Jet Fan Systems

Ventilation and smoke control for car parks.

wolter

Jet Fan Systems.

The combination of CO ventilation and smoke control in underground car parks.

Given the continuously rising volume of inner-city traffic it is virtually mandatory to provide for adequately sized car parks as a part of every major real-estate development project, whether it be private or public, such as office buildings or shopping malls, museums or theatres. As these locations are frequented by a large number of individuals, high standards apply with respect to building services engineering and public safety. More often than not, conventional car park ventilation systems fail to meet these requirements.

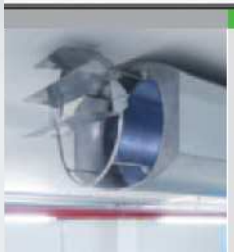
Functional principle

In recent years, jet fan technology has established itself as the new standard in car park ventilation in many countries all over the world. In Europe today, more than 2.500 jet fan systems are in operation in car parks of various sizes. As opposed to conventional ventilation concepts based on transverse ventilation and ducted systems, the concept of jet ventilation (frequently also referred to as impulse ventilation) is derived from the longitudinal ventilation systems found in most road tunnels, whereby a high-velocity stream of air is injected by a series of free-blowing silenced axial fans. Thus, jet fans effectively distribute and transport the air on each car park level from the supply to the exhaust points. The decisive design parameters being the air speed profile and the thrust generated by the fan.

Advantages of the jet ventilation system

Smoke control in the event of a fire

Careful project planning allows to use the jet fan system not only as a means of CO ventilation and mechanical smoke exhaust, but also to effectively control the spreading of smoke. By utilising fully reversible impellers, the thrust direction of each individual fan can be changed in order to contain the smoke within the affected area and to transport it to the nearest exhaust point. This keeps emergency exits free of smoke and prevents smoke from contaminating non-affected areas of the car park. Depending on the detected location of the fire within the car park, the standard direction of airflow can automatically be reversed so that the air supply inlets can serve as fume exhaust points should they be nearer to the location of the fire. If required, the control logics for this emergency ventilation mode can be designed and programmed by Wolter. This direction-controlled containment of fire gases allows for effective fire-fighting, as the



The Wolter jet fan system in a real fire test.

location of the fire remains visible and can be safely approached by fire-fighters from the upstream side of the airflow.

As early as 1998 the TNO institute (Delft) examined the effectiveness of the impulse ventilation system in a series of 18 real fire tests in an underground car park in Amsterdam. The results of this test series have been published in a research paper, which, among other aspects, addresses smoke production, smoke propagation and occuring temperatures as well as the possibility of effective smoke control in case of a car fire in an enclosed space. It has been verified that the jet ventilation system, as opposed to a conventional ducted system which was subject to the same fire test, could effectively cool and contain the occurring fire gases. Air ducts, however, failed to provide sufficient exhaust capacity and even had the tendency to further the diffusion of smoke fumes in the worst case.

System controllability allows for efficient operation

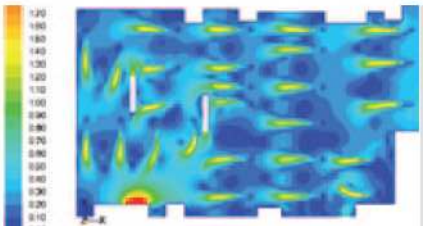
The jet ventilation system can be automatically controlled in a way that adjusts the required ventilation volume contingent on the current occupancy level of the car park. CO concentration is continually monitored by an adequate number of CO detection heads spread throughout the car park. As long as pollution limits are not exceeded, individual fans in designated areas of the car park may be switched off, thus saving energy and lowering the noise level within the building.

Lower energy consumption reduces operating costs

Given the almost continuous operation of the ventilation system throughout the year, the jet ventilation system taps a considerable potential for lowering operational costs. Ducted ventilation systems, usually designed as a compromise between required air volume, installation space and installation cost, cause high air velocities and subsequently high pressure losses in the ducted system. The ventilation fans must operate against this pressure drop and will consequently absorb more power. In a ductless jet ventilation system, the architecture of the car park itself serves as the air duct. Air velocities are much lower and there is no resistance caused by a duct system. The total amount of energy consumed by a jet ventilation system is therefore significantly lower.

Lower construction costs and more efficient use of floor space

Jet fans will require additional wiring and electronic controls, but this is more than compensated for by significant savings in installation costs, as air ducts become obsolete when using an impulse ventilation system. Furthermore, fan sizes and installed motor powers can be reduced. With increasing floor space, the cost advantage of the jet fan system becomes even more significant. The low profile of the jet fan allows to keep the ceiling height of the car park to a minimum.

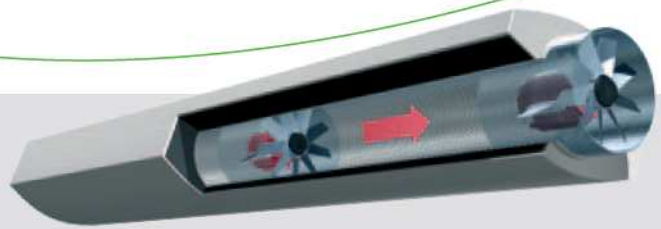


Jet fans will allow the creation of virtual fire compartments within the car park, as their airstreams prevent smoke from spreading to adjacent areas of the car park not affected by the fire. The physical division of the floor space by fire walls is no longer necessary and even the use of a sprinkler system might become obsolete. Thus, the use of a jet fan system allows for a more open-plan design of the car park and enhances manoeuverability. The overall number of parking spaces is increased, effectively enhancing operating results.

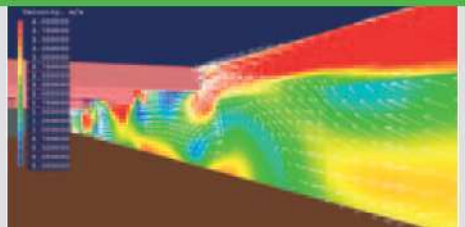
Improved air quality throughout the entire car park

In enclosed car parks, the induction effect of Wolter jet fans creates a constant movement of air from the supply to the exhaust points, keeping CO levels to a minimum. A well-designed distribution of jet fans throughout the car park will prevent the accumulation of exhaust fumes in dead spots. The high-velocity air stream along the ceiling level will induce a low-velocity airstream at floor level, ensuring the required mixing of low-level and high-level atmosphere which is generally insufficient in a ducted system, while keeping the air speed at walking height still comfortably low.

The use of jet fans achieves ventilation results superior to the conventional ducted systems and offers substantial advantages. The additional capital cost of the jet fans is more than compensated by savings in construction and operating costs.



The integral fan-motor-assembly can easily be extracted from the fan casing for inspection or servicing purposes without dismounting the entire jet fan from the ceiling.



Air-speed profile of a crosssection.

Frankfurt am Main. OpernTurm.

Office Building OpernTurm

- Completion: spring 2010.
- Car park floor space: app. 18.000m².
- Parking spaces: 650.
- With sprinkler system.

Scope of Supply Wolter / Burkhardt Projekt GmbH:

- 42 Jet fans.
- 4 Axial exhaust fans.
- Dampers and grilles.
- Control cabinet.
- CO detection system.
- Installation and commissioning.

Project management
from design stage to commissioning.

Wolter and its co-operation partner Burkhardt Projekt GmbH will assist you through all stages of your car-park project, from the initial layout to the final acceptance test. We will provide all documentation necessary to obtain a homologation from local authorities.

Planning Phase

Design and layout by means of computational fluid dynamics analysis (CFD)

The initial step in the design of a jet ventilation system should always be a careful analysis of air distribution and movement based on computational fluid dynamics (CFD). Customised software allows us to create a 3-dimensional image of the car park. After determining all relevant parameters such as required air-change rates, exhaust volume and airflow direction, different ventilation scenarios for standard and emergency operation can be studied. Taking into account all relevant local regulations, the number, size and positioning of jet fans can be optimised.

CFD software visualizes direction vectors of airflows and air distributions in all areas of the underground car park. CFD design can also be used to simulate smoke propagation for different fire scenarios and to study the smoke-control effects of alternative jet fan distributions.

Installation Phase

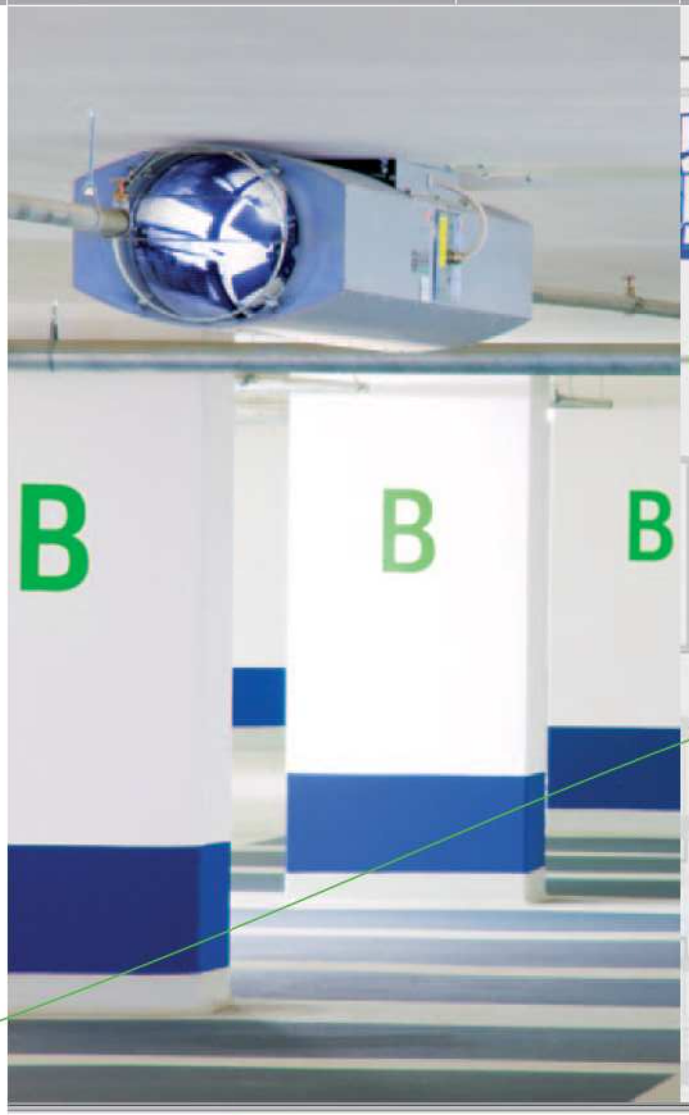
- Installation-ready supply of fans and ancillary equipment such as volume control dampers, guards and sound attenuators.
- Delivery of CO-sensors, smoke detectors and control cabinet and integration with the central building control systems.
- Implementation of the control cabinet PLC programming.
- Testing of the CO monitoring system.

Commissioning and acceptance tests

- Functional demonstration of the installation by means of hot or cold smoke tests, if required.
- Complete system documentation for submittal to car park operators and civil protection authorities.

Service

- Periodical inspections and maintencance.
- Adjustment of running patterns according to changes in traffic volume.



Frankfurt am Main. **MyZeil (PalaisQuartier).**

Shopping Center MyZeil
Office/Hotel Building PalaisQuartier

- Completion: spring 2009.
- Car park floor space: app. 45.000m².
- Parking spaces: 1.400.
- With sprinkler system.

Scope of Supply Wolter / Burkhardt Projekt GmbH:

- 105 Jet fans.
- 12 axial supply and exhaus fans.
- Dampers and grilles.
- Control cabinet.
- CO detection system.
- Installation and commissioning.

Components of the Jet Fan System.

As a turn-key supplier, Wolter and Burkhardt Projekt GmbH offer all services and components required to implement a jet ventilation system.

Jet Fans

Both Wolter JF series jet fans as well as AXV supply and exhaust axial fans are tested and certified in accordance with DIN EN 12101-3 and are subject to CE supervision by notified body MPA Braunschweig. They ensure operation at elevated temperatures of 300°C for at least 2 hours, or 400°C for at least 2 hours, respectively.

Wolter Jet Fans are manufactured in standard sizes ranging from 250 – 400 and cover all thrust requirements usually found in relevant specifications. The integral fan-motor-unit of JFUO/JFRO type jet fans is inserted into an oval-shaped, integral sound-attenuated casing made from sheet steel. As the fan-motor-assembly can easily be extracted from the casing, it is not necessary to dismount the entire fan from the ceiling for revision or maintenance purposes. In addition to the standard casing of 2.250mm length (version L), a short-cased fan (version S) of 1.200mm length is available for limited installation space. Fan types JFUC/JFRC feature a split circular sound attenuator of 1.800mm length. Guide vanes mounted on the pressure side direct the airstream underneath downstand beams if necessary. Each jet fan is equipped with a detachable mounting bracket as standard. These brackets allow for an easy installation of the fan unit as they can be fixed to the ceiling separately. The fan itself is subsequently

screwed to the mounting bracket. Standard as well as high-temperature isolator switches can be fitted as an option. Wolter high-temperature isolator switches have been tested in accordance with DIN EN 12101-3 in conjunction with the jet fan. Due to the low construction profile, the ceiling height of the car park can be kept to a minimum.

Impellers

The aerodynamically shaped impellers are manufactured from injection-moulded aluminium, the pitch angle can be adjusted during standstill. Impellers are balanced to grade G6,3 according to VDI 2060 / ISO 1940-1:2003. Jet fans

can be manufactured in uni-directional or fully reversible executions, providing almost the same thrust performance in either direction.

Motors

Each unit is equipped with a 2-speed motor (2/4-poles in Dahlander connection, protection class IP55). 4-pole speed is usually sufficient for CO-ventilation under normal conditions. In the event of fire, a considerable power reserve is disposable by doubling the fan speed. All motors can be prepared for frequency inverter drive. Mains supply is connected either through a terminal box or an optional disconnect switch in standard or high temperature execution. Both are located in a recessed opening in the fan casing accesible from the outside by a removable cover.

Custom-designed executions are possible, e.g. fans can be fitted with two motors and two impellers in order to comply with the run/standby-requirements of some countries.

Wolter-BP Control Cabinet.

Recessed terminal box / disconnect switch.

AXV Main Exhaust and Supply Fans

AXV axial fans are available up to diameter 1.800, also for F300 (300°C/2h) and F400 (400°C/2h) temperature ratings, tested and CE certified according to DIN EN 12101-3.

The jet fan system has to be designed in a way that sufficient air circulation in all areas is guaranteed and waste air is transported to the exhaust point without creating an aerodynamic "short circuit" whereby the supply air is extracted too early without achieving a thorough mixture of the atmosphere. Adequately sized main exhaust fans are an important part of the overall system. Where natural air supply, e. g. through ramps, is insufficient, supply fans have to be installed. If required by the ventilation design, exhaust and supply fans can also be manufactured as reversible units.

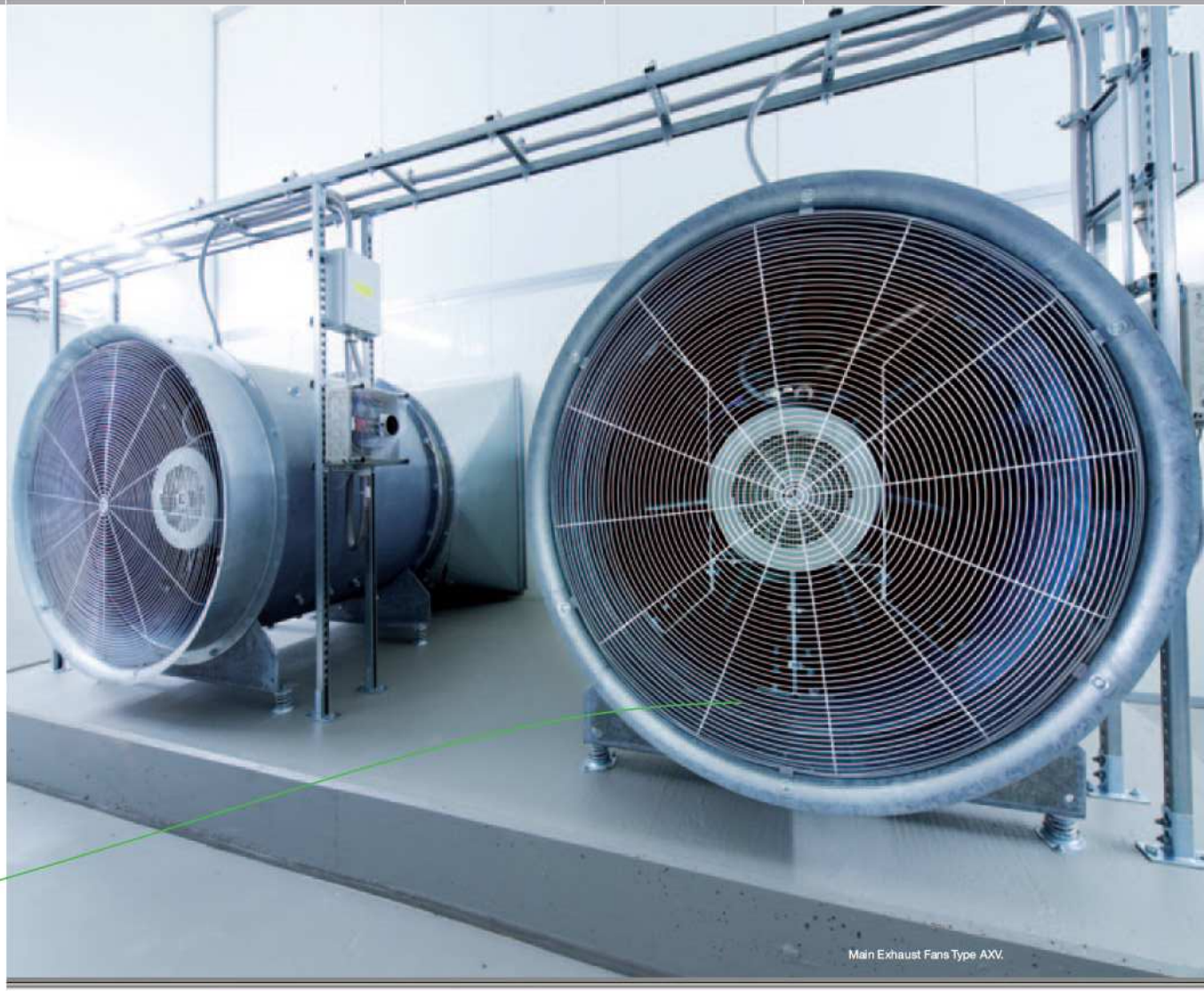
Sensors and Controls

The running pattern of the jet fans depends on current ventilation needs as determined by the network of CO sensors and fire detectors throughout the car park. It can be adjusted according to pre-defined programs in the course of the day or dependant upon continually monitored CO levels in different locations.

The jet fans are operated by a programmable logic control cabinet that enables the individual control of each single fan. The PLC programming has to ensure minimal start-up times of the fans and provide overriding capabilities in the case of fire or malfunction. The required quantity of CO-sensors and smoke detectors and their distribution in the car park has to be individually determined during the design stage. Also, the smoke-control running pattern has to be carefully designed in order to determine exactly which fans have to be put in reverse mode should a fire occur in a specific area. In fire mode, individual start-up times of fans in different zones have to be observed, which is vital for the functioning of the entire sytem. Wolter, in cooperation with Burkhardt Projekt GmbH, is a turn-key system supplier, i.e. all necessary sensors, smoke detectors and the programmed control cabinet can be obtained from a single source, ensuring optimal integration of all components as well as trouble-free connection to the central building control system.

Ancillary Components

All necessary ancillary components such as volume-control dampers, guards or silencers are available from Wolter. Where, due to architectural conditions, standard components can not be used, their design can be adapted to suit the requirements of a specific installation.



Main Exhaust Fans Type AXV.

Reference Project **The Squaire.**

The Squaire (Airrail Center).

Frankfurt am Main. **The Squaire (Airrail Center).**

Office/Hotel Building
The Squaire (Airrail Center)

- Completion: spring 2011.
- Car park floor space: app. 15.000m².
- Parking spaces: 1.400.
- With sprinkler system.

Scope of Supply Wolter / Burkhardt Projekt GmbH:

- 117 Jet fans.
- Dampers and grilles.
- Control cabinet.
- CO detection system.
- Installation and commissioning.

Reference Project **EZB.**

Frankfurt am Main. **European Central Bank**

ECB New Construction
Office Building

- Completion (car park): 2011.
- Car park floor space: app. 17.000m².
- Parking spaces: 650.
- With sprinkler system.

Scope of Supply Wolter / Burkhardt Projekt GmbH:

- Jet fans.
- Axial exhaust fans.
- Dampers and grilles.
- Control equipment.
- CO detection system.
- Installation and commissioning.

ECB.

Reference Project **Allianz Arena.**

Jet Fans in Vertical Arrangement.

Applying jet fan technology to open car parks.

Wolter supplied 149 vertical impulse fans of sizes 1.000 and 1.400 for the car park ventilation system of Munich's new soccer stadium Allianz-Arena. The Espalande car park can house approximately 9.800 cars and is among the largest ones in Europe.

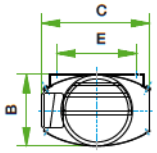
The fans are mounted on the bottom of large atriums and point vertically upwards, thus inducing a secondary airstream that ventilates the open parking decks above.

Technical Data.

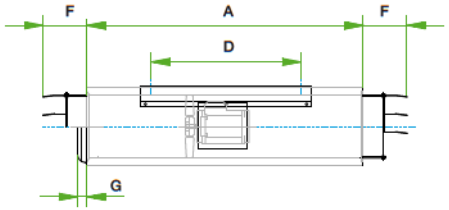
Fan Type	Motor Power 300°C/2h [kW]	Nom. Current 300°C/2h [A]	Motor Power 40°C [kW]	Nom. Current 40°C [A]	Fan Speed [1/min]	Volume Flow [m³/s]	Thrust [N]	Sound Pressure [dB(A) 3m/45°]	Weight [kg]
JFUO L - Jet Fan, Uni-directional, Oval, Long									
JFUO 300 L	1,1/0,25	2,41/0,75	1,4/0,3	3,33/0,82	2.880/1.440	1,43/0,72	28/7	62/47	82
JFUO 315 L	1,23/0,28	2,86/0,81	1,4/0,3	3,33/0,82	2.880/1.440	1,72/0,85	45/12	66/50	111
JFUO 315 L	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	1,9/0,95	55/14	67/51	114
JFUO 355 L	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,20/1,10	56/14	71/53	114
JFUO 355 L	2,2/0,5	4,63/1,54	2,5/0,65	5,06/1,76	2.880/1.440	2,30/1,15	62/15	72/56	116
JFUO 370 L	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,42/1,2	58/14	70/53	106
JFUO 370 L	2,2/0,5	4,63/1,54	2,5/0,65	5,06/1,76	2.880/1.440	2,64/1,32	70/17	72/57	108
JFRO L - Jet Fan, Fully Reversible, Oval, Long									
JFRO 300 L	1,1/0,25	2,41/0,75	1,4/0,3	3,33/0,82	2.880/1.440	1,3/0,65	25/6	62/46	83
JFRO 370 L	1,23/0,28	2,86/0,81	1,4/0,3	3,33/0,82	2.880/1.440	2,19/1,09	48/12	68/51	104
JFRO 370 L	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,36/1,16	55/13	69/52	107
JFUO S - Jet Fan, Uni-directional, Oval, Short									
JFUO 250	on request	on request	on request	on request	on request	on request	on request	on request	on request
JFUO 300 S	1,1/0,25	2,41/0,75	1,4/0,3	3,33/0,82	2.880/1.440	1,43/0,72	28/7	66/51	56
JFUO 315 S	1,23/0,28	2,86/0,81	1,4/0,3	3,33/0,82	2.880/1.440	1,72/0,85	45/12	70/54	82
JFUO 315 S	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	1,9/0,95	55/14	71/55	85
JFUO 355 S	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,20/1,10	56/14	75/57	85
JFUO 355 S	2,2/0,5	4,63/1,54	2,5/0,65	5,06/1,76	2.880/1.440	2,30/1,15	62/15	76/60	87
JFUO 370 S	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,42/1,2	58/14	74/57	79
JFUO 370 S	2,2/0,5	4,63/1,54	2,5/0,65	5,06/1,76	2.880/1.440	2,64/1,32	70/17	76/61	81
JFRO S - Jet Fan, Fully Reversible, Oval, Short									
JFRO 250	on request	on request	on request	on request	on request	on request	on request	on request	on request
JFRO 300 S	1,1/0,25	2,41/0,75	1,4/0,3	3,33/0,82	2.880/1.440	1,3/0,65	25/6	66/50	57
JFRO 370 S	1,23/0,28	2,86/0,81	1,4/0,3	3,33/0,82	2.880/1.440	2,19/1,09	48/12	72/55	77
JFRO 370 S	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,36/1,16	55/13	73/56	79
JFUC - Jet Fan, Uni-directional, Circular									
JFUC 355	1,23/0,28	2,86/0,81	1,4/0,3	3,33/0,82	2.880/1.440	2,09/1,04	51/13	68/53	69
JFUC 355	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,28/1,14	60/15	70/54	72
JFUC 400	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,84/1,42	76/19	73/55	77
JFUC 400	2,2/0,5	4,63/1,54	2,5/0,65	5,06/1,76	2.880/1.440	3,06/1,53	85/21	75/55	79
JFRC - Jet Fan, Fully Reversible, Circular									
JFRC 355	1,23/0,28	2,86/0,81	1,4/0,3	3,33/0,82	2.880/1.440	1,92/0,96	43/11	64/49	70
JFRC 355	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,18/1,09	55/14	66/50	73
JFRC 400	1,8/0,43	4,11/1,39	1,9/0,4	4,14/1,07	2.880/1.440	2,67/1,33	65/16	67/51	78
JFRC 400	2,2/0,5	4,63/1,54	2,5/0,65	5,06/1,76	2.880/1.440	2,82/1,41	76/19	73/55	80

Dimensions.

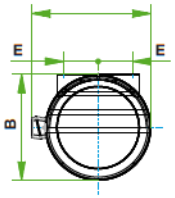
JFUO S - Jet Fan, Uni-directional, Oval, Short



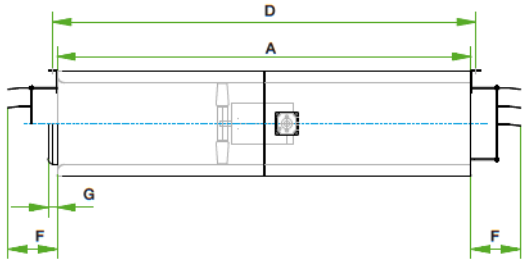
JFRO S - Jet Fan, Fully Reversible, Oval, Short



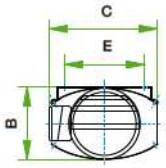
JFUC - Jet Fan, Uni-directional, Circular



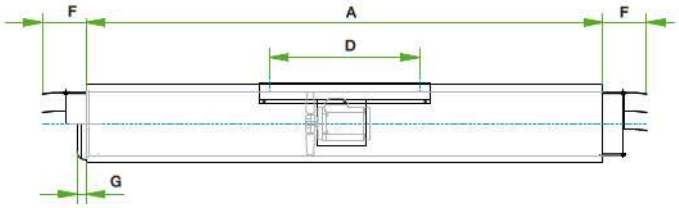
JFRC - Jet Fan, Fully Reversible, Circular



JFUO L - Jet Fan, Uni-directional, Oval, Long



JFRO L - Jet Fan, Fully Reversible, Oval, Long



All dimensions in mm.

Type	A	B	C	D	E	F*	G*
JFUO 250	1.200	270	395	450	255	170	46
JFRO 250	1.200	270	395	450	255	170	-
JFUO 300 L	2.250	343	530	650	380	190	46
JFUO 300 S	1.200	343	530	650	380	190	46
JFRO 300 L	2.250	343	530	650	380	190	-
JFRO 300 S	1.200	343	530	650	380	190	-
JFUO 315 L	2.250	415	600	650	450	190	46
JFUO 315 S	1.200	415	600	650	450	190	46
JFUO 355 L	2.250	415	600	650	450	190	46
JFUO 355 S	1.200	415	600	650	450	190	46
JFUO 370 L	2.250	415	600	650	450	190	46
JFUO 370 S	1.200	415	600	650	450	190	46
JFRO 370 L	2.250	415	600	650	450	190	-
JFRO 370 S	1.200	415	600	650	450	190	-
JFUC 355	1.800	460	518	1.840	150	190	46
JFRC 355	1.800	460	518	1.840	150	190	-
JFUC 400	1.800	506	562	1.840	175	190	46
JFRC 400	1.800	506	562	1.840	175	190	-

* Uni-directional jet fans JFUO/JFUC: inlet guard (dimension G) on inlet, discharge guide vanes (dimension F) on outlet;
Fully reversible jet fans JFRO/JFRC: discharge guide vanes (dimension F) on both sides

All technical details are subject to change without prior notice.

Expertise in design and installation. **Globally.**

Experience is paramount when it comes to the planning and installation of a jet ventilation system. Our reference list stands out. Wolter specialist engineers will be happy to assist you in every way possible – send us your plans or contact us to arrange for a meeting.

Selected Reference Projects as of February 2011.

Project	Location	Parking Spaces (app.)	Year
Allianz Arena	Munich	9.800	2005
IKEA	Hannover	1.250	2006
Zeilhöfe	Frankfurt am Main	30	2006
Krankenhaus	Lingen	250	2006
Oskar-Miller-Strasse	Frankfurt am Main	75	2006
Platanenplatz	Freiburg	40	2006
Becker-Gundahl-Strasse	Munich	35	2006
City Carree EKZ **	Salzgitter	600	2006
Schillerstrasse	Bad Nauheim	40	2006
Altmarkt **	Dresden	490	2006
Ledenhof	Osnabrück	660	2007
BMW MITZ Phase 1	Munich	2.000	2007
L-Bank	Karlsruhe	120	2007
Tower-Parc-Offices I	Bonn	170	2007
KröpelinerTor Center	Rostock	200	2007
EKZ Mühlenweg	Wedel	230	2007
Telekom	Wiesbaden	80	2007
Maritim Airport Hotel	Düsseldorf	500	2007
Arena Plaza Shopping Center	Budapest, Hungary	2.500	2007
Hotel MOTEL ONE	Munich	100	2007
European Investment Bank EIB	Luxembourg	400	2007
Siesmayerstrasse	Frankfurt am Main	100	2007
Shopping Forum	Denizli, Turkey	580	2007
Ärztehaus	Ratingen	215	2007
Al Jafiliyal Condominiums	Dubai, UAE	115	2007
Depot	Bornheim	200	2007
Marina Quays	Dubai, UAE	450	2007
Altmarkt	Dresden	490	2007
Business Bay Executive Towers	Dubai, UAE	5.800	2007
Boscolo NewYork Palace Hotel	Budapest, Hungary	750	2007

Project	Location	Parking Spaces (app.)	Year
Grand Century Place	Hong Kong	250	2007
Hummel & Dachs	Garmisch-Partenkirchen	80	2007
OpernTurm	Frankfurt am Main	600	2007
City Carree Shopping Center	Salzgitter	600	2007
Outlet Center	Wertheim	360	2007
Hegau Tower	Singen	95	2007
Arcone-Höhenkirchen	Munich	260	2007
Al Barsha	Dubai, UAE	130	2007
Julfar Towers	Dubai, UAE	1.000	2007
Two Towers	Dubai, UAE	370	2007
Forum Duisburg	Duisburg	610	2007
BMW MITZ Phase 2	Munich	2.000	2008
Jida Motor Tower	Doha, Qatar	50	2008
Rathausgarage	Würzburg	100	2008
Porto Arabia - The Pearl	Doha, Qatar	2.000	2008
Havard Medical College	Dubai, UAE	390	2008
Am Theater	Würzburg	100	2008
DEG Zentrale	Köln	110	2008
Komet	Besigheim	100	2008
Riedbergzentrum	Frankfurt am Main	320	2008
MZH „Das Auge“	Darmstadt	160	2008
Haerder Center	Lübeck	210	2008
Mavir Office Building	Budapest, Hungary	750	2008
Airport Sabiha Gokcen	Istanbul, Turkey	4.000	2008
Opus	Frankfurt am Main	40	2008
Landeszentralbank LZO	Oldenburg	230	2008
PalaisQuartier (MyZeil)	Frankfurt am Main	1.400	2008
Pendik Krea Shopping Center	Istanbul, Turkey	1.100	2008
Shopping Forum	Istanbul, Turkey	2.300	2008
Condominium Complex	Dorog, Hungary	250	2008
Cambridge Mall	Medan, Indonesia	1.440	2008

Project	Location	Parking Spaces (app.)	Year
Bäderland	Hamburg	130	2008
St. Josefs Hospital	Giessen	90	2008
V-Markt EKZ	Munich	260	2008
Uniqua Insurance Office Building	Budapest, Hungary	600	2008
212 Shopping Center	Istanbul, Turkey	4.000	2008
Saarbrücker Platz	Idstein	160	2008
City of Dreams - Podium	Macau	200	2008
Hauptstrasse	Hofheim/Taunus	100	2009
Yas Island	Abu Dhabi, UAE	1.450	2009
CulturalVillage	Doha, Qatar	2.800	2009
Plegezentrum	Lingen	40	2009
Hansa-Allee	Frankfurt am Main	40	2009
Gemlik	Istanbul, Turkey	230	2009
Königsfeldergasse	Landshut	70	2009
Kagithane	Istanbul, Turkey	290	2009
AlTadamon	Libya	30	2009
Parc-Offices PO II	Bonn	350	2009
Health Care Center	Oberkirch	130	2009
The Cube	Zilina, Slovakia	70	2009
PD Viktoria	Bratislava, Slovakia	140	2009
Rohde + Schwarz Gebäude 11	Munich	80	2009
The Squaire (Airrail Center)	Frankfurt Airport	600	2009
Homburger Landstrasse	Frankfurt am Main	140	2009
Schlossplatz **	Koblenz	450	2009
Wohnen in Bamberg Mitte	Bamberg	350	2009
ICK Building	Jakarta, Indonesia	120	2009
IKEA Shopping Center	Lodz, Poland	2.000	2009
313@somerset Shopping Center	Singapore	230	2009
BluLotus	Istanbul, Turkey	450	2009
Decathlon	Istanbul, Turkey	865	2009
BD Letna	Bratislava, Slovakia	104	2009
St. Urbanus-Kirchplatz	Gelsenkirchen	160	2009
Parkcity	Istanbul, Turkey	490	2010
Spiegel Verlag	Hamburg	240	2010
Ericuscontor	Hamburg	220	2010
Sign Hafenoffice	Düsseldorf	250	2010
Universitätsplatz	Fulda	220	2010
Retro	Bratislava, Slovakia	620	2010
BD Kollarova	Brno, Czech Republic	30	2010
Marmara Forum	Istanbul, Turkey	4.500	2010
Stop Shop	Bratislava, Slovakia	145	2010

Project	Location	Parking Spaces (app.)	Year
KGW Universität	Salzburg, Austria	100	2010
Marka Spot	Istanbul, Turkey	270	2010
Saarbrücker Platz 2. BA	Idstein	80	2010
Merter Metro	Istanbul, Turkey	210	2010
MFH Gartenbreie	Münster	30	2010
V-Markt EKZ	Illertissen	140	2010
Kulturzentrum	Worms	100	2010
Europäische Zentralbank	Frankfurt am Main	650	2010
IKEA	Berlin	380	2010
Diakonie-Klinikum 1. BA	Hamburg	150	2010
Alexanderplatz	Berlin	600	2010
ECE Shopping Center	Oldenburg		2010
Pairc an Clochar	Oranmore, Ireland	500	2010
AKBATI Shopping Center	Istanbul, Turkey	3.500	2010
Quartier Unterlinden	Freiburg	250	2010
PGGM Investments	Zeist, The Netherlands	1.000	2010
HDI-Gerling Versicherung	Hannover	620	2010
Metro Markt	Izmir, Turkey	230	2010
Panorama Resort	Tatra, Slovakia	80	2010
Office Building	Ljubljana, Slowenien	80	2010
Royal Breeze Buildings	Ras Al Khaimah, UAE	800	2010
Millenium Hall Shopping Center	Rzeszow, Poland	1.000	2010
Muratpas	Istanbul, Turkey	230	2010
Marienplatz-Galerie	Schwerin	150	2010
Wehrheimer Mitte	Wehrheim	70	2010
Baumax Shopping Center	Izmir, Turkey	235	2010
Neue Mitte	Ingelheim	450	2010
Administration Building	Khartoum, Sudan	100	2010
Sparkasse	Nürnberg	110	2011
Philipp-Reis-Schule	Friedrichsdorf	90	2011
Zaailand Shopping Center	Leeuwarden, The Netherlands	200	2011
Kai Tak Airport **	Hong Kong	250	2011
Mega Bangna Shopping Center **	Bangkok, Thailand	4.200	2011
Festival City *	Cairo, Egypt	5.600	2011
Medimall Shopping Center *	Rotterdam, The Netherlands	700	2011
HDI-Gerling Versicherung *	Hannover	300	2011
Sparkasse Nürnberg *	Nürnberg	110	2011
Le Flair Condominium Complex *	Düsseldorf	230	2011
Hauptzollamt Hamburg *	Hamburg	50	2011

* under contract
** design contract