

## HOWDEN VENTILATOREN

Air for  
underground traffic



## Experience

Howden Ventilatoren located in Heidenheim is part of the Howden Group of companies, the world's biggest and leading fan supplier. The most important tunnel owners worldwide are our customers.

Howden has been designing and manufacturing fans for more than 150 years. This experience has ensured that Howden has become the leader in state of the art fan design and technology.

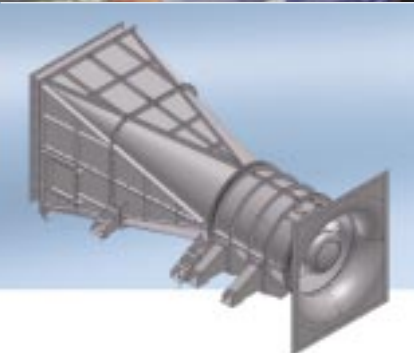
Our products are well known for their high efficiency and excellent reliability under the most arduous operating conditions.

From 400 mm diameter fans up to the most modern and biggest axial fans for tunnel ventilation, our delivery program always provides the best possible solution.

## Always fresh air in the tunnel

Road tunnels are getting longer and longer. Traffic density, lack of space in towns and cities, and the need for winterproof routes through mountains and connections beneath rivers and seas, often compel traffic to go underground. And it's there where clean air is absolutely essential.

# OUR SERVICES



## Advice

Whoever needs our advice will get it, whether consultant, owner, or builder. We have experience in the planning and realisation of all ventilation systems and assist our partners in the design and optimization of their plant. When existing plants need improvement we always find the best solution for the customer.

## Development

Finding new ways, and further improving existing ways. This ranges from methods to systems, from component groups to the smallest detail. Howden development is both fundamental and specific. Where necessary, we perform investigations on scaled down models or on 1:1 equipment at site.

## Design

No tunnel is equivalent to the next. Despite the large-scale application of building block systems, the ventilation system is always tailor-made. Our design department will develop a scheme optimising the interaction of all components.

## Manufacture

Of benefit to our clients (and us) on manufacture: the wealth of experience of Howden Group and very long experience in all areas of aerodynamics.

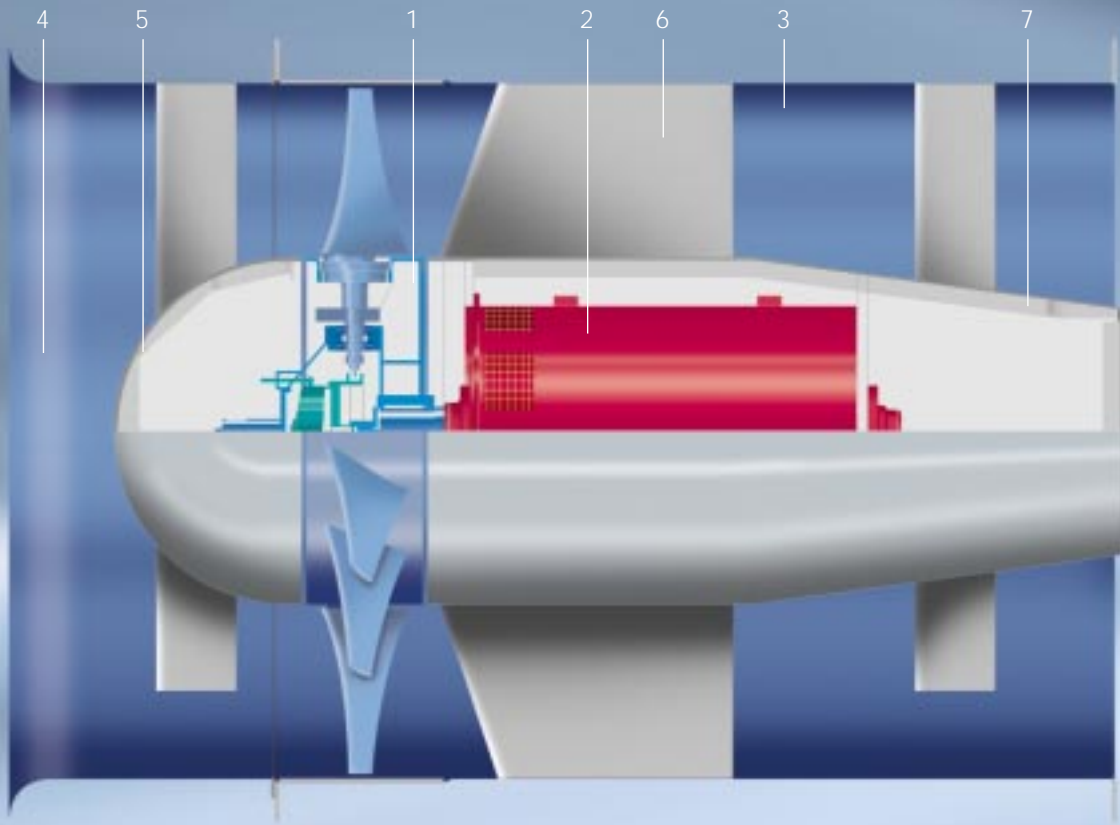
## Erection

Our understanding of supply means: erection, test run and handing-over. Our fitters and commissioning engineers feel at home in all parts of the world.

## Service

Service must be reliable, easy to reach and quick at site. Even though it is seldom needed.

# AXIAL-FLOW FANS



## Principle

### **Axial-flow fans with adjustable impeller blades.**

The variation of blade pitch allows for an infinitely variable adjustment of the volume flow to prevailing conditions. The blades are simultaneously adjusted during rotation.

### **Axial-flow fans with individually or simultaneously adjustable blades during standstill, in combination with variable speed drive.**

While changing the speed of rotation, the volume flow is adjusted to prevailing conditions.

## Areas of application

In all applications where large quantities of air are needed:

- Longitudinal ventilation with Saccardo jet, injector or extraction
- Transverse ventilation
- Semi-transverse ventilation of road tunnels (when necessary with reversible operation)
- Smoke extraction

## Mechanical design and mode of operation

Fan impeller 1, basic components: Impeller hub, impeller blades, adjustment mechanism and upstream fairing. The blade pitch can be adjusted in three different ways:

- Mechanically while stationary
- Electro-mechanically during operation
- Hydraulically during operation

The driving motor 2, three-phase squirrel cage motor. Models: B 5 or B 3 . Direct start, star-delta start, softstart or operation with frequency converter. Impeller directly driven or indirect via intermediate shaft.

Fan station  
cavern north  
at the  
Plabutschunnel

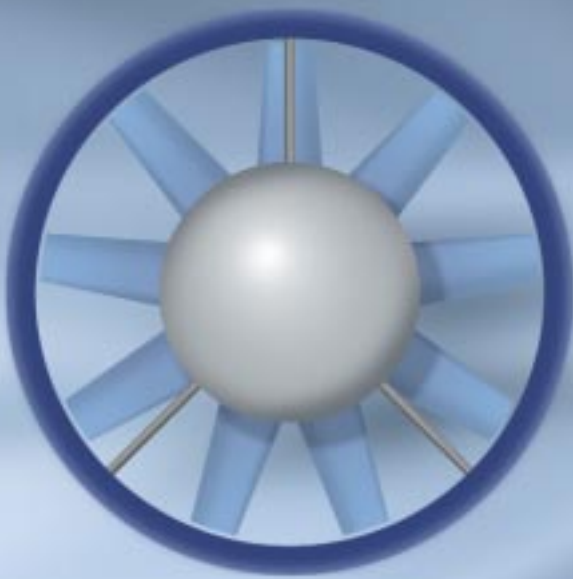


Fan station  
Raach at the  
Plabutschunnel





  
**Howden**  
Howden Ventilatoren

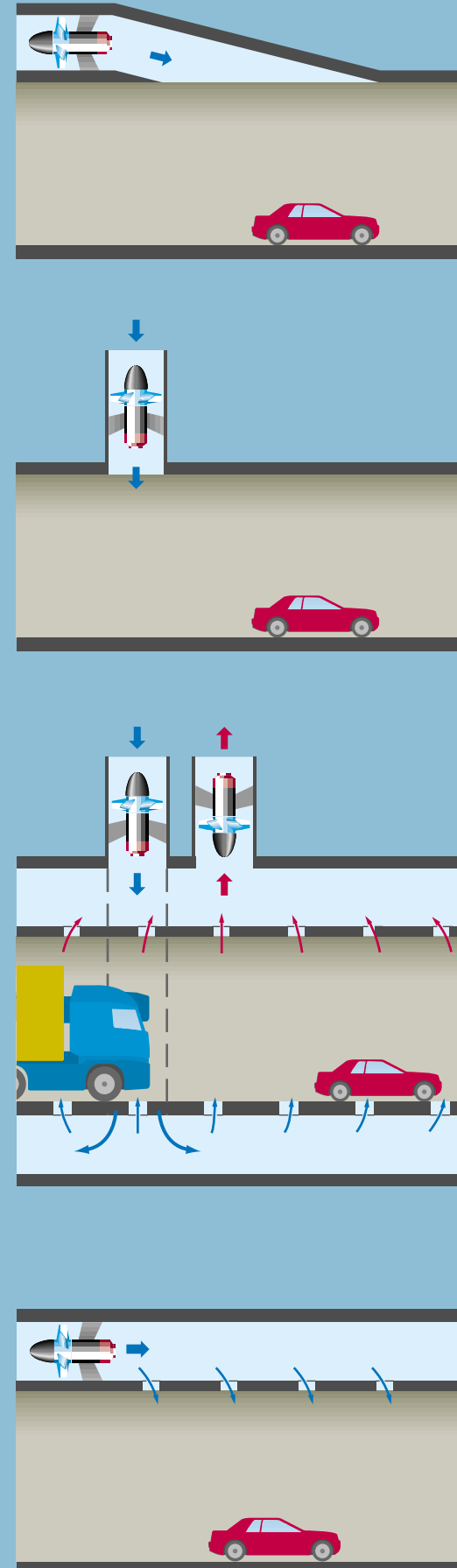


The fan housing 3 consists of the housing itself, the inlet venturi 4, and the upstream centre fairing 5. Other essential aerodynamic components are the guide vanes 6 and the downstream centre fairing 7.

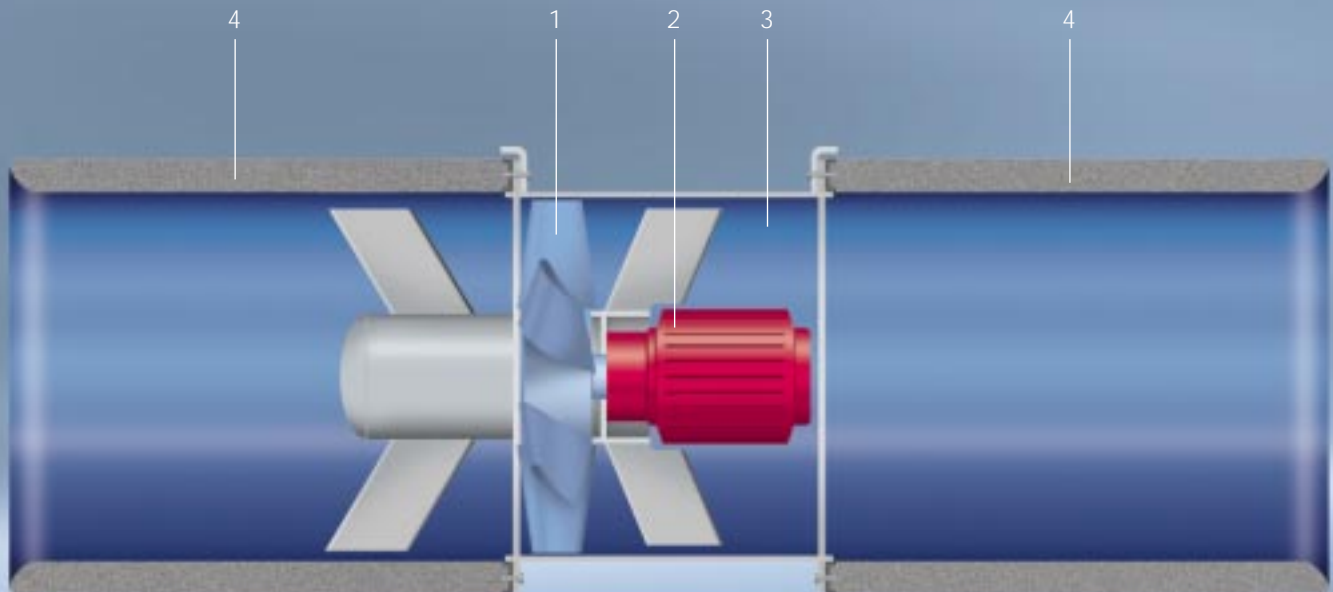
### Features and advantages

- High efficiency
- Low noise operation
- Robust and durable
- High operating reliability
- Low maintenance
- Adaptable to requirements
- Comprehensive programme (standard sizes)
- Unit-construction principle
- First class workmanship
- Reliable corrosion protection

### Modes of installation



# JET FANS



## Principle

Jet fans are axial-flow fans specially designed to produce the highest possible jet impulse (thrust) from the power installed.

## Field of application

Predominantly for the longitudinal ventilation of road tunnels and for support of smoke extraction in case of emergency ventilation.

## Mechanical design and mode of operation

The fan impeller 1 has either symmetrically (type APR) or asymmetrically (type APA) profiled blades. All impellers are dynamically balanced in two planes. The driving motor 2 is a 3-phase squirrel cage motor, design B 5 or B 14. Designed for direct start, star-delta start or softstart, voltage 400 V, 50 Hz, optionally 60 Hz or 690 V. The fan can be equipped with a pole-reversing motor  $n = 1:2$  as well. The motor bearings are self-lubricating. The fan housing 3 contains the flange for the driving motor and support blades (stator). With the type APR, an internal cone at the opposite end to the motor caters for

a uniform thrust in both blowing directions. The silencers 4 have a double casing (lined on the inside with perforated steel plate) and are filled with sound-absorbing material. The suspension is in every case adapted by us to suit installation conditions, either rigid or flexible with dampers as required.

Picture illustrates a Howden jet fan at our test rig



## Types

There are 2 standard types with 14 different sizes available.

### Type APR

The impeller blades are symmetrically profiled. This permits a reversal of the blowing direction with thrust remaining the same. Type APR is especially suitable for tunnels with two-directional traffic, with alternating major traffic direction, or where wind influence is high.

### Type APA

The impeller blades and stator are asymmetrically profiled. The thrust in the principal blowing direction is very high and, for this reason, this type is particularly suitable for tunnels with unidirectional traffic flow. Reversal operation at reduced thrust is possible.

## Features and advantages

- High thrust with low power consumption
- High operating reliability
- Robust and durable
- Low maintenance
- Low noise operation due to efficient silencers and dynamic balancing of all rotating parts
- Reversible direction of flow
- Easy to accommodate in the tunnel cross-section outside the traffic space
- Special ventilation buildings unnecessary
- Reliable corrosion protection with hot dipped galvanising and special paint or stainless steel.

## Aerodynamic testing

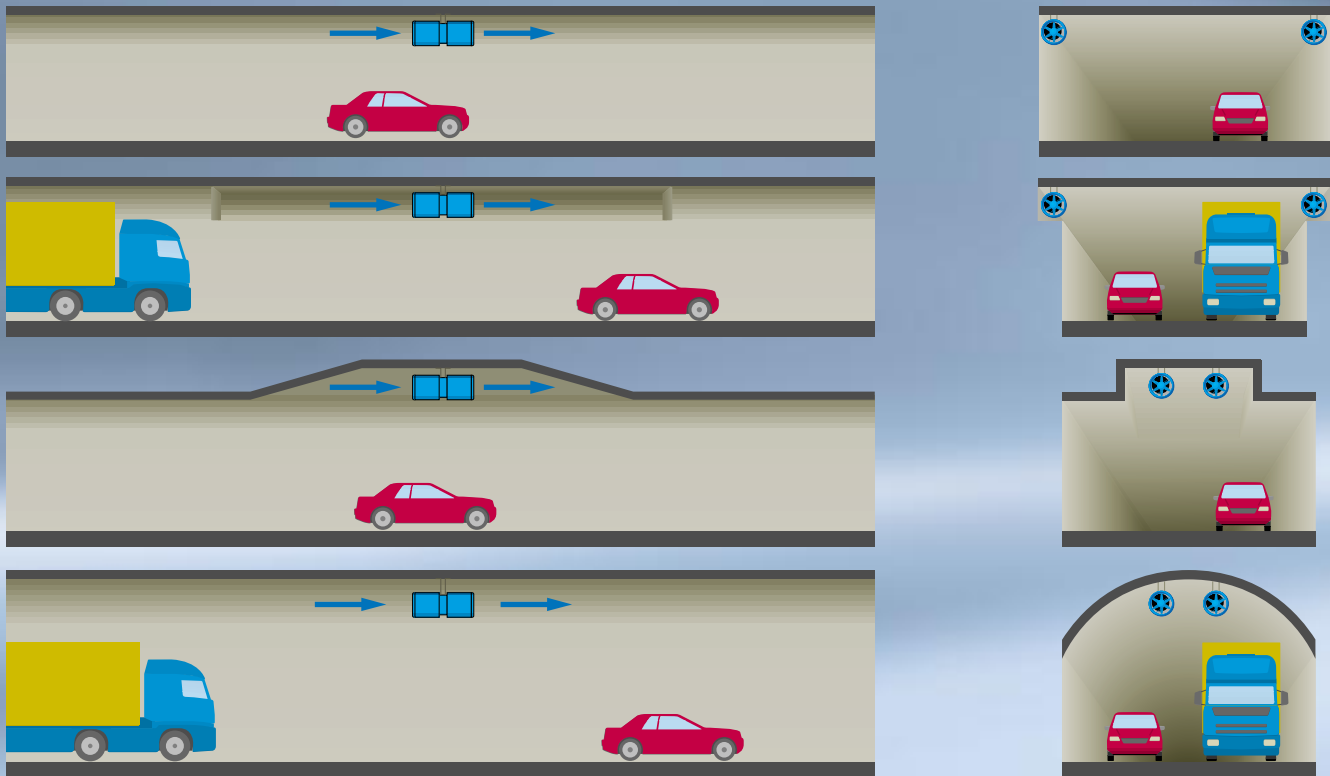
Jet fans have been developed for an optimum relationship between installed motor power and thrust produced. For the direct measurement of thrust, Howden has designed a special test rig. Normally, the thrust,  $F$ , of a jet fan at a basic specific gravity of air,  $p$ , is calculated from the volume flow,  $V$ , and the air exit velocity,  $c$ , in accordance with the formula

$$F = p \cdot V \cdot c \text{ [N]}.$$

The thrust actually produced, however, always is a few percent below this value.

For a jet fan, the ratio of thrust to power, not the efficiency, is the criterion for assessment, .

## INSTALLATION IN THE TUNNEL

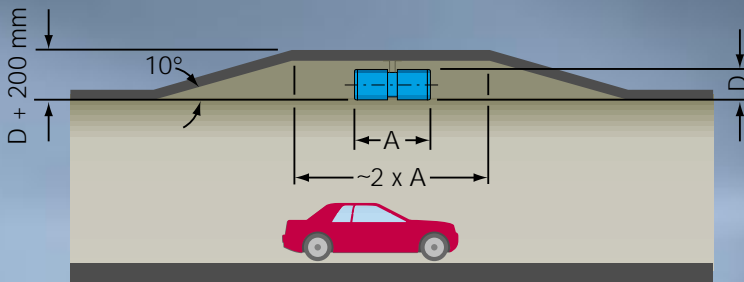


For space reasons, jet fans must always be installed in close proximity to at least one wall. The dimensions of jet fans normally permit their installation in the tunnel outside the traffic space. They are fitted singly, in pairs, or in larger groups. From group to group, there should be an interval of at least 50 m to obtain optimum jet miscibility. The high exit velocity of jet fans leads to a relatively high wall friction in the vicinity of the fan which must be accounted for as a loss in thrust.

Howden has carried out numerous tests with the aim of solving this question. The additional wall friction loss can only be determined for the respective individual case, since its magnitude is dependent upon factors such as jet velocity, tunnel air velocity, fan diameter, and distance from the wall. With normal plant conditions, one can normally calculate roughly with a loss in thrust of about 5-10%. Howden jet fans can also be supplied with jet deflectors or in special appli-

cations. A calculation must demonstrate an optimum in energy economy with the different possible variations (proximity of wall and ceiling, niche installation, or jet deflector).

# CONTROL



**Example for niche installation**  
(jet fan fully accommodated).

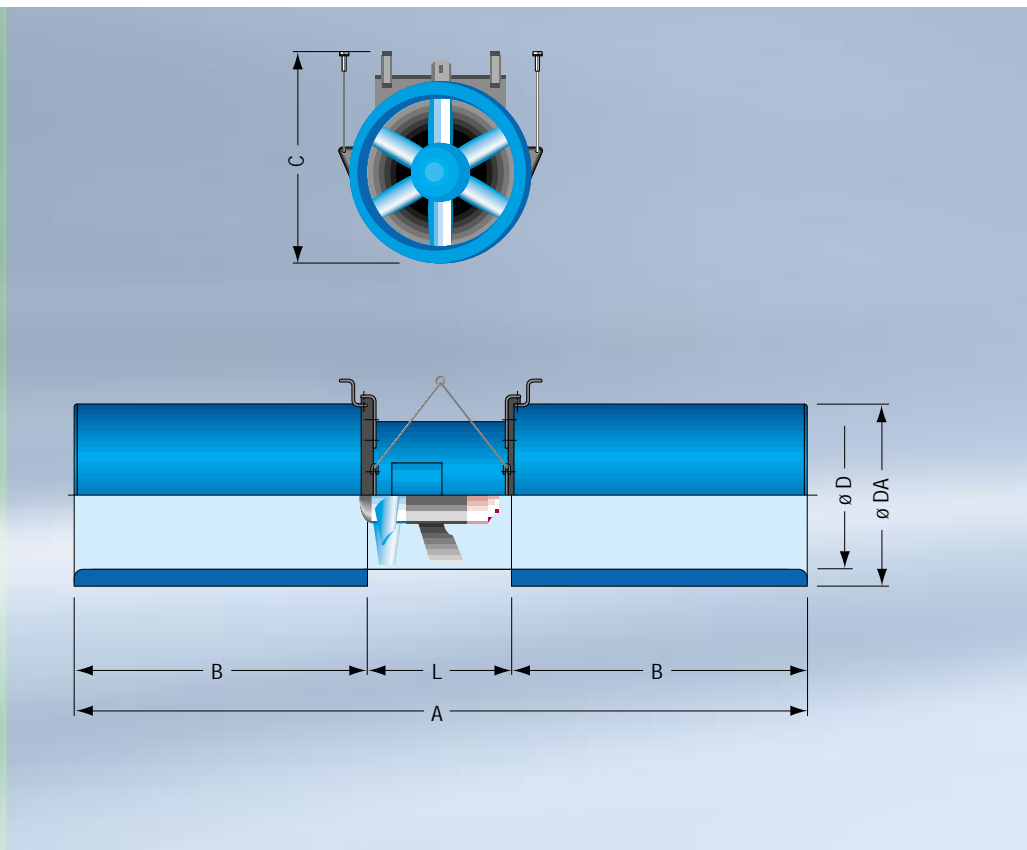
For especially restricted conditions, jet fans can also be accommodated in niches. However, thrust losses are higher than normal installations in such cases.

In normal cases, jet fans are controlled depending on CO-concentration (petrol driven vehicles) and visibility impairment (diesel powered vehicles). The control pulses are transmitted from separate measuring instruments for CO-concentration and visibility impairment. According to these criteria, jet fans are switched on and off in groups as required.



# TECHNICAL DATA AND DIMENSIONS

## Type APA



All figures given in the tables relate to the standard design. They represent the result of many years of practical experience in the field of aerodynamics and high-quality manufacture.

### Corrosion protection

Prior to assembly, all components of steel plate are carefully pretreated and protected against corrosion by hot dipped galvanising, two coats of primer and one top coat of paint. No welding of components is necessary during assembly after painting.

References supplied on request.

Fan type	A	B *)	C **) min.	Ø D	Ø DA	L
040 K	1444	522	860	400	560	400
050 K	1474	522	960	500	660	430
APA - 560 / 280	2104	772	1010	560	715	560
APA - 630 / 280	2174	772	1080	630	790	630
APA - 710 / 330	2754	1022	1180	710	880	710
APA - 800 / 330	3754	1522	1280	800	990	710
APA - 900 / 403	2944	1022	1400	900	1110	900
APA - 1000 / 403	3444	1272	1525	1000	1210	900
APA - 1120 / 403	3444	1272	1625	1120	1330	900
APA - 1250 / 403	3944	1522	1750	1250	1460	900
APA - 1250 / 578	5144	2022	1750	1250	1460	1100
APA - 1400 / 578	6144	2522	1950	1400	1660	1100
APA - 1500 / 578	6144	2522	2050	1500	1760	1100
APA - 1600 / 578	6144	2522	2150	1600	1860	1100

All dimensions in mm

\*) Silencer length related to 75 dB(A) sound pressure, 10 m / 45° at free field with max. motor power

\*\*) Other dimensions on request

# OVERVIEW

## Howden Jet Fans for uni-directional thrust, Type APA

Fan type	Static thrust* [N]	Air flow [m³/s]	Outlet velocity [m/s]	Shaft power* [kW]	Motor-rating [kW]	Fan speed [1/min]	Thrust power ratio [N/kW]	LW(A) [dB(A)]	LP(A)** [dB(A)]	Emergency temperatures	
										max. 2h 250 °C	max. 2h 400 °C
040 K	105	3.4	27.0	2.2	2.2	2860	47.7	103	75	X	
050 K	250	6.6	33.6	6.5	6.5	2895	38.5	103	75	X	
APA - 560 / 280	255	7.5	30.1	6.5	6.5	2830	39.2	103	75	X	X
	365	8.9	36.0	11	11	2890	33.2	103	75	X	X
	445	9.8	39.8	11.4	15	2910	39.0	103	75	X	X
APA - 630 / 280	410	10.6	33.9	11	11	2890	37.3	103	75	X	X
	505	11.7	37.6	15	15	2910	33.7	103	75	X	X
	580	12.6	40.3	18.5	18.5	2930	31.4	103	75	X	X
	645	13.3	42.5	22	22	2925	29.3	103	75	X	X
APA - 710 / 330	745	14.3	45.7	28	28	2920	26.6	103	75	X	
	695	15.5	39.2	22	22	2925	31.6	103	75	X	X
	815	16.8	42.4	28	28	2920	29.1	103	75	X	
	855	17.2	43.5	30	30	2930	28.5	103	75	X	X
APA - 800 / 330	980	18.5	46.5	37	37	2930	26.5	103	75	X	X
	1030	18.9	47.7	40	40	2925	25.8	103	75	X	
	755	18.2	36.3	22	22	2925	34.3	103	75	X	X
	900	19.9	39.6	28	28	2920	32.1	103	75	X	
	950	20.4	40.7	30	30	2930	31.7	103	75	X	X
APA - 900 / 403	1100	22.0	43.8	37	37	2930	29.7	103	75	X	X
	1160	22.6	44.9	40	40	2925	29.0	103	75	X	
	685	19.5	30.7	15	15	1460	45.7	103	75	X	X
	780	20.8	32.8	18.5	18.5	1460	42.2	103	75	X	X
	860	21.9	34.4	22	22	1465	39.1	103	75	X	X
APA - 1000 / 403	1010	23.8	37.3	30	30	1465	33.7	103	75	X	X
	860	24.3	31.0	18.5	18.5	1460	46.5	103	75	X	X
	960	25.7	32.7	22	22	1465	43.6	103	75	X	X
	1150	28.1	35.8	30	30	1465	38.3	103	75	X	X
	1290	29.8	37.9	37	37	1465	34.9	103	75	X	X
APA - 1120 / 403	1355	30.5	38.9	40.8	45	1460	33.2	103	75	X	X
	935	28.4	28.8	18.5	18.5	1460	50.5	103	75	X	X
	1050	30.1	30.5	22	22	1465	47.7	103	75	X	X
	1280	33.2	33.7	30	30	1465	42.7	103	75	X	X
	1450	35.4	35.9	37	37	1465	39.2	103	75	X	X
	1620	37.4	37.9	45	45	1460	36.0	103	75	X	X
APA - 1250 / 403	1395	38.7	31.5	30	30	1465	46.5	103	75	X	X
	1600	41.4	33.8	37	37	1465	43.2	103	75	X	X
	1800	44.0	35.8	45	45	1460	40.0	103	75	X	X
APA - 1250 / 578	2025	46.6	38.0	55	55	1475	36.8	103	75	X	X
	2490	51.7	42.1	75	75	1470	33.2	103	75	X	X
	2795	54.8	44.6	90	90	1480	31.1	103	75	X	X
APA - 1400 / 578	2180	54.2	35.2	55	55	1475	39.6	103	75	X	X
	2725	60.6	39.4	75	75	1470	36.3	103	75	X	X
	3085	64.5	41.9	90	90	1480	34.3	103	75	X	X
APA - 1500 / 578	2235	58.8	33.3	55	55	1475	40.6	103	75	X	X
	2845	66.3	37.5	75	75	1470	37.9	103	75	X	X
	3240	70.8	40.1	90	90	1480	36.0	103	75	X	X
APA - 1600 / 578	2240	62.8	31.2	55	55	1475	40.7	103	75	X	X
	2925	71.8	35.7	75	75	1470	39.0	103	75	X	X
	3360	86.9	38.2	90	90	1480	37.3	103	75	X	X

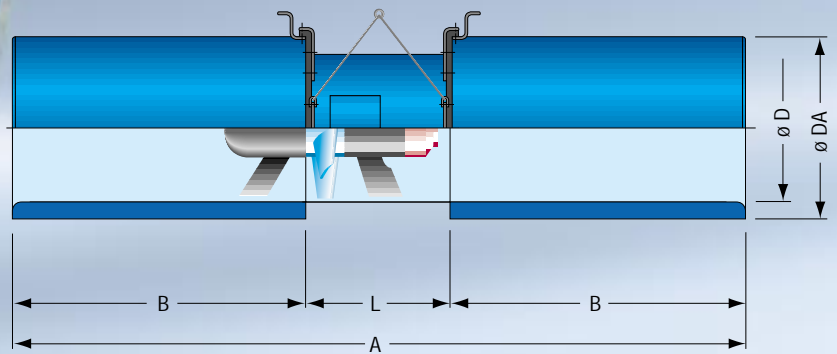
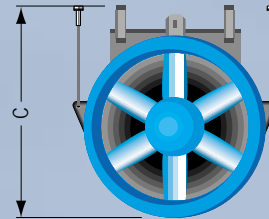
\* Static thrust and shaft power at air density  $\rho = 1.2 \text{ kg/m}^3$

\*\* Measured at fan suction side under free field conditions at 10 meters under 45° from the fan axis

X = available

# TECHNICAL DATA AND DIMENSIONS

## Type APR



Fan type	A	B *)	C **) min.	Ø D	Ø DA	L
040 T	1444	522	860	400	560	400
050 T	1474	522	960	500	660	430
APR - 560 / 280	2104	772	1010	560	715	560
APR - 630 / 280	2174	772	1080	630	790	630
APR - 710 / 330	2754	1022	1180	710	880	710
APR - 800 / 330	3754	1522	1280	800	990	710
APR - 900 / 403	2944	1022	1400	900	1110	900
APR - 1000 / 403	3444	1272	1525	1000	1210	900
APR - 1120 / 403	3444	1272	1625	1120	1330	900
APR - 1250 / 403	3944	1522	1750	1250	1460	900
APR - 1250 / 578	5144	2022	1750	1250	1460	1100
APR - 1400 / 578	6144	2522	1950	1400	1660	1100
APR - 1500 / 578	6144	2522	2050	1500	1760	1100

All dimensions in mm

\*) Silencer length related to 75 dB(A) sound pressure, 10 m / 45° at free field with max. motor power

\*\*) Other dimensions on request

# OVERVIEW

## Howden Jet Fans for reversible thrust, Type APR

Fan type	Static thrust* [N]	Air flow [m³/s]	Outlet velocity [m/s]	Shaft power* [kW]	Motor-rating [kW]	Fan speed [1/min]	Thrust power ratio [N/kW]	LW(A) [dB(A)]	LP(A)** [dB(A)]	Emergency temperatures	
										max. 2h 250 °C	max. 2h 400 °C
040 T	92	3.3	26.2	2.2	2.2	2860	41.8	103	75	X	
050 T	215	6.3	32.0	6.5	6.5	2895	33.1	103	75	X	
APR - 560 / 280	240	7.3	29.2	6.5	6.5	2830	36.9	103	75	X	X
	325	8.4	34.0	11	11	2890	29.5	103	75	X	X
	330	8.5	34.2	11.4	15	2910	28.9	103	75	X	X
APR - 630 / 280	365	10.0	32.0	11	11	2890	33.2	103	75	X	X
	440	11.0	35.1	15	15	2910	29.3	103	75	X	X
	495	11.6	37.3	18.5	18.5	2930	26.8	103	75	X	X
	535	12.1	38.8	22	22	2925	24.3	103	75	X	X
APR - 710 / 330	555	12.3	39.5	26.5	28	2920	20.9	103	75	X	
	645	14.9	37.8	22	22	2925	29.3	103	75	X	X
	750	16.1	40.7	28	28	2920	26.8	103	75	X	
	780	16.5	41.5	30	30	2930	26.0	103	75	X	X
APR - 800 / 330	845	17.1	43.2	37	37	2930	22.8	103	75	X	X
	860	17.3	43.6	40	40	2925	21.5	103	75	X	
	710	17.7	35.2	22	22	2925	32.3	103	75	X	X
	835	19.2	38.1	28	28	2920	29.8	103	75	X	
	870	19.6	38.9	30	30	2930	29.0	103	75	X	X
APR - 900 / 403	995	20.9	41.6	37	37	2930	26.9	103	75	X	X
	1040	21.4	42.5	40	40	2925	26.0	103	75	X	
	535	17.3	27.1	15	15	1460	35.7	103	75	X	X
APR - 1000 / 403	575	17.9	28.1	18.5	18.5	1460	31.1	103	75	X	X
	590	18.2	28.5	20.1	22	1465	29.4	103	75	X	X
	730	22.4	28.5	18.5	18.5	1460	39.5	103	75	X	X
APR - 1120 / 403	800	23.4	29.9	22	22	1465	36.4	103	75	X	X
	900	24.9	31.7	29.9	30	1465	30.1	103	75	X	X
	875	27.5	27.9	18.5	18.5	1460	47.3	103	75	X	X
APR - 1250 / 403	980	29.1	29.5	22	22	1465	44.5	103	75	X	X
	1165	31.7	32.2	30	30	1465	38.8	103	75	X	X
	1260	33.0	33.5	35.5	37	1465	35.5	103	75	X	X
	1325	37.7	30.7	30	30	1465	44.2	103	75	X	X
APR - 1250 / 578	1475	39.8	32.4	37	37	1465	39.9	103	75	X	X
	1600	41.5	33.8	45	45	1460	35.6	103	75	X	X
	1715	42.9	35.0	55	55	1475	31.2	103	75	X	X
APR - 1400 / 578	2025	46.7	38.0	75	75	1470	27.0	103	75	X	X
	2125	47.8	38.9	89.1	90	1480	23.8	103	75	X	X
	1905	50.7	32.9	55	55	1475	34.6	103	75	X	X
APR - 1500 / 578	2320	55.9	36.3	75	75	1470	30.9	103	75	X	X
	2595	59.2	38.4	90	90	1480	28.8	103	75	X	X
APR - 1500 / 578	2100	57.0	32.2	55	55	1475	38.2	103	75	X	X
	2550	62.8	35.5	75	75	1470	34.0	103	75	X	X
	2860	66.5	37.6	90	90	1480	31.8	103	75	X	X

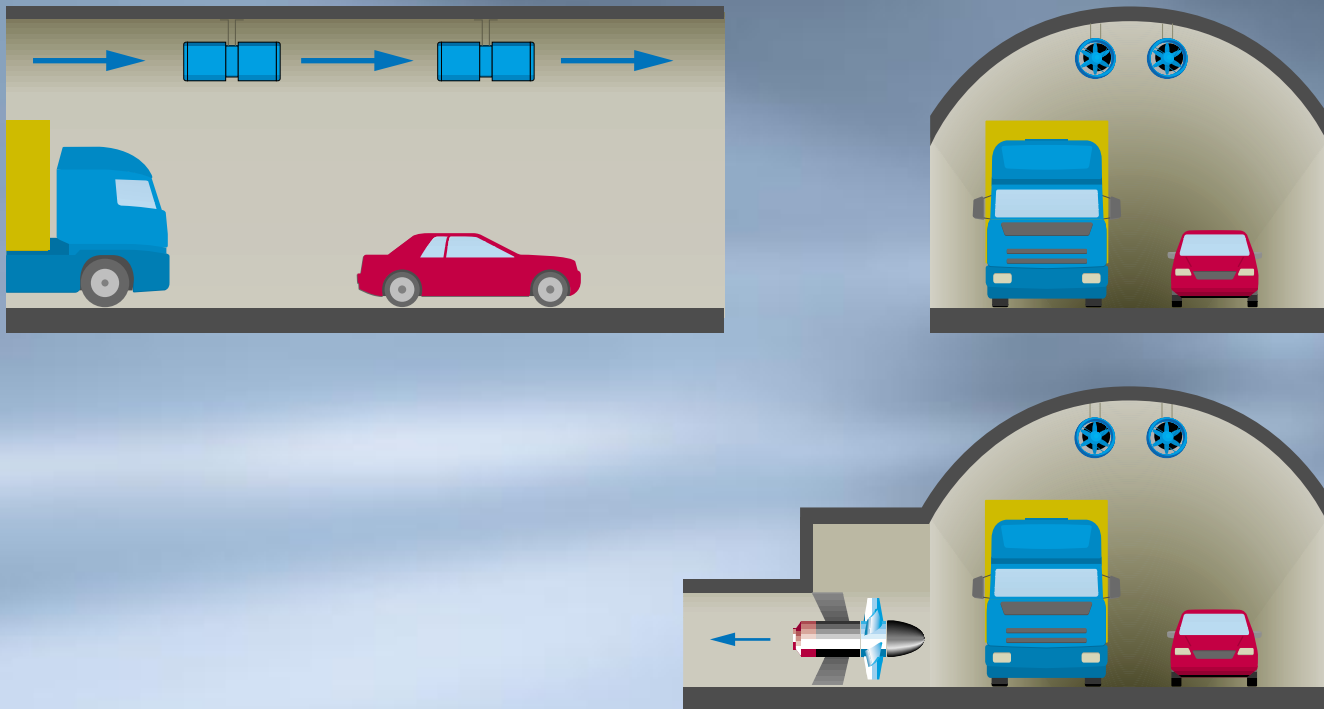
\* Static thrust and shaft power at air density  $\rho = 1.2 \text{ kg/m}^3$

\*\* Measured at fan suction side under free field conditions at 10 meters under 45° from the fan axis

X = available

# VENTILATION SYSTEMS

## Longitudinal ventilation with jet fans



### Principle

The function is based on the principle of impulse transmission. A relatively small portion of the total air stream passing through the tunnel is sucked up by the jet fans and blown back with high kinetic energy. Due to the change of impulse between the driven jet and the remaining air stream, energy is injected into the latter, causing it to move in the direction of the tunnel exit.

### Application

Generally employed in road tunnels up to 2 km in length, yet also up to 5 km with uni-directional light traffic. If the ventilation system can be divided up into several sections, tunnel lengths of over 10 km can be catered for.

### Advantages

Longitudinal ventilation with jet fans is simple and economical, both in construction and operation. Ventilation buildings are not required.

### Examples

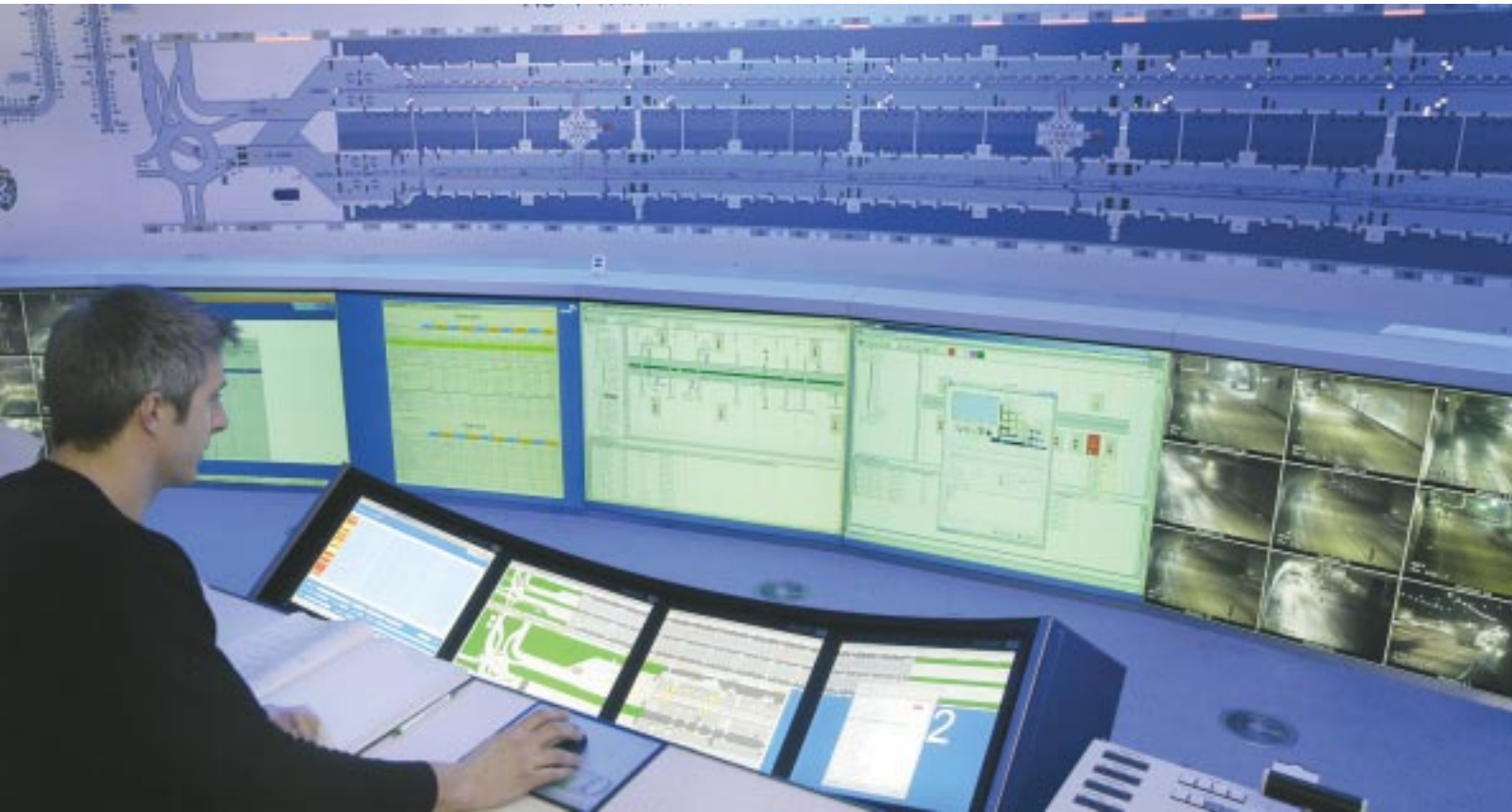
#### Example Gräbern Tunnel (A)

A classical longitudinal ventilation with large jet fans and, thus favourable thrust/power ratio. Automatic control via carbon monoxide and visibility monitoring instruments.

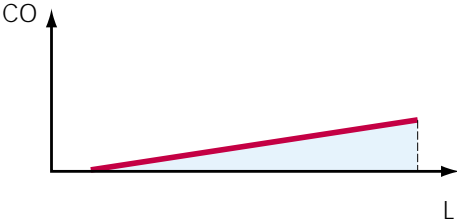
#### Example Landwasser (CH)

Longitudinal ventilation with jet fans and supplementary extraction system using axial-flow fans in the centre of the tunnel.

Tunnel operation room  
Plabutschunnel

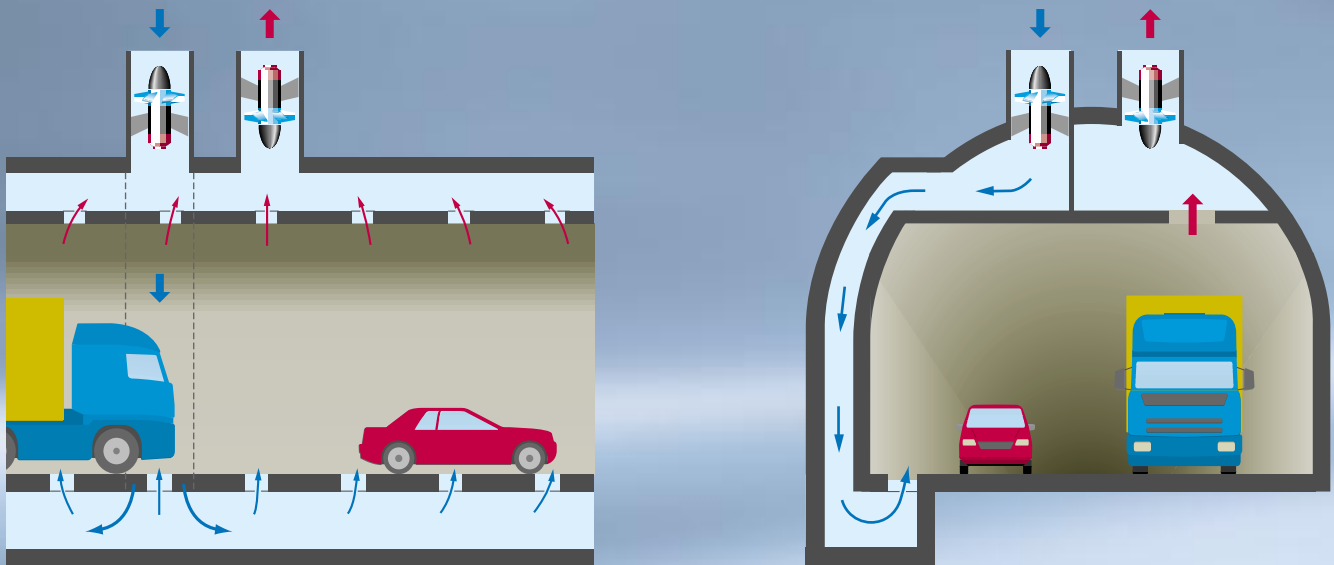


Concentration (CO) curve  
with uni-directional traffic



# VENTILATION SYSTEMS

## Transverse ventilation



### Principle

Fresh air is delivered uniformly over the entire tunnel length and the vitiated air uniformly extracted. Air flows transversely across the traffic space. Fresh air injection at the sides above the road surface and extraction above the traffic space is the most effective form of air exchange (transverse ventilation from below to above). According to tunnel length and traffic loading, one or more ventilation stations must be built.

### Application

For medium and long road tunnels with heavy traffic load.

### Advantages

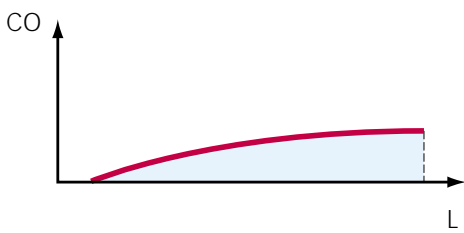
Although expensive in construction, operation, and maintenance, a transverse ventilation system is the best system for road tunnels. It is largely independent of meteorological influences, wind at the portal, and air movement caused by vehicles.

### Examples

**Example Elbe Tunnel Hamburg (D)**  
Designed for extreme traffic conditions, the Elbe Tunnel in Hamburg is equipped with a transverse ventilation system. The tunnel is sub-divided into 5 ventilation sections with their own equipment, and has 3 ventilation stations. Before the planning stage, we investigated 8 different installation possibilities on scaled models 1:40.

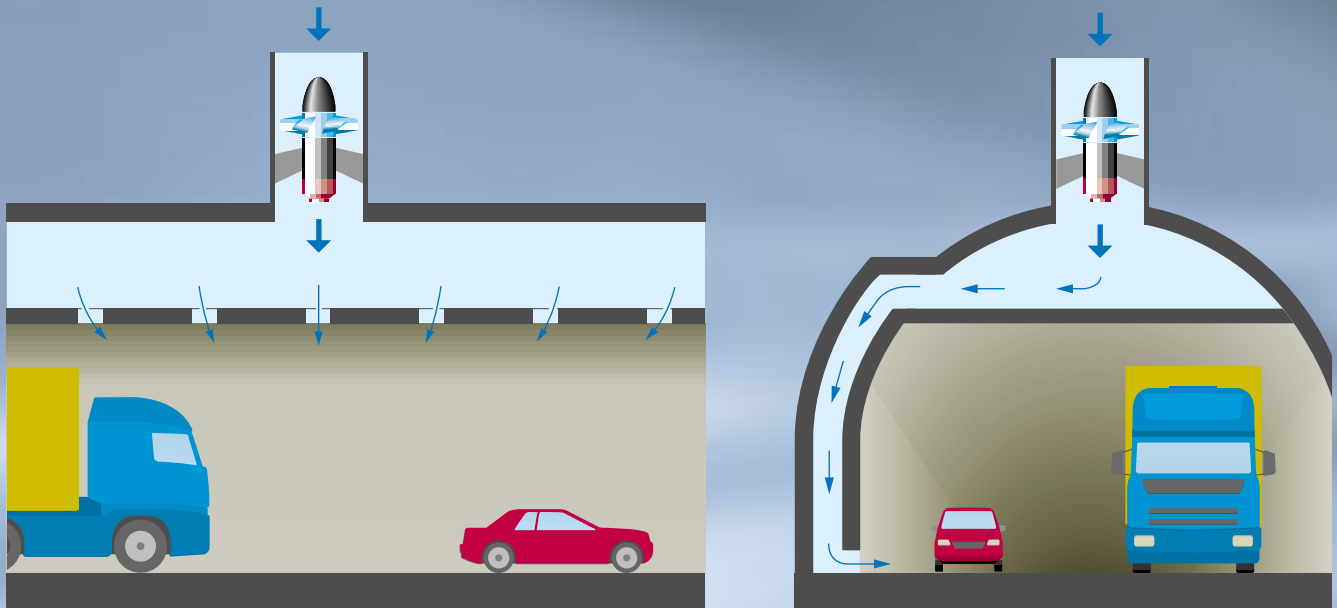
**Example Pfänder Tunnel (A)**  
Second longest alpine tunnel in Austria. Reduced transverse ventilation (80% extraction, 20 % vitiated air through portals). In the event of fire, the extractor fans can withstand a temperature of + 350 °C for a period of 30 minutes, followed by + 250 °C for a period of 150 minutes.

Concentration (CO) curve  
with uni-directional traffic



# VENTILATION SYSTEMS

## Semi-transverse ventilation



### Principle

Semi-transverse ventilation is a combination of longitudinal and transverse ventilation. Particularly reliable is a fresh air semi-transverse system with which fresh air is delivered uniformly over the whole tunnel length (transverse) and the vitiated air is removed through the tunnel portals (longitudinal). In the event of fire, the axial-flow fans can be reversed from fresh air to exhaust air operation, thus dispensing with the necessity of a separate fan for fire operation.

Optional:  
Exhaust air semi-transverse ventilation.

### Application

For medium-length tunnels with medium to heavy traffic loading.

### Advantages

Building and operating costs are less than those for transverse-ventilation.

In case of special requirements, i.e. with respect to local smoke extraction in case of a tunnel fire, a combination of the named ventilation systems could provide the best possible solution for the given parameters.

### Examples

#### Example Lermoos (A)

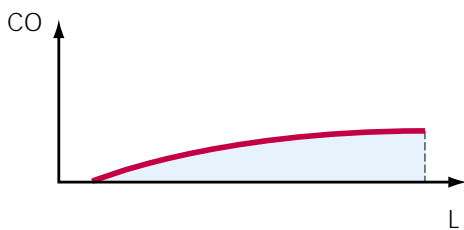
At each of the two portals, an axial-flow fan caters for the supply of exhaust air. The exhaust air duct is located above the traffic space.

#### Example Arisdorf (CH)

A combination of semi-transverse and transverse systems is also possible. The plant in the Arisdorf Tunnel operates as a semi-transverse system under normal conditions. In the event of fire, the system can be switched over to offer a transverse system. In this way, the persons at the scene of the fire are supplied with fresh air while smoke is sucked out at the ceiling.



Concentration (CO) curve with uni-directional traffic.



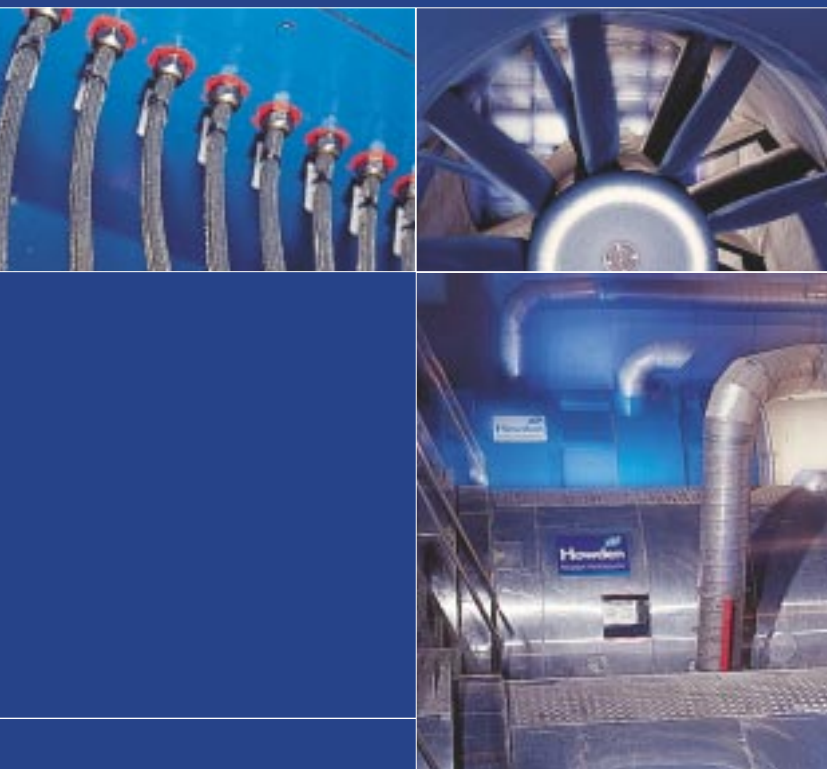
## Fans for:

- Tunnel ventilation (axial fans)
- Tunnel ventilation (jet fans)
- Metro fans
- Wind tunnels and test rigs
- Temporary ventilation for tunnel construction
- Mine ventilation
- Fresh-air and flue-gas handling in fossil fired power stations
- Special fans

## Our scope of supply includes:

- Research
- Development
- Advice
- Engineering
- Design
- Manufacture
- Installation
- Start-up
- Service

Electronic protection and control systems



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