JET
- Fans

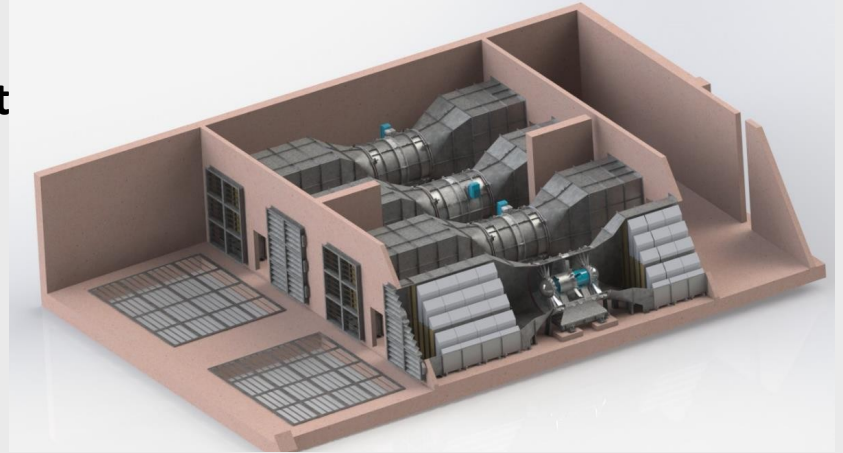


# PRODUCT SELECTION CONSIDERATIONS



## TUNNEL VENTILATION DESIGNERS PRODUCT SELECTION CONSIDERATIONS

1. Acoustic Assessment
2. System Resistance
3. Selection
4. Iterate



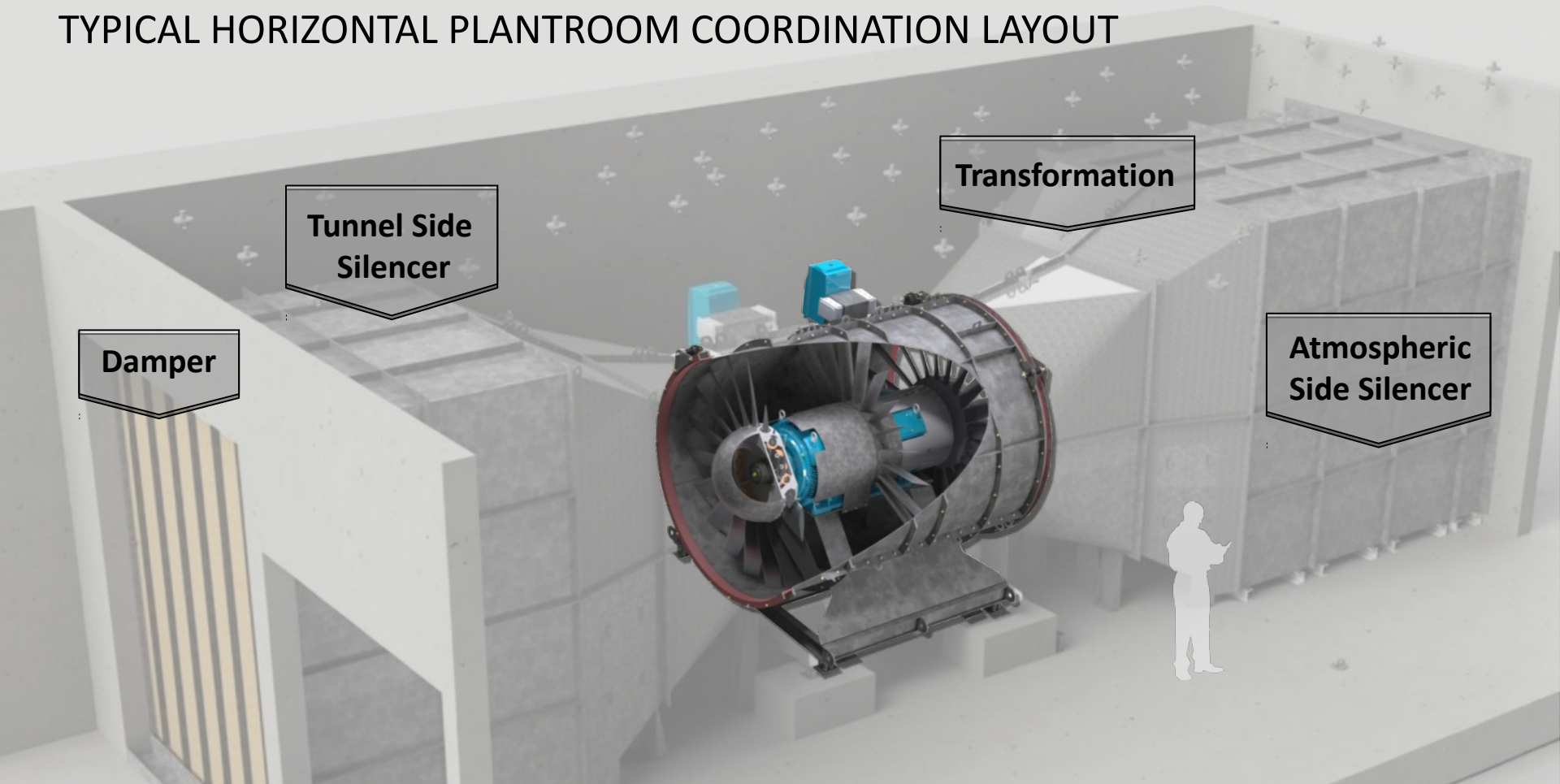
**Tunnel Design – Airflow flow / Acoustic Requirements – Tunnel resistance – Initial Fan selection - Attenuator selection - Reselection.**

- Optimise layout design for Energy Efficiency, Velocity Pressure effect & Acoustic Performance.



# SYSTEM INTEGRATION

## TYPICAL HORIZONTAL PLANTROOM COORDINATION LAYOUT



**Damper**

**Tunnel Side  
Silencer**

**Transformation**

**Atmospheric  
Side Silencer**



# PRODUCT SELECTION

**AXIAL FANS  
FANS**

**JET**

# AEROFOIL AXIAL FANS

## PRODUCT FEATURES:

- Emergency Operation up to 400°C for 2 Hours
- Ambient conditions >50°C
- 315mm to 2800 mm Diameter
- Uni-Directional and Truly Reversible
- Horizontal and vertical Installations
- Certified to EN 12101-3 & ISO 21927-3

## Ancillary options:

- Integral Anti-Stall solution
- Fan Condition Monitoring Panel
- Motor Condition Monitoring Equipment
- Variable Speed Drive option
- Vibration/Shock Pulse monitoring
- Vertical and Horizontal Installations
- Anti-Vibration Mounts
- Flexible Connectors
- Inlet Cone/Bellmouth



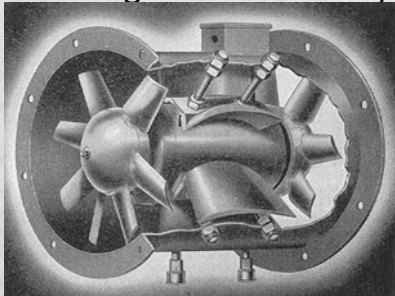


# (TRULY REVERSIBLE AXIAL FLOW FAN SOLUTION)

## TWIN IMPELLER FANS

### Key Benefits:

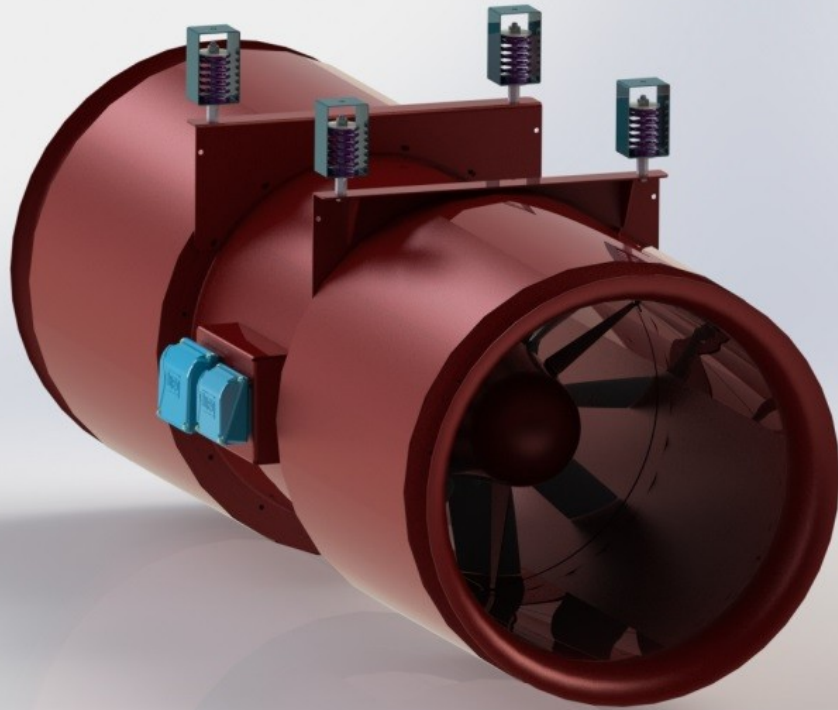
- Compact design
- 1.8 times Pressure generation
- Reduced Cabling requirements
- Single Control Panel/Drive required



Twin Impeller fans have been Used since 1950's for light industry and mining applications (left).







## TUNNELS & METROS JET FANS

- Horizontal Installations
- Emergency Operation up to 400°C for 2 Hours
- Diameter 400mm – 1600 mm
- Uni-directional & Truly reversible
- Silencers
- Certified to EN 12101-3 & ISO 21927-3

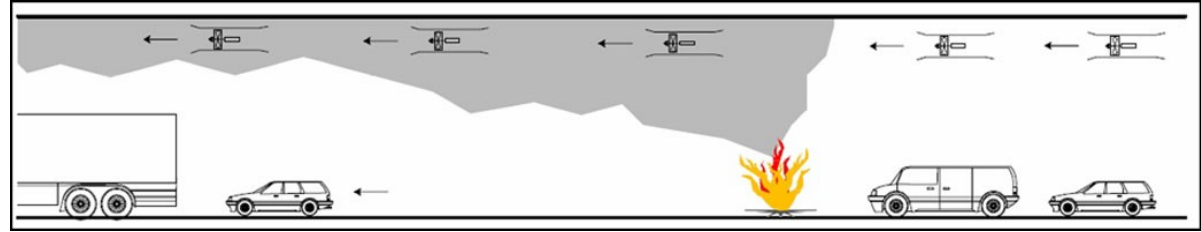
### Ancillary options

- Deflectors
- Integral bellmouth inlets
- Guards optional-performance effect.
- Vibration isolation hangers and mounts

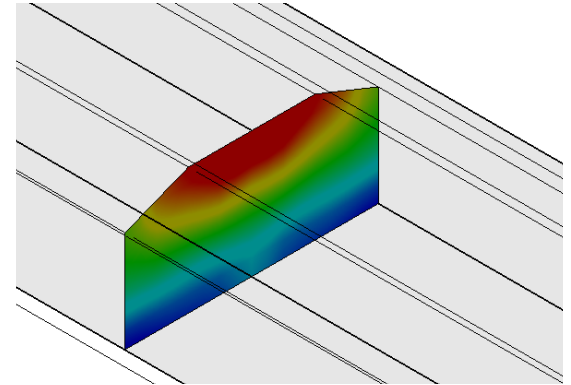


# PRODUCT DESIGN TOOLS

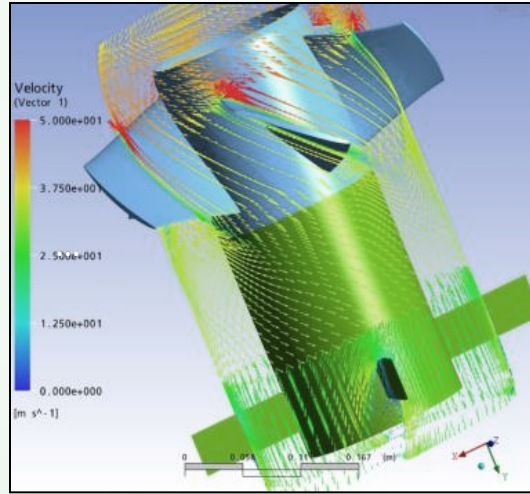
## CFD Ventilation Simulation during design



- Verification of calculations
- Validates Fan size, thrust requirements  
Fan spacing.
- Complex geometry
- Non ideal installation position modelling
- Ability to assess multiple fire scenarios
- Aids client and civil defence approval



## COMPUTATIONAL FLUID DYNAMICS (CFD)

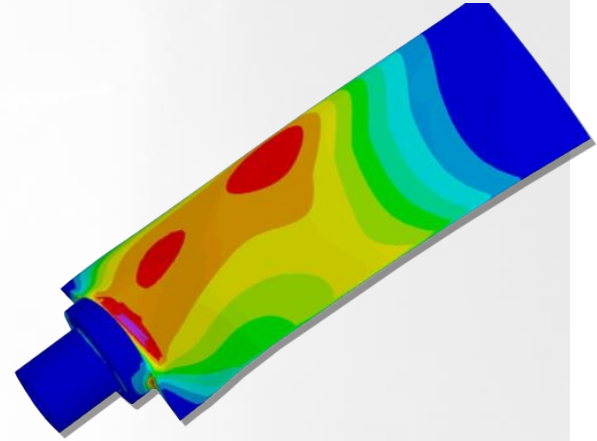


- Ansys CFX
- Carrying out 'Turbo Machinery Parts' analysis on Blades, Hubs and Guide Vanes, as well as analysing ducts and systems using Steady and Unsteady State Analysis
- Research and development on Tip vertices, Boundary layer growth, Stall inception



## FINITE ELEMENT ANALYSIS (FEA)

- Ansys Mechanical and SolidWorks Simulation
- Analysing Static/ Dynamic, Linear/ Non-Linear, Modal, and Fatigue ensuring structural integrity of parts and assemblies
- Fluid Structure Interaction (FSI) analysis, allowing the resultant CFD forces and deformation to be transferred into the FEA analysis, and visa-versa, structural deformations transferred into the CFD analysis



# HIGH TEMPERATURE TEST

High Temperature Range of Fans are independently certified by BSRIA/BSI to allow EN12101-3 / ISO 21927-3 certification of Large Axial Fans.

Certification Body: **bsi.**

Independent Test Bodies: **BSRIA** **TST TUNNEL SAFETY TESTING S.A.**

## Local market certification:

 HONG KONG FIRE SERVICES	 UNITED ARAB EMIRATES CIVIL DEFENSE	 QATAR CIVIL DEFENSE	 SINGAPORE CIVIL DEFENSE
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# TUNNEL & METRO PRODUCT DESIGN SOLUTIONS





## BLADE DESIGNS

Designed for maximum performance and efficiency with truly symmetrical reversible blade sections for the same performance in both the forwards and reverse direction.

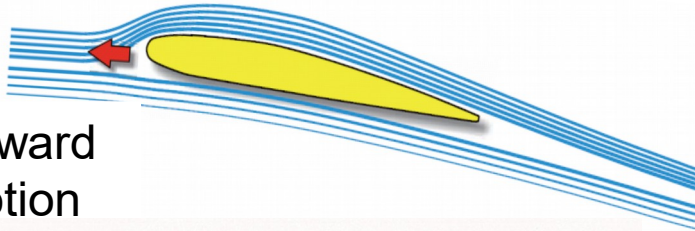
Uni-directional Fans are designed for optimised performance in single direction with blade profiles matched to guide vane technology improving overall fan efficiency and reduced running costs.



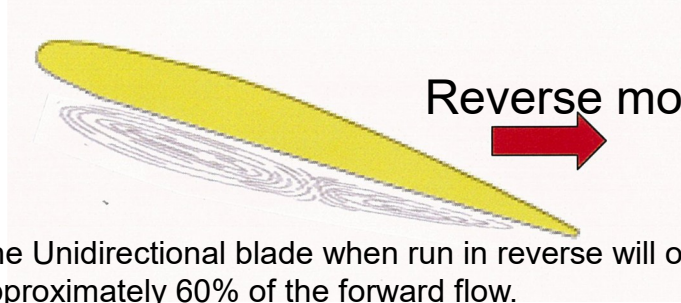
## Uni-Directional

# BLADE DESIGNS

Forward motion



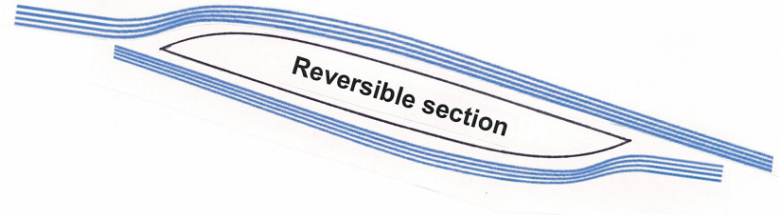
Reverse motion



The Unidirectional blade when run in reverse will offer approximately 60% of the forward flow. Reverse operation **must** be limited to emergency use only. The additional air turbulences created increase vibration levels in the blade which leads to reduced performances and will lead to premature structural failure

## Reversible

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.



A truly symmetrical blade avoids any turbulence, will have a smoother flow, and **no risk** of blade failure

A close-up photograph of a large, industrial metal wheel, likely a flywheel or a component of a machine. The wheel features a central hub and numerous radial spokes. The metal surface is dark and shows signs of wear and use. A green rectangular overlay is positioned on the right side of the image, containing white text.

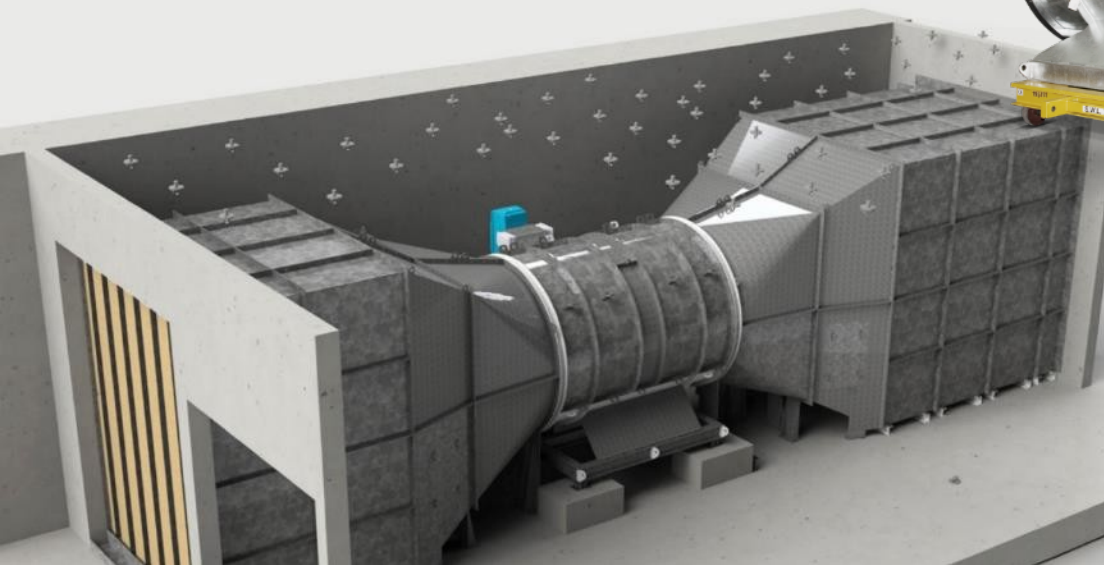
# CASE STUDY PROJECTS

TUNNELS & METRO CASE STUDIES

# TUNNEL PROJECT IN MARMARY, TURKEY

RAIL TUNNEL – opened in 2013, Istanbul Turkey, Prestigious Project connecting the continent Europe to Asia.

3 underground stations, connected by a 1.4km long earthquake proofed immersed tube 60m below sea level, the deepest undersea immersed tube tunnel in the world.



## KEY PRODUCTS

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Double Impeller  
Axial Fan

## PROJECT DETAILS

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*PROJECT:* Railway tunnel stretching 8.5 miles across Istanbul and under the Bosphorus Strait.

*LOCATION:* Istanbul, Turkey

*NEED:* tunnel ventilation systems which could provide adequate ventilation for train fire scenarios under the Bosphorus Sea, as well as withstand major earthquakes.

*SOLUTION:* 30 double impeller fans with diameters 2.5/2.8m, as well as 18 single impeller units with diameters over

# DELHI METRO, INDIA



## Phase 1 (2000)

Turnkey contract for Tunnel Ventilation System

Trackway exhaust fans reversible type were supplied, installed & commissioned for air conditioning of 7 U/G stations.

## Phase 2 (2011)

2m Reversible Axial

Fans Smoke Extract

1.6m Axial Fans Supply Fans

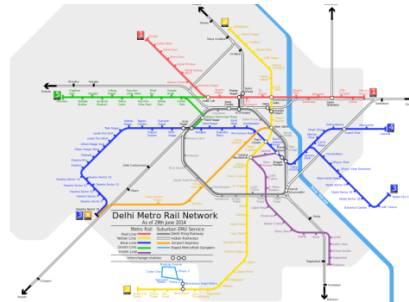
1.12m Tunnel Booster Fans Jet Fans

## Phase 3 (2016)

2m Reversible Axial

Fans Smoke Extract

1.12m Tunnel Booster Fans Jet Fans



दिल्ली मेट्रो रेल कॉर्पोरेशन लिमिटेड  
DELHI METRO RAIL CORPORATION LTD.  
(भारत सरकार एवं दिल्ली सरकार का संयुक्त उपक्रम)  
(A JOINT VENTURE OF GOVT. OF INDIA AND GOVT. OF NCT DELHI)

## PROJECT DETAILS

**PROJECT:** 8.1 miles of Underground system across Delhi connecting with 40 miles and 58 stations

**LOCATION:** Delhi, India

**NEED:** Turnkey tunnel ventilation system to provide adequate air conditioning and ventilation for train fire scenarios

### SOLUTION:

- Products supplied and commissioned in DMRC Ph1 26 No 2.0m dia. reversible Tunnel Ventilation Fans 2 No 1.8m dia. reversible Tunnel Ventilation Fans 42 No 1.25m dia. reversible, track exhaust fans 8 No 1.6m dia. tunnel booster fans (Jet Fans) 2 No 1.12m dia. tunnel booster fans (Jet Fans) 3.5m W x 3.5m H sound attenuators for TVF fans: 56 Qty. Sound Attenuators for TEF and Jet Fans: 136 No Stainless steel nozzles 152 No fire proof

## KEY PRODUCTS



Large Diameter Axial Fan



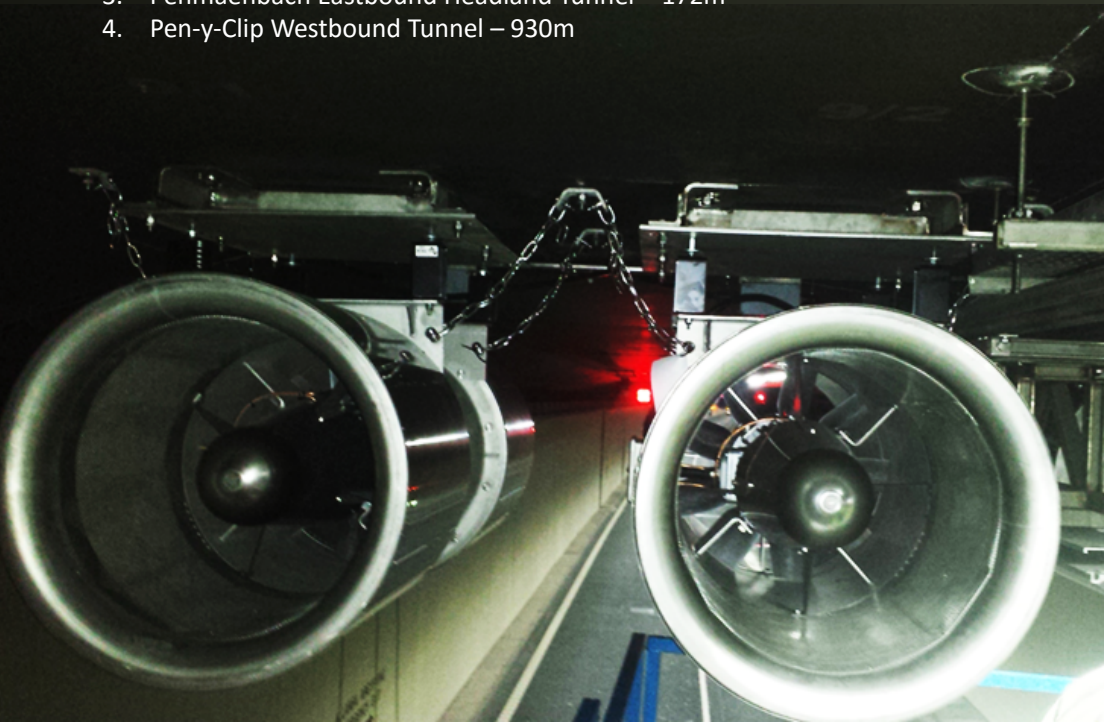
Jet Fans



# A55 TUNNEL CONWY, WALES

Series of 4 Road Tunnels on A55 Road

1. Conwy Tunnel – 1060m
2. Penmaenbach Westbound Tunnel – 658m
3. Penmaenbach Eastbound Headland Tunnel – 172m
4. Pen-y-Clip Westbound Tunnel – 930m



## KEY PRODUCTS

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Stainless Steel Jet Fans  
with 1D Silencers.

400 deg. C for 2 hour  
rated Large  
Axial Reversible Jet Fans  
– Stainless Steel  
Construction

Mounting Frames,  
Safety Chains and  
Spring Hangars.



## PROJECT DETAILS

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*PROJECT:* Series of Road  
Tunnels in North Wales, UK  
comprising total tunnel  
length of 2.820 km.

*LOCATION:* North Wales, UK

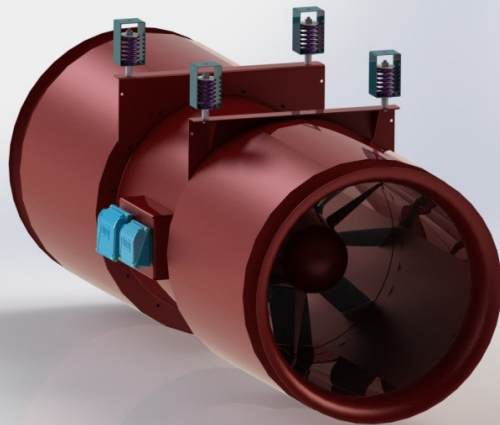
*NEED:* Smoke Extraction High  
Temperature rated and  
pollution control Reversible  
Jet Fans.

*SOLUTION:* 58 x 1.8-1.6m  
diameter Reversible High  
temperature rated fans.  
32 x 1.12m diameter Axial  
Supply Fans

# ELEFSINA-TSAKONA MOTORWAY, GREECE

The project represents a new, highway, with a total length of 365.4 km, through which a more direct and safe connection between Elefsina and Tsakona of Messinia region of Greece.

Comprises 5 Road Tunnels at Platanos, Panagopoula, Marva Litharia, Derveni and Akrata.



## KEY PRODUCTS

1250mm diameter and  
1000mm dia. Jet Fans  
with 1D Silencers.

Large Axial Fans and  
associated Transitions  
and Silencers  
2 x 2.8m Diameter  
Uni-directional Large  
Axial Fans

300 deg. C for 2 and  
400 deg. C for 2 hour  
rated Large  
Axial Reversible Jet Fans

Mounting Frames,  
Safety Chains and  
Spring Hangars.



## PROJECT DETAILS

*PROJECT: 5 Road Tunnels in  
Greece along Elefdina-Tsakona  
Motorway.*

*LOCATION: Greece, UK*

*NEED: Smoke Extraction High  
Temperature rated and pollution  
control Reversible Jet Fans.*

*SOLUTION: 10 x 1.0m diameter Jet  
Fans rated at 400 deg. C for 2  
hours, 60 x 1.0m diameter Jet  
Fans rated at 300 deg. C for 2  
hours and 26 x 1.25m diameter  
Jet Fans rated at 300 deg. C for 2  
hours.*

*2 x 2.8m dia. Axial Fans for Mid*



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THANK YOU

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