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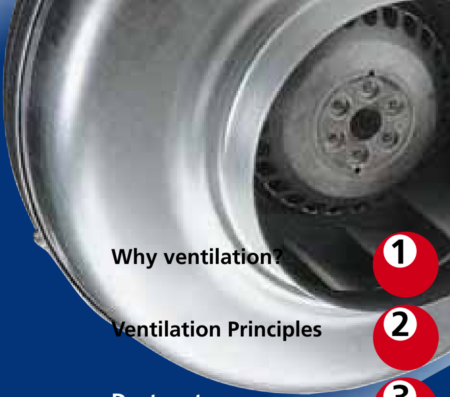
step by step

*" Some small steps,
or one giant leap
for an efficient
ventilation."*

step by step



WHY VENTILATION?

This handbook is yet another step in Östberg's effort to give everyone the possibility of clean indoor air. We know that good ventilation is important for good health and well-being, and to ensure that our homes are not damaged by moisture and mould.

Many of our customers share our interest in good ventilation and want to learn more about it.

This book is structured in several stages, ranging from the basics of a good ventilation system and various ventilation principles, to how to use our products most effectively and how pressure drop and sound calculations are made. The final sections describe certain elements in more detail and use charts, tables and Mollier diagrams to further describe the properties of air and ventilation.

We also demonstrate the benefits of energy recovery using several calculation examples. The rising cost of energy makes this quite interesting reading

The last pages of the book also contains a glossary with explanations.

We hope that this book will serve to increase both your interest in and your understanding of good ventilation and what is required to achieve it.

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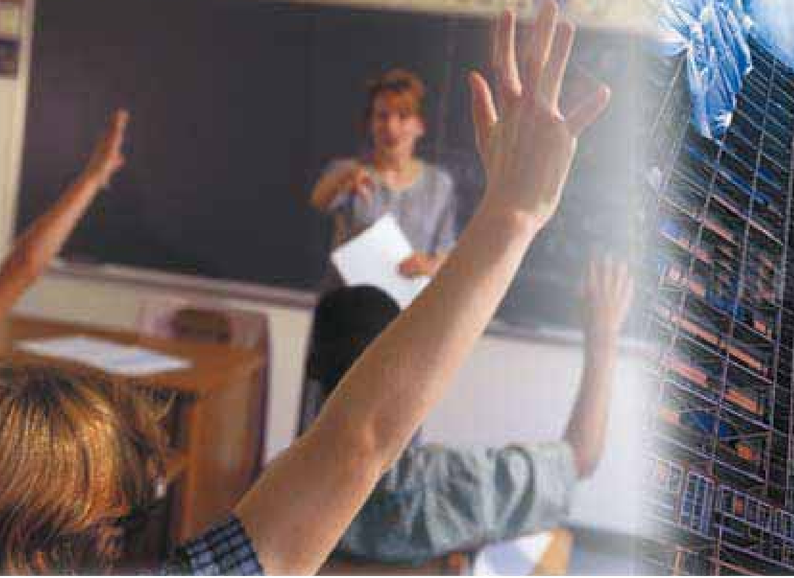

A GOOD INDOOR ENVIRONMENT

Ventilation serves several purposes: it ventilates away impurities from building materials, moisture, body odours, cooking odours and harmful substances (such as radon), and replaces these with fresh air.

Minimum requirements for airflow are often specified in national housing standards. The design flow for each specific house, however, depends on how the building is used and by how many people.

The majority of studies show that inadequate ventilation leads to health complications such as asthma, allergies, poor sleep and difficulty concentrating. Excessive amounts of radon can even cause cancer.

OXYGEN NEEDS

A person at rest breathes 4-6 litres of air every minute. During heavy physical exertion, these figures can increase to 100-120 litres a minute.

Oxygen is required to oxygenate the body's cells. The

lungs then ventilate out the carbon dioxide and water that is formed during the body's metabolic process. This is a vital process to maintain proper body function.

RESIDUAL PRODUCTS

Building construction materials can include a number of different materials that over time secrete particles and gases that are detrimental to health and need to be removed from the building. Furniture and textiles may also contain various types of substances to make them more fire-resistant and stain-resistant.

Different types of plastics contain softening agents and solvents that are not good for human health. Human beings produce carbon dioxide as a waste product during the metabolic process. A high concentration of carbon dioxide in the air we inhale makes us tired and have difficulty concentrating.

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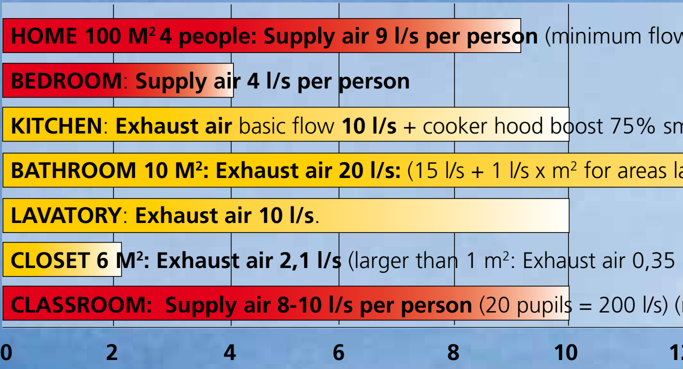


MOISTURE

Moisture enters our homes through washing, bathing and cooking, but the air we breathe out also contributes to increased moisture content in indoor air. Too much moisture can lead to mould and also stimulates the growth of mites, which in turn are allergy-inducing.

SURPLUS HEAT

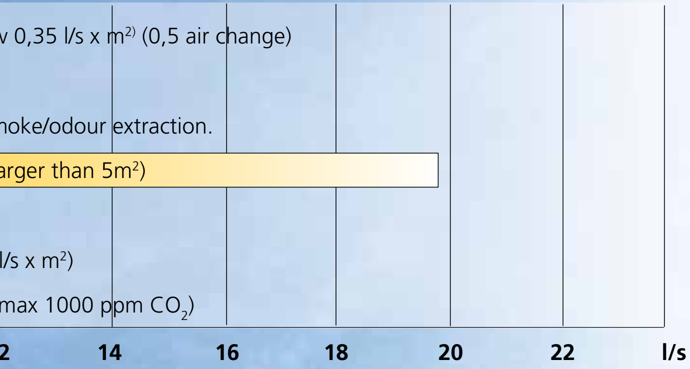
A good indoor temperature contributes to increased comfort and productivity.

Designing ventilation to remove a portion of the surplus heat is a good investment.

DESIGN REQUIREMENTS FOR VENTILATION

Some of the minimum airflow requirements in force in Sweden are shown here as examples.

When planning and designing ventilation, heating, etc., you must refer to the laws and ordinances in force in your own country.

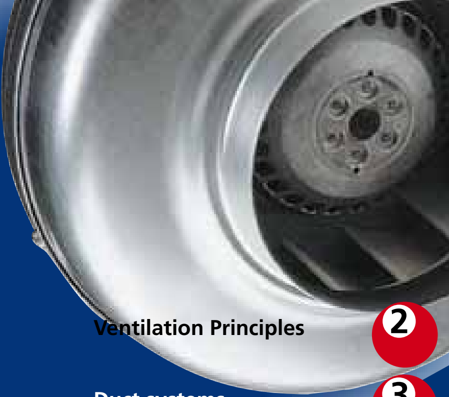


'BBR' (Swedish Board of Housing, Building and Planning) stipulates that the minimum airflow for home ventilation systems in Sweden be set so that the air is replaced at a rate of **0.5 times per hour**. If the home is used by a large number of people or sees a great deal of activity, however, this figure will not be sufficient to maintain a good indoor environment.

'BBR' gives the following advice: *"Planning and design should take into account the effect of occupancy rates, activities, additional moisture, and emissions from materials, ground and water."*

If the building is not in use for a period of time during the day, the quantity of air may be reduced, though may never be less than 0,1 l/s x m^2.

step by step



VENTILATION PRINCIPLES

The function of ventilation is to provide fresh air wherever people are present. In homes, fresh air is supplied to the living room and the bedrooms. The used air is directed away from areas such as bathrooms, laundry rooms and kitchens.

To ensure good ventilation, you must choose the right ventilation principles. This means that all areas must be ventilated using the correct airflow, regardless of external circumstances.

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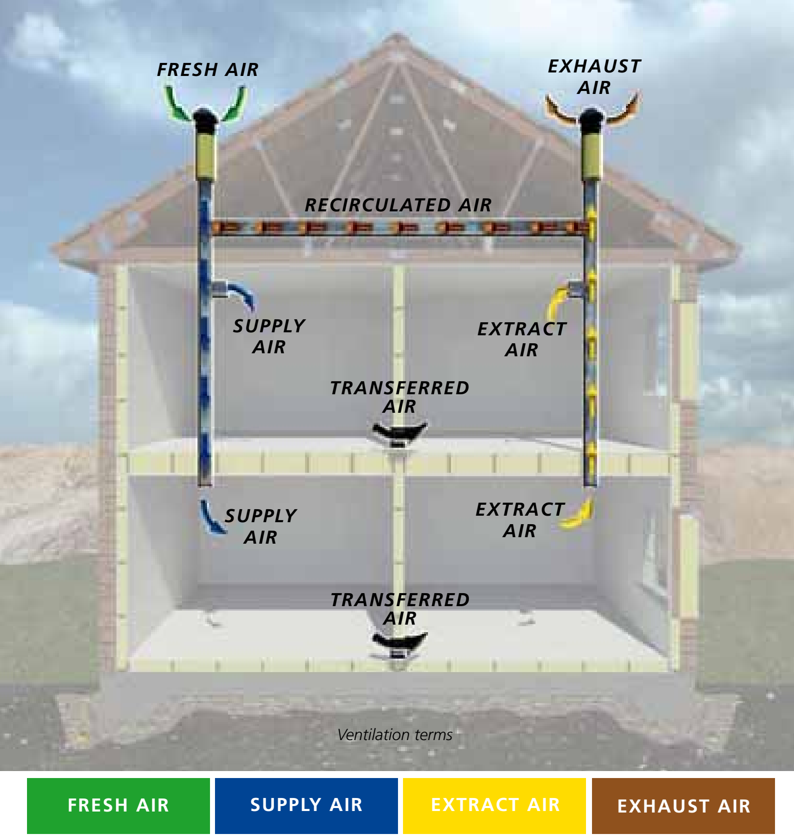
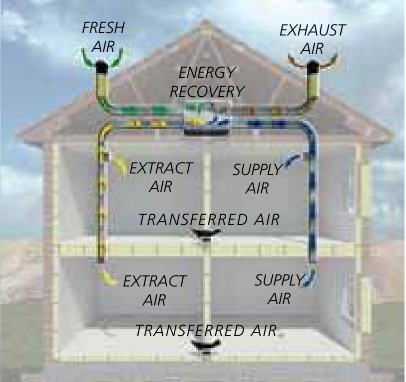


Ventilation terms

VENTILATION TERMS

Air travels through a building on a path from clean areas to areas that are less clean.

To ensure that the air travels the path it is supposed to (regardless of ventilation principles), transfer air devices or slots in the bottom of doors are required. This helps to optimally utilize the outdoor air supply.



Supply and exhaust air ventilation with energy recovery

SUPPLY AND EXHAUST AIR VENTILATION WITH ENERGY RECOVERY

With rising energy prices and an increased demand for energy recovery, this type of ventilation should be the primary option in new installations.

Supplying filtered and tempered fresh air to the occupied zone without draught, and with flows adjusted for both supply and exhaust air, these systems are also best in terms of comfort.

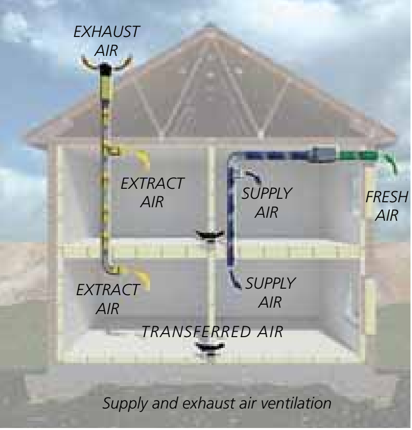
These units also often have the option of demand-controlled ventilation, i.e. a higher flow when necessary and a minimum flow when possible.

In addition to all these other benefits, the systems also recover heat/cold in the exhaust air.

Energy recovery can take various forms, but recovery rates in rotating heat exchangers can be up to 86%. This means that 86% of the energy – in the form of either heat or cold – in the exhaust air is recovered and transferred to the supply air. This system thus works just as well for the recovery of cold and can, for example, be used when there is a separate cooling system in the home and the indoor temperature is lower than the outdoor temperature.

In certain circumstances, the rotating heat exchanger can also transfer moisture. This is particularly advantageous in countries with cold climates, where during the winter it is desirable to retain and restore moisture in the indoor air that could otherwise become quite dry.

Operating costs derive from the energy consumption of the fans and the energy loss from the heated exhaust air that is not recovered (approx. 15%).



Supply and exhaust air ventilation

SUPPLY AND EXHAUST AIR VENTILATION

In this system, both the exhaust air and the supply air are fan-controlled. This means that flow can be adjusted on both the supply air side and the exhaust air side, i.e. you can control both the flow and where you want to have it.

This system can be equipped with filters and cooling or heating coils to heat/cool the supply air. This provides a high degree of comfort.

The disadvantage is that energy recovery from the exhaust air is not possible.

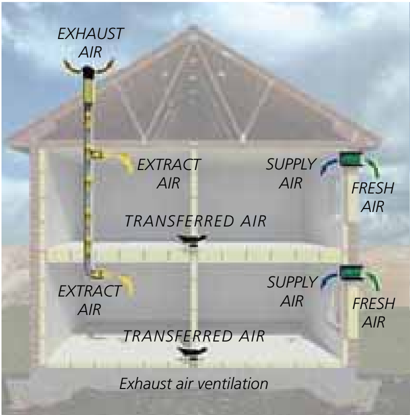
Operating costs derive from the energy consumption of the fans and the energy loss from the cooled/heated exhaust air (100%).

EXHAUST AIR VENTILATION

This type of ventilation is commonly found in older constructions.

The system consists of a duct system for exhaust air with a fan to ensure an even and adjustable airflow.

Fresh air is supplied to the rooms unheated and unfiltered through openings above the windows or in walls. Because the air just takes the simplest route into the building (open windows, places that are not sealed correctly), it is difficult to control where the air enters the building and therefore to adjust air volume. There is therefore a great risk for draughts and inflow of cold air in countries with cold climates.



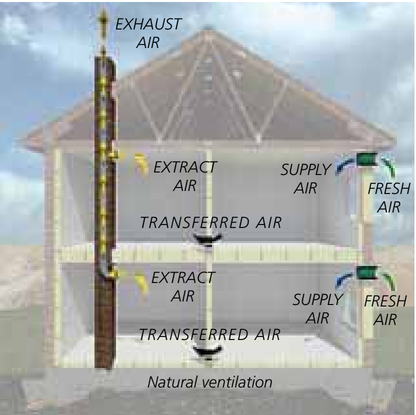
Exhaust air ventilation

Another drawback is that it is not possible to recover energy from the exhaust air

Operating costs derive from the energy consumption of the fans and the energy loss from the heated/cooled exhaust air (100%).

One variant of exhaust air ventilation is the exhaust air heat pump. This type of system works in the same way as a regular exhaust air ventilation system, but also uses heat pump technology. The heat in the exhaust air is recovered in the heat pump and transferred to a tap water system or a heating system.

Operating costs derive from running the heat pump and from the heat that is not recovered (100%).



Natural ventilation

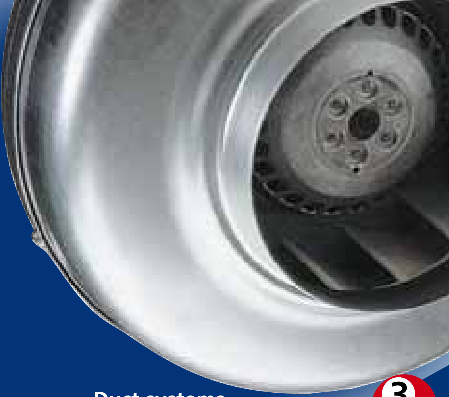
NATURAL VENTILATION

The simplest type of ventilation, natural draught, has been used throughout history. In its earliest forms, natural ventilation consisted of a hole in the roof or wall to direct smoke out of the structure. Ventilation shafts later came into use. Natural ventilation is based on differences in air density at different temperatures.

The drawback is that temperatures vary throughout the day, and particularly with the seasons.This means that the ventilation airflow fluctuates, and also that the flow is greatest when the difference in temperature is greatest, i.e. in the winter when it is cold outside and warm inside. It is not possible, in other words, to adjust airflow to the desired rate. Fresh air is unfiltered and is supplied to the room untempered through openings above the windows or in walls. There is therefore a great risk for draughts and cold air inflows in cold countries. The energy from the exhaust air cannot be recovered.

Operating costs derive from losses from the heated/cooled exhaust air that leaves the building (100%).

step by step



DUCT SYSTEMS

A duct system must meet the requirements set for the construction.

Duct systems lead fresh air to the areas fresh air is desired and evacuate the used air from other designated areas.

This places many demands on the duct system: It must be fully sealed, it must not generate noise and it must not cause unnecessary pressuredrops. It must also be possible to clean a duct system after many years of use.

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A duct system can consist of a number of different components, each with its own function. However, they must work effectively together to meet the requirements of the construction.

One thing that is very important to consider is the speed of the air through the duct system. High airspeeds create both noise and high pressure drop. High pressure drop means that the fan has to work harder than what is actually necessary, which leads to higher power consumption.

The rule of thumb is that the nearer the duct system is to the rooms it is servicing, the lower the flow velocity should be.

In ventilation systems used in homes, speeds should not exceed 3 m/s and no more than 2 m/s at the diffuser.

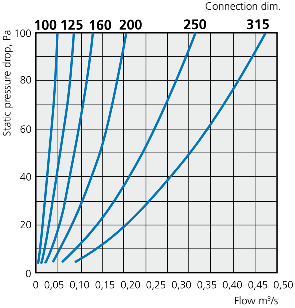
PRESSURE DROP

In order to be able to choose the correct unit/fan, a pressure drop calculation must be made on the duct system.

A well-designed duct system with good components, which takes into account low speed in the ducts and low rates of pressure drop in the components (such as diffusers and grilles), is free from leaks, generates less sound and requires less energy to run.

If you use spiral ducts in the ventilation system, the manufacturer will provide information on pressure drop at different air speed.

Read more about pressure drop calculations on page 88.



Example of pressure drop diagram, here for filter boxes.

DUCTS

Circular, spiral ducts of galvanized steel sheet should be used if possible.

Ducts are connected to fans and other units in the system using duct components equipped with sealing rings to reduce vibrations and ensure good sealing. Where rubber seals are not possible, mounting clamps are used instead.

Mounting clamp MK.

Each of these prefabricated components, such as bends, bifurcations and connections, has its own pressure drop diagram showing the pressure drop at different airflows.

If flexible ducts are used, these must be fully stretched and the bends must be wide and soft so that the pressure drop in the system will not be too high.

The ducts are mounted with rod hangers or attached to the building in some other way (e.g. with perforated strips).

Ducts and duct components are attached to each other using riveted joints or approved screws/bolts to stop it coming apart.

INSULATION

Insulation in ducts can serve several purposes: heating, cooling, protection from condensation, or fire-proofing.

Different types of insulation are used for different purposes.

Thermal insulation is used when warm air is transported in ducts that are routed to cold areas (attics, etc). The thickness of the insulation depends on the diameter of the duct and on the climate.

Anti-condensation insulation consists of thermal insulation with an airtight top layer. This type of insulation is primarily used in ducts that transport cold air through warm areas. The insulation prevents condensation from forming on the exterior of the duct and risking moisture damage in the surrounding areas. In air conditioning systems, anti-condensation insulation is used in conjunction with thermal insulation.

Fire insulation must be type-approved and the thickness of the insulation must correspond to the type-approval for the desired fire class for the insulated area. This type of insulation is used when the duct passes through a fire cell and in the insulation of exhaust outlet ducts such as kitchen flues.

Example of an insulated duct (bottom duct). The two ducts above have silencers

SILENCERS

Silencers are almost always required in ventilation systems, as all fans generate sound. In most cases, the room the duct is servicing or the surroundings (neighbours) will determine sound requirements.

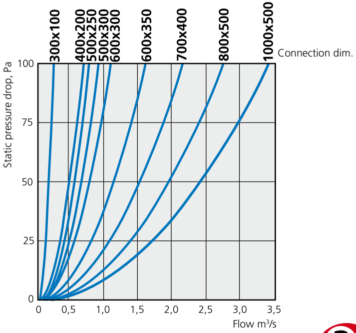
The most common type of silencer consists of a pipe or a box made of galvanized sheet steel that is insulated on the inside. These are fitted with circular or rectangular duct connections.

This capacity, however, depends on the length of the silencer and the thickness of the insulation.

The rectangular silencers also have internal baffles (walls) to improve sound attenuation.

The silencer are placed between the fan and the areas being serviced.

The pressure drop for circular silencers is usually negligible; when using rectangular silencers, you must refer to the manufacturer's pressure drop diagram.



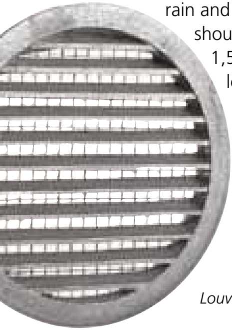
Example of pressure drop for rectangular silencers.

Silencers are also available as flexible hoses that are also insulated in the inside, but with a top layer of heavy plastic or thin fibreglass-reinforced aluminium foil.

These have poorer sound attenuation abilities than silencers made of steel sheet and as such, usually cannot replace these. However, they can instead be used as supplemental silencers in the duct system. The drawbacks of these silencers include pressure drops if they are mounted in sharp bends and a "leaking" of sound to the surrounding area. They should therefore not be placed in sound-sensitive areas.

AIR INTAKE

Louvres should be mounted to best advantage on the shadiest side of the building. To prevent noise and moisture accumulation through rain and snow, speeds should not exceed 1,5 m/s over the louvre.



Louvre, YG.

DAMPERS

The function of the damper in the system can vary. Dampers are used both as shut-off valves for outdoor air or smoke from fires, and to adjust airflow. They all have different characteristics in terms of degree of sealing, temperature resistance and function.

The most common type of damper in ventilation systems is for controlling the air volume. These are used primarily in slightly larger duct systems in which it is desirable to adjust air volumes individually in each section of ducting.

Using dampers for throttling is not desirable, as this gives the fan a higher pressure to work against and thereby also increases energy consumption.

In a well-balanced system, the diffuser is primarily used to measure the airflow.

Balancing valves are almost never used in home ventilation systems, as these duct systems are so small and the airflow is adjusted by the diffuser.

DIFFUSERS

There are a number of different types of diffusers with different characteristics, and the choice of which to use depends entirely on your objectives and the placement options available.

Diffusers are available for placement in ceilings, walls or floors.

Floor diffusers are of the ”displacement” variety. This means that fresh air is supplied at floor level, is heated in the room and then rises toward the ceiling where the exhaust air diffuser is located.

Ceiling and wall diffusers are of the mixing system variety, in which fresh air is mixed with the air in the room and then directed out. Most ceiling and wall diffusers have adjustable distribution patterns and throw.

Ceiling or wall diffusers are most commonly used in home ventilation systems. The objective is for the supplied air to have the longest route possible in the ventilated room without creating draught.

Throw is often specified as L0.2 or L0.15, and the distances from the diffuser expressed in air velocity are 0.2 m/s and 0.15 m/s. These speeds should not be exceeded in the comfort zone (where people are present).

Other properties that are important to consider when selecting a diffuser is how much sound the diffuser produces and how much pressure drop it generates.

Floor-installed diffuser with exhaust air diffuser in ceiling.

Ceiling and wall-installed diffusers.

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FILTERS

A high collecting efficiency at a low pressure drop is the objective. For home ventilation, an F7 filter, which stops particles as small as 0.001 mm (1 μm), is a good choice.

Basic G-class filters are used when there are no requirements for collecting efficiency (e.g. in circulation cooling of devices), but should not otherwise used unless as pre-filters in a fine filter.

Filter class	Minimum collection efficiency 0,4 μm	0,85 μm
F5	2%	14%
F6	12%	30%
F7	50%	70%
F8	70%	86%
F9	80%	91%

The fine particles from road traffic and other types of combustion are considered the most dangerous to health (about 1 μm in diameter).

Pollen particle size varies from 10 to 30 μm in diameter (0,010 – 0,030 mm).

DUCT HEATERS

There are two types of duct heaters used in ventilation systems: Electric or hot water. A duct heater heats the air that passes through it. The number of degrees the air is heated depends on the power of the duct heater.

The electric duct heater must have some type of control so that the air can be heated to a set temperature.

Pulsers are often used in conjunction with temperature sensors as controls for electric duct heaters. The pulser releases voltage for different durations of time according to how many degrees the air needs to be heated. An electric duct heater should have some type of interlocking device so that the heater cannot be activated when there is no flow. The airflow over an electric duct heater may not be too low either, because then the surface temperature on the heater will be too high.

On heating coils, a control unit opens and closes a valve which increases and decreases the flow of hot water through the heating coil.

A heating coil must be equipped with some type of anti-freeze device to protect the heater coil from freezing and causing water damage.

Units with heat recovery may also require duct heaters in very cold climates.

COOLING COILS

Cooling coils are not very common in ventilation in single family houses, but can provide a more comfortable indoor climate on warm summer days.

Water from downhole heat exchangers (geothermal heating), which maintain a temperature of 6-8°C in Sweden, are often used instead of cooling coils. To achieve a greater cooling effect, air volumes should be increased somewhat above normal levels.

The cooling coil must be equipped with a condensation water draining device, as the cooling coil also dehumidifies the supply air through condensation in the coil. Controls consist of a unit with a temperature sensor that opens/closes a valve to adjust the flow through the coil (2-way valve) or increases/decreases the ratio of warmer return water to adjust the cold water temperature (3-way valve).

step by step

DIFFERENT TYPES OF FANS AND AIR HANDLING UNITS (AHU)

The fan's role in the system is to put the air in motion, supplying the kinetic energy required for the air to reach the serviced areas by moving through the duct system and its components.

The fan must meet many requirements: it must be energy-efficient, quiet, small and easy to install. It must also have a low installed cost, require little maintenance and have a long life.

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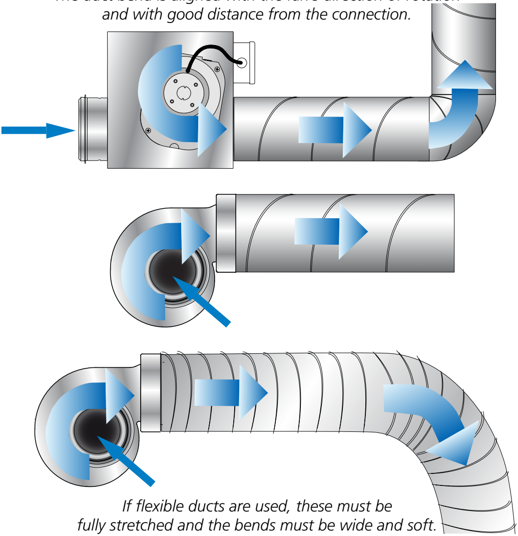
CORRECT

The duct bend is aligned with the fan’s direction of rotation and with good distance from the connection.



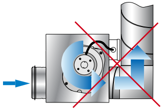
If flexible ducts are used, these must be fully stretched and the bends must be wide and soft.

If possible, the fan/unit should not be placed in direct connection to sound-sensitive areas such as bedrooms, living rooms or offices.

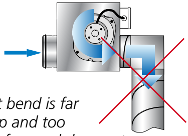
It is very important to ensure that the fan is connected properly to the duct system, for reasons of both pressure drop and sound. If not connected correctly, sound levels could increase by 4-6 dB and pressure by several (or at worst, hund-reds) of Pascals.

Because the air velocity at the inlet and outlet of the fan can be relatively high, and the speed profile after the fan uneven, special care must be taken at bends and bifurcations. If possible, bends should be preceded by 4-5 diameters of straight duct, and the bend itself should be smooth and

INCORRECT

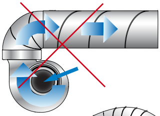


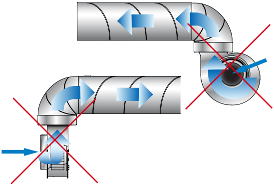
The duct bend is far too sharp and too near the fan.



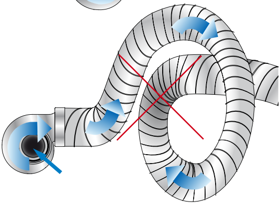
The duct bend is far too sharp and too near the fan, and does not follow the fan's direction of rotation.

The duct bend is too near the fan.





The duct bend does not follow the fan's direction of rotation. The total sound level and pressure drop increases. If the fan is also turned in the wrong direction, sound levels increase even more.



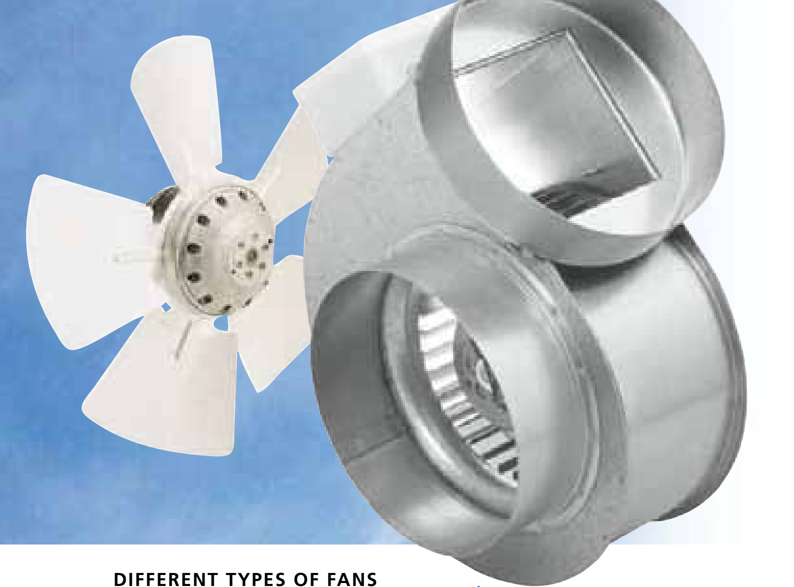
A flexible duct with too many and sharp bends. The pressure drop increases.

follow the direction of fan rotation.

The fan/unit must be installed in such a way that it is easily accessible for cleaning and service.

The unit and larger fans must be installed so that structure-bound sound cannot be transmitted. These should be placed on thick sheets of insulation or on vibration dampers. Wall-hung units must be fitted with vibration damping mounting devices.

If the fan distributes dirty air, a filter should be installed before the fan, as this will increase the service life of the fan and help prevent the impeller from getting dirty and impairing fan function.

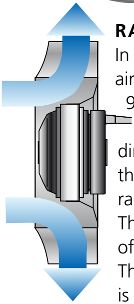


DIFFERENT TYPES OF FANS

Generally speaking, there are three main groups of fans: Radial (centrifugal), axial and tangential.

The most common fans used in ventilation are radial fans with either backward or forward curved blades.

In addition to impeller size, fan rotation speed (rpm) is a determining factor in the resulting pressure and flow. High rotation speeds lead to high flow and pressure, but higher rotation speeds also generate more sound and consume more energy.

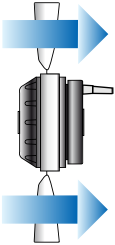


RADIAL FANS

In a radial fan, the air stream is angled 90°, the supply air enters in an axial direction and leaves the fan wheel in a radial direction. There are two types of radial impellers. The most common is impellers with forward or backward curved blades. Radial fans with straight blades are common when particles are transported with the gas/air.

Radial fans with forward curved impellers must be combined with a scrollshaped fan housing in order to run. The design of the scroll is very important to the fan's performance. For other radial fans, the shape of the fan blades is the most determining factor in fan performance. A scroll is not required, but can be used to further increase fan pressure.

Raidal fans are used almost everywhere gases are transported.



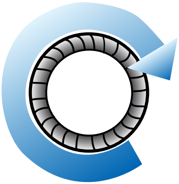
AXIAL FANS

Axial fans have an axial airstream and give relatively high airflows, but relatively low pressure rates and high sound levels.

Axial fans are used where there is a need to transport a large amount of gas where there is a low pressure drop.

Common uses are as cooling fans, drying fans, tunnel fans, etc. Axial fans are also used in conjunction with guide vanes in certain types of duct fans where the design of the guide vanes and impellers improve fan pressure. However, sound levels increase even more in this method.

A major drawback of axial fans is that power needs increase with increasing pressure, which can cause the motor to overheat, for example when the filter becomes clogged.



TANGENTIAL FANS

Tangential fans have a tangential airstream and are also used for transporting relatively large amounts of gas/air at low pressure.

Tangential fans are compact in construction and work very well in small air curtains, etc.

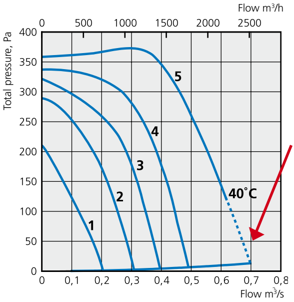
DIFFERENT IMPELLERS (FAN WHEELS)

FORWARD CURVED

Fans with forward curved impellers provide a compact solution and are most competitive at relatively high pressures, where they also have their highest efficiency.

It is important when choosing a fan with a forward curved impeller to ensure that it is correctly positioned in the area shown in the diagram. At low pressure and high airflow, a forward curved impeller requires a great deal of power from the motor, but the motors are often not designed for this. This is shown with a dotted line in the pressure/flow diagram and referred to as “prohibited work area”. Within this area, the motor overheats very quickly. One drawback of forward curved impellers is that dirt and impurities easily get caught on the concave side of the impeller, which impairs capacity and can cause imbalance. If the impeller gets dirty, it must be cleaned, which can be rather difficult. But a fan with a swing-out function makes this easier.

Forward curved impellers are used in several of our fans, including our LPK and RK duct fans, IRE insulated duct fan, RF and DF single and double inlet centrifugal fans, etc.



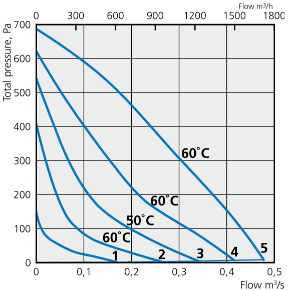
It is important when choosing a fan with a forward curved impeller to ensure that it is correctly positioned in the area shown in the diagram. At low pressure and high airflow, a forward curved impeller requires a great deal of power from the motor, but the motors are often not designed for this. This is shown with a dotted line in the pressure/flow diagram and referred to as ”prohibited work area”. Within this area, the motor overheats very quickly.

BACKWARD CURVED

If you choose a fan with backward curved impeller for the same pressure and flow as a fan with forward curved impeller, the fan with backward curved impeller will be larger than the forward curved.

The advantage of choosing this type of fan is that the backward curved impellers have higher efficiency, which means that the fan consumes less energy at the same pressure and flow. The backward curved impeller has the highest power consumption where the efficiency rate is best.

Another advantage of these fans is that the impeller does not get dirty as fast as the forward curved, and they are significantly easier to clean when they do.



Fans with backward curved impellers have higher efficiency, which means that the fan consumes less energy at the same pressure and flow. The backward curved impellers has the highest power consumption where the efficiency rate is best.

Backward curved impellers are used in our CK, LPKB and RKB duct fans, IRB and RKBI insulated duct fans, RB single inlet duct fans, etc.

MIXED FLOW WHEELS

Mixed flow wheels (or diagonal fans) are a cross between axial and radial fan wheels. They have lower pressure and efficiency rates than centrifugal fans and lower flow than axial fans.

AIR HANDLING UNITS (AHU)

An air handling unit (AHU) is a composite machine with several different functions compiled into one unit. What components are used in the system depend on the end function desired.

An air handling unit can consist of a filter component that cleans the incoming air, a cool/heat exchanger that recovers the energy that otherwise would have followed the exhaust air out of the building, and a fan component that transports the clean and heated/cooled air to the various rooms being serviced.

The unit can also contain a heating or cooling coil for warming or cooling the supply air, as well as a damper that shut out the fresh air intake. Larger units may also contain a humidifier, either on the exhaust air side for evaporative cooling or in the supply air side for humidification.

There are several types of heat exchangers, exchangers that also utilize the energy in the moisture (ERV, Energy Recovery Ventilation), and exchangers that only transfer heat (HRV, Heat Recovery Ventilation).

If moisture transfer is desired, use a rotating heat exchanger.

A control system is necessary for the operation of the air handling unit. This system controls all functions, such as supply air temperature, and alarms if the system is not functioning properly or if it is time for service.

Many air handling units come pre-equipped with an integrated control system adapted to the specific model and functions desired.

HERU®

HERU® is a supply and exhaust air unit with energy recovery.

HERU® contains a filter with a high collection efficiency rate to separate pollen and other particles from the air, and a rotating heat exchanger energy recovery component with a high efficiency.

A built-in electric duct heater is included standard on most models. If a heating coil or cooling coil is preferred instead, these are available as accessories for installation in ducts.

The fans used in HERU® have high efficiency with both AC and EC motors. The HERU® S has 50 mm of insulation in the casing and can be placed in cold areas such as attics. HERU® T must be placed in warm areas such as in utility rooms or laundry rooms.

HERU® is an air handling unit containing an advanced and integrated control system with many smart functions. It allows both constant supply air temperature and room temperature regulation. You can set it to reduce the temperature at night or provide demand-controlled ventilation via the CO_2 sensor or humidifier. If you choose a unit with EC motors, you can also have constant flow. The unit's flow can also be increased or decreased with a timer.

The status of the unit, e.g. temperature and current operating mode, is shown continually in the remote control. The remote control can also be used to change all settings if necessary.

SAU

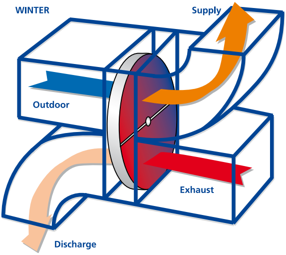
SAU is an air handling unit for only supply air without energy recovery.The unit supplies filtered and clean air, heated via an electric heater or heating coil, to the premises via an energy efficient fan with backward curved impeller and an external rotor motor.

HEAT EXCHANGER

A heat exchanger transfers energy in the form of heat between two media without mixing.

In a ventilation system, heat is transferred from the exhaust air to the supply air, or the reverse if you would like it to be cooler inside than it is outside.

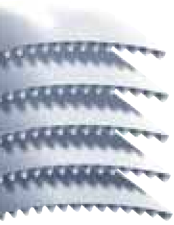
There are two main types of heat exchangers:
Regenerative (rotating)
and
Recuperative (plate/cross-flow).



REGENERATIVE

In regenerative heat exchange, the material in the exchanger is heated by a warm airstream (exhaust air) that is then transferred to a cold airstream (supply air), where it can emit its heat.

Rotating heat exchangers are an example of regenerative heat exchange.



ROTATING HEAT EXCHANGER

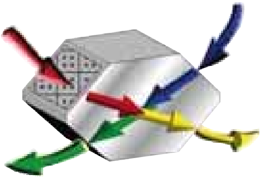
A rotating heat exchanger consists of one corrugated and one smooth aluminium plate that are wound to a wheel. The air moves past the rotating wheel through the channels. The warm exhaust air heats the rotating exchanger which in turn heats the cold outside air.

Heat recovery is controlled by the on/off switch or by controlling the rotation speed.

In cold weather, moisture is also transferred from the exhaust air to the supply air, which prevents dry indoor climate.

The temperature efficiency can be up to 85%. Specially designed rotors with moisture-transfer coatings. These provide a moisture transfer of up to 90%, which can be compared to standard rotors that have of 50-60% when there is condensation.

The rotors are also used in evaporative cooling, where the exhaust air is humidified and the input heat vaporization then lowers the temperature of the supply air by 3-5°C.



RECUPERATIVE

In recuperative heat exchangers, heat is transferred from the warm side (exhaust air) to the cold side (supply air) by directing the heat through the wall that separates the two media.

Plate/Cross-flow heat exchangers are one type of recuperative heat exchanger.

HEAT PLATE EXCHANGERS

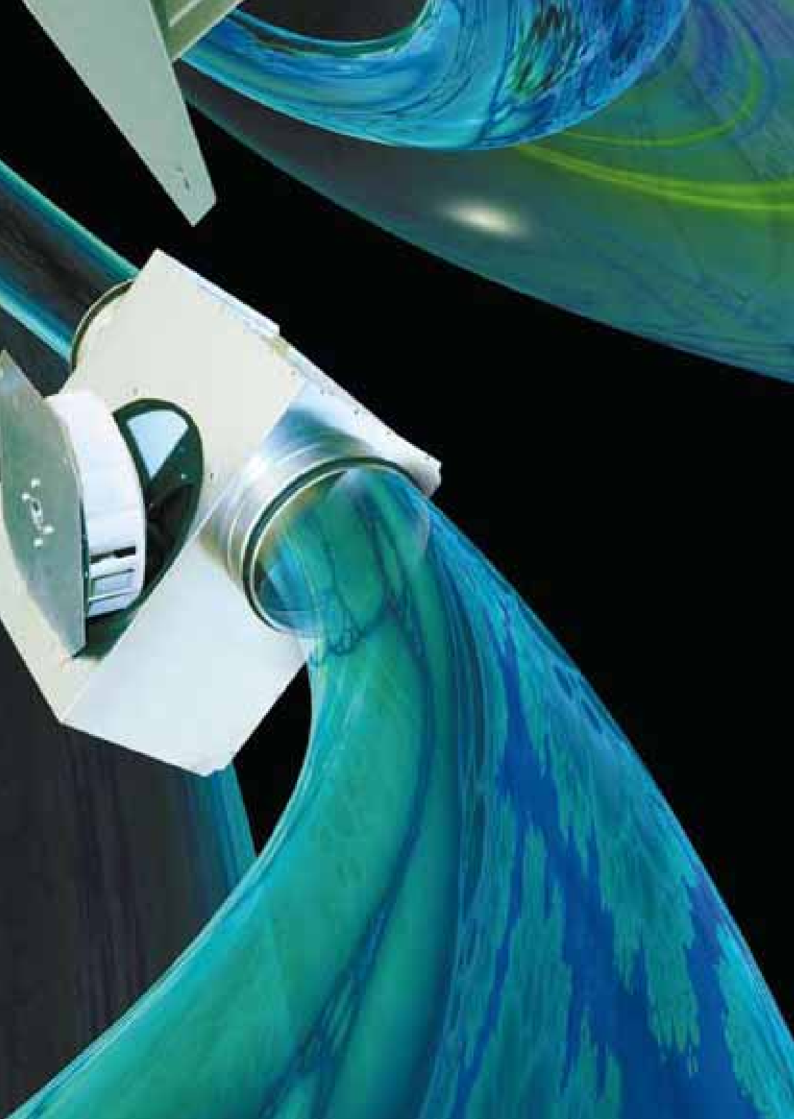
A plate heat exchanger consists mainly of parallel aluminium plates, where the warm air passes on one side of the plate and the cold air passes on the other side. Heat is transferred through the plate. Moisture cannot be transferred and the temperature efficiency is 50-70%. To raise temperature efficiency, two exchanger units can be mounted one in front of the other.

Condensation can occur in the heat exchanger and must then be conducted away. This condensation can cause the exchanger to freeze and can lead to reduced flow and function. This problem requires some sort of control to solve. One way is to reduce the supply airflow and thus heat up the exchanger with a larger proportion of exhaust air. Another way is to preheat the fresh air by placing a heating coil before the heat exchanger.

Temperature is controlled via a bypass damper when the air is routed past the heat exchanger or in simpler constructions, where the exchanger must be taken out of the unit.

Read more about calculating temperature efficiency rates and energy savings on page 98.

step by step



FLOW REGULATION

Often, a fan's airflow needs to be regulated, either by setting it to the desired flow or by using some type of demand-control. In demand control, a low flow is permitted to save energy when the premises are not heavily occupied, and higher flow is used when necessary.

There are several different ways to regulate flow, but the most common is to change the voltage to the fan. In demand control, additional equipment may be required. This may comprise anything from a simple switch for manual control of fan speed to a regulator that continually adjusts the flow as needed.

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FLOW CONTROL BY REGULATING THE FAN'S ROTATION SPEED

In this type of control, flow and pressure in the system are changed according to the system curve.

On our fans, rotation speed can be controlled by voltage or frequency regulation.

What is important to consider when choosing what type of controls to use is that they must be able to handle the fan's maximum current consumption. When choosing controls for large fans, you should take into account the starting current and make sure there is sufficient margin for this.

TRANSFORMER

The transformer lowers the voltage but maintains the alternating current sine wave, which is beneficial to fan function. Lowering voltage, however, will often cause current to increase, which is something that must be taken into account when using current-sensing circuit breakers. The fan's maximum possible temperature on transported air is reduced when the current increases and the cooling airflow decreases.

THYRISTOR

The function of the thyristor is to “chop up” the voltage into pieces. The alternating current sine wave is therefore affected.

When lowered substantially, this can lead to a buzzing sound in the motor.

Current may also increase, which will result in a reduced possible temperature on transported air.

FREQUENCY CONTROL

The sine wave is affected in such a way that the periodicity is changed from its normal 50 Hz. This method of speed control is costly and most common on large 3-phase motors. Single phase external rotor motors should not be frequency-controlled.

One drawback of frequency control is that the equipment can emit radio waves that may interfere with the radio receiver and transmitter, which means that the equipment must be EMC-approved and installation must be performed in an approved manner.

FLOW REGULATION BY CHANGING PRESSURE

It is possible to regulate the flow in a system by means of dampers and valves.

In this type of control, the pressure in the system is changed and the operating point is moved in the fan diagram.

Normally, achieving the lowest pressure possible in a system is the objective. Increasing the pressure in a system to reduce flow is not a good solution from an energy efficiency standpoint. High pressure usually also leads to higher sound levels.

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step by step

FRESH AIR

SUPPLY AIR

EXTRACT AIR

EXHAUST AIR

EXAMPLES OF DIFFERENT VENTILATION SOLUTIONS

A ventilation system should be planned and designed according to the various requirements set by authorities, customers, etc. These requirements may concern minimum air quantity, noise, filtering rate, sealing and energy consumption. Requirements vary according to the type of premises and what activities are conducted there.

To ensure the best ventilation, highest energy efficiency and lowest noise levels possible, it is important that the fans are installed correctly.

The following pages show some examples of ventilation solutions in various types of premises.

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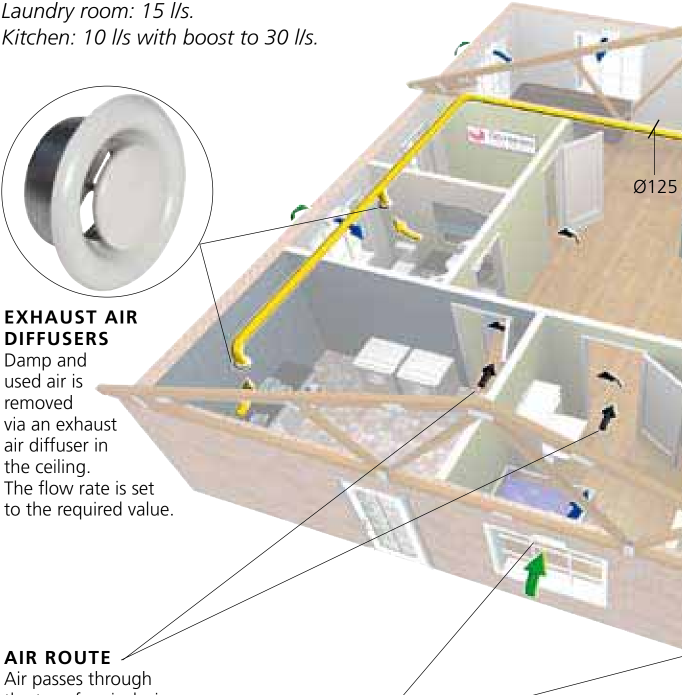
HOME, EXHAUST AIR

120 m²: 0,35 x 120 = 42 l/s.

Bathroom 7 m²: 15 l/s + 2 = 17 l/s.
Laundry room: 15 l/s.
Kitchen: 10 l/s with boost to 30 l/s.

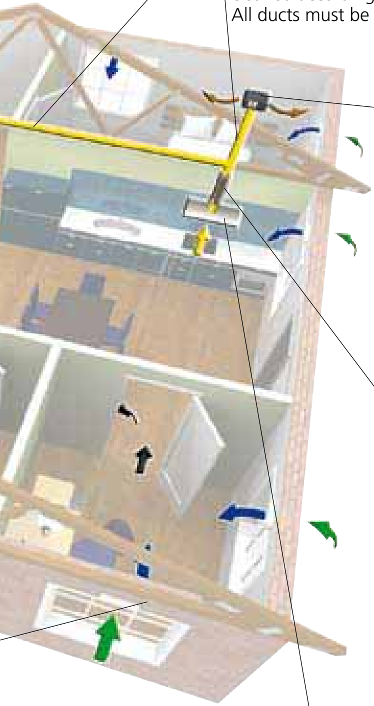


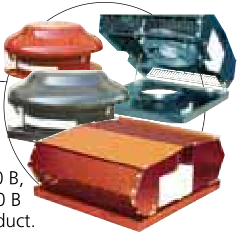
EXHAUST AIR DIFFUSERS
Damp and used air is removed via an exhaust air diffuser in the ceiling. The flow rate is set to the required value.

AIR ROUTE
Air passes through the transfer air device or slot in the bottom of the door to bathrooms, lavatories, kitchens and laundry rooms.

FRESH AIR INTAKE
Fresh air enters the bedroom and living room.

DUCTING
Ducting in the attic is thermal insulated to prevent condensation of warm and damp air in the ducts.
NOTE: The kitchen duct from the cooker hood must be cleaned according to law.
All ducts must be able to be cleaned.





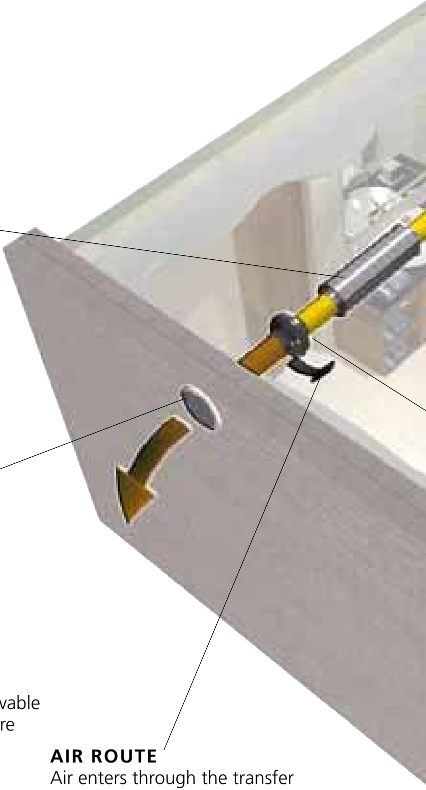
ROOF FAN
TKC/TKS 300 B,
TKV/TKH 300 B
with ceiling duct.
Easily opened for cleaning.
Transformer controlled via cooker hood.

SILENCER
Diameter Ø 125 mm,
between fan and residence.

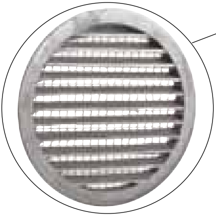
BASE FLOW
taken through cooker hood. Boosting the cooker hood opens the damper and/or increases fan speed.

BATHROOM, EXHAUST AIR

Approx. 7 m^2: *5 m^2=15 l/s + 1 l/s /m^2 = 17 l/s.*

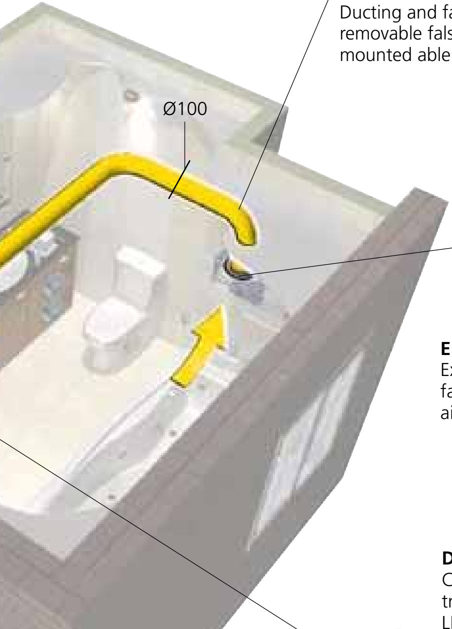


SILENCER
Diameter Ø 100 mm,
500-1000 mm long and
30-50 mm insulation.



LOUVRE
This installation requires a removable false ceiling for service and louvre of type YG 125.

AIR ROUTE
Air enters through the transfer air device or slot in the bottom of the door from adjoining rooms.



DUCTING
Ducting and fan are installed above removable false ceiling. The fan must be mounted able to be cleaned.

EXHAUST AIR DIFFUSER
Exhaust air diffuser placed farthest from the transfer air device or slot under door.

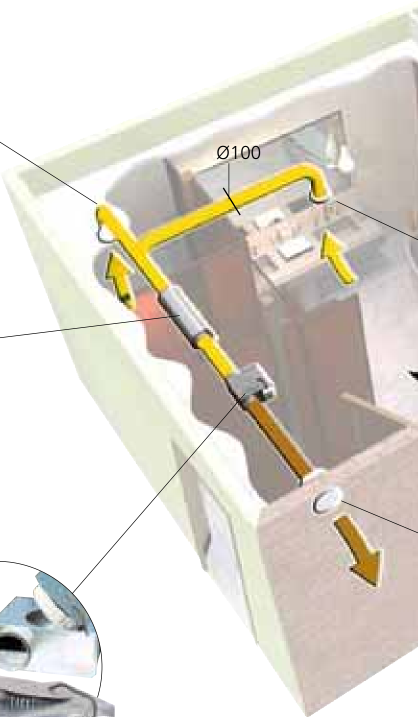
DUCT FANS
CK 100 A exhaust air fan with transformer for adjusting. LPK, LPKB or LPKBI are also excellent options in this application.

HOTEL ROOM/BATHROOM, EXHAUST AIR

Approx. 8 m²: *5 m²=15 l/s + 1 l/s /m² = 18 l/s*

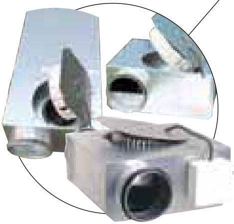
DUCTING

Ducting and fan are installed above removable false ceiling. The fan must be mounted able to be cleaned.



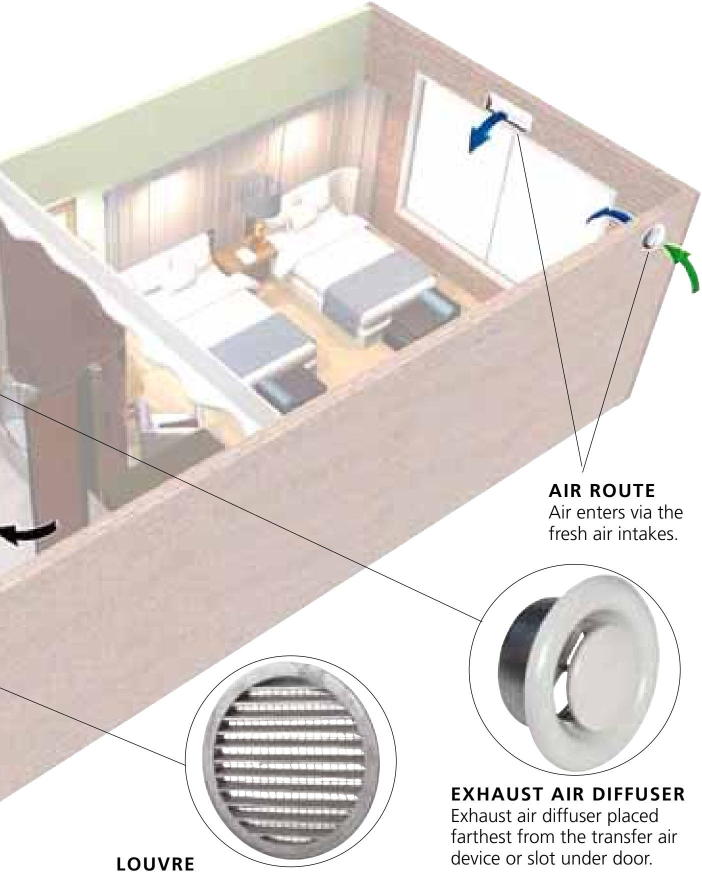
SILENCER

Diameter Ø 100 mm, 500-1000 mm long and 30-50 mm insulation.



DUCT FANS

LPK 100 A exhaust air fan with transformer/thyristor. LPKB or LPKBI are also excellent options in this application.



AIR ROUTE
Air enters via the fresh air intakes.

EXHAUST AIR DIFFUSER
Exhaust air diffuser placed farthest from the transfer air device or slot under door.

LOUVRE
This installation requires a removable false ceiling for service and YG 125 louvre. If the environment outside the louvre is sound-sensitive, a silencer will also be required after the fan.

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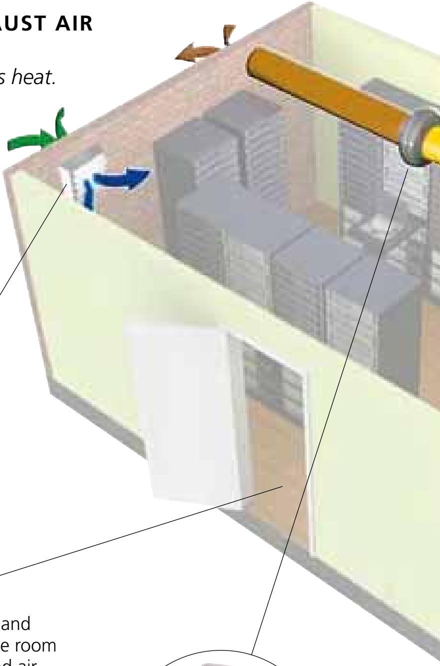
SERVER ROOM, EXHAUST AIR

Approx. 8 m²:

For ventilating away excess heat.



BASE FLOW

Airflow depends on power and temperature.

FRESH AIR INTAKES

YG 160 louvre with VK shutter on interior wall.

AIR ROUTE

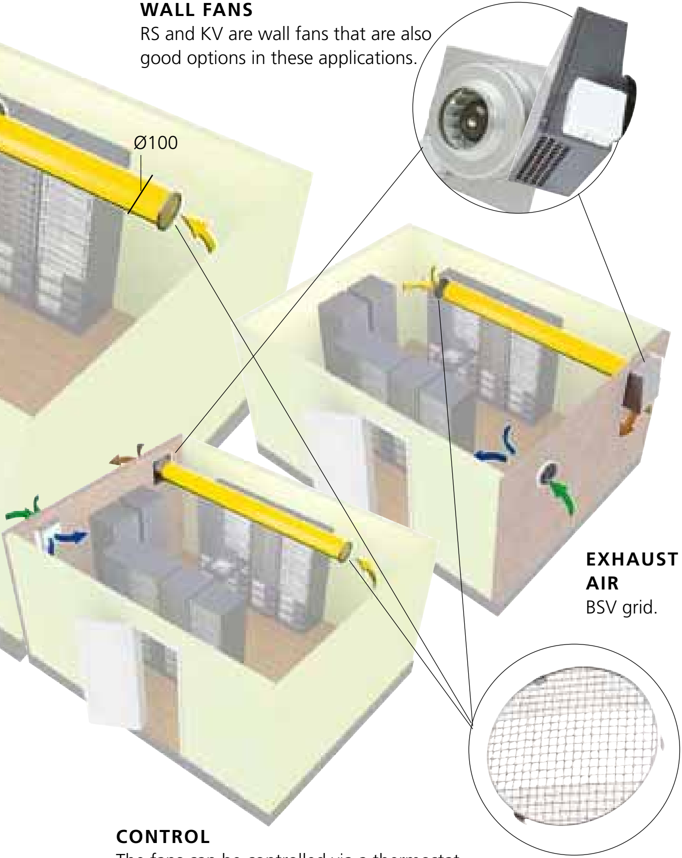
Air passes the fresh air intake and out on the opposite side of the room to achieve good circulation and air mixture and to extract the warm air.

DUCT FANS

CK 100 A exhaust air fan with transformer for adjusting. LPK, LPKB or LPKBI are also excellent options in this application. For larger quantities of air and higher power, RK and RKB may be required.

WALL FANS

RS and KV are wall fans that are also good options in these applications.



EXHAUST AIR

BSV grid.

CONTROL

The fans can be controlled via a thermostat start/stop or with a thyristor with temperature set point adjustment.

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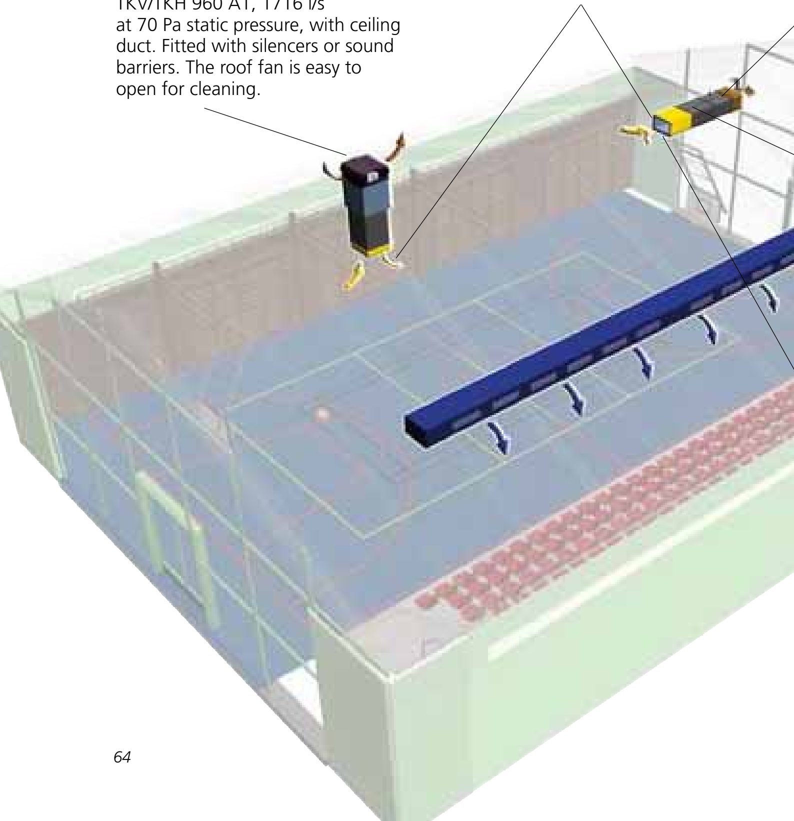
GYMNASIUM, SUPPLY AND EXHAUST AIR

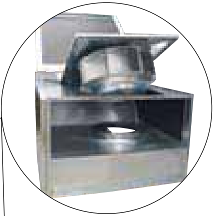
520 m² and approx. 56 people: 520 x 3,3 l/s = 1716 l/s.

Flow calculated based on 0.3 people/m² and 800 PPM.

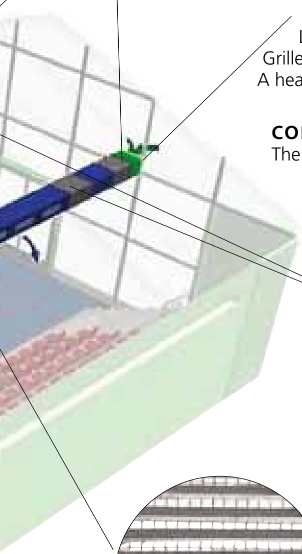
ROFF FAN
TKV/TKH 960 A1, 1716 l/s at 70 Pa static pressure, with ceiling duct. Fitted with silencers or sound barriers. The roof fan is easy to open for cleaning.

EXHAUST AIR
Duct or roof fan.





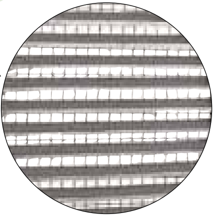
DUCT FANS
Duct fan RKBI 800x500 B1,
1716 l/s at 140 Pa static pressure.



SUPPLY AIR
Large airflows require a supply air fan.
Grilles in the ducts spread the air evenly in the rooms.
A heating coil and filter box FLR may also be required.

CONTROL
The fans are controlled by timers and/or CO_2 sensor.

SILENCERS
LDR 800x500 mm, installed
before resp. after fan.



EXHAUST AIR
Damp and used air is removed via a centrally located exhaust grid. The flow is set to the required value and can be reduced by using a speed controller.

HOME, SUPPLY AND EXHAUST AIR WITH ENERGY RECOVERY

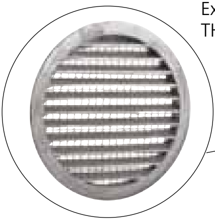
120 m^2: min. flow 0,35 x 120 = 42 l/s.

EXHAUST AIR 17+15+17=50 l/s:
Bathroom 7 m^2: 15 l/s + 2 = 17 l/s.
Laundry room: 15 l/s.
Kitchen: 17 l/.
SUPPLY AIR 22+24=46 l/s:
Bedroom 2 beds: 10 l/s.
Bedroom single bed: 2 x 6 l/s.
Living room: 24 l/s.

DUCTING
Ducting in attics is thermal insulated to prevent condensation of warm and damp air in the ducts.

ROOF CURB
Extract air via TH 300 roof curb.

LOUVRE
Fresh air intake via louvre of type YG 160.



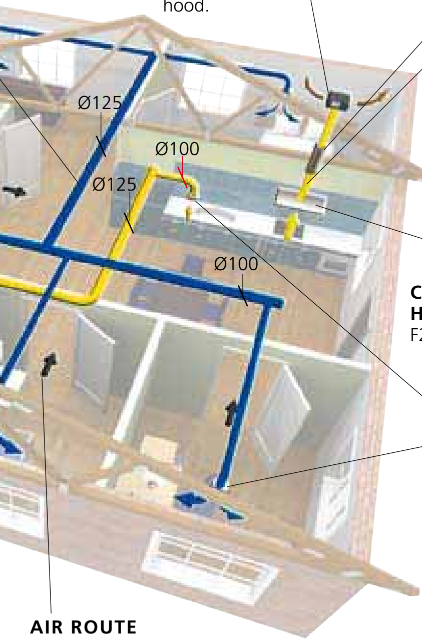
ENERGY RECOVERY UNIT
HERU®62 T for installation in warm areas, such as laundry rooms.

SILENCER
Of diameter Ø 125 mm, in steel sheet 1200 mm long with 100 mm insulation, and flexible silencer 600 mm long with 25 mm insulation.

ROOF FAN
Separate exhaust air fan for cooker hood. TKC/TKS 300 B, TKV/TKH 300 B with ceiling duct. Easily opened for cleaning. Transformer controlled via cooker hood.

SILENCER
Of diameter Ø 125 mm, between fan and residence.

DUCTING
The kitchen duct from the cooker hood is an exhaust outlet duct and must, by law, be cleaned. All ducts must be able to be cleaned.



COOKER HOOD
F251-16.

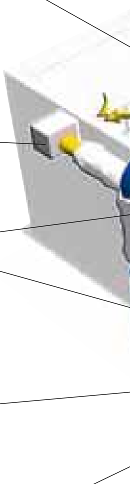
SUPPLY/ EXHAUST AIR DIFFUSERS
Supply air via adjustable ceiling diffuser and with adjustable distribution pattern. Damp and used air is removed via an exhaust air diffuser in the ceiling. The flow rate is set to the required value.

AIR ROUTE
Fresh air is supplied to the living room and the bedrooms. The air passes through the home and is removed in the bathrooms, lavatories, kitchen and laundry room.

CLASSROOM, SUPPLY AND EXHAUST AIR WITH ENERGY RECOVERY

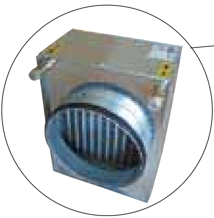
16-20 pupils:
SUPPLY AIR 20 x 8 l/s = 160 l/s.
EXHAUST AIR 160 l/s.

ROOF CURB
Extract air via
TH 400 roof curb.



EXHAUST AIR
Internally insulated box with grid for exhaust air, 250x250 mm.

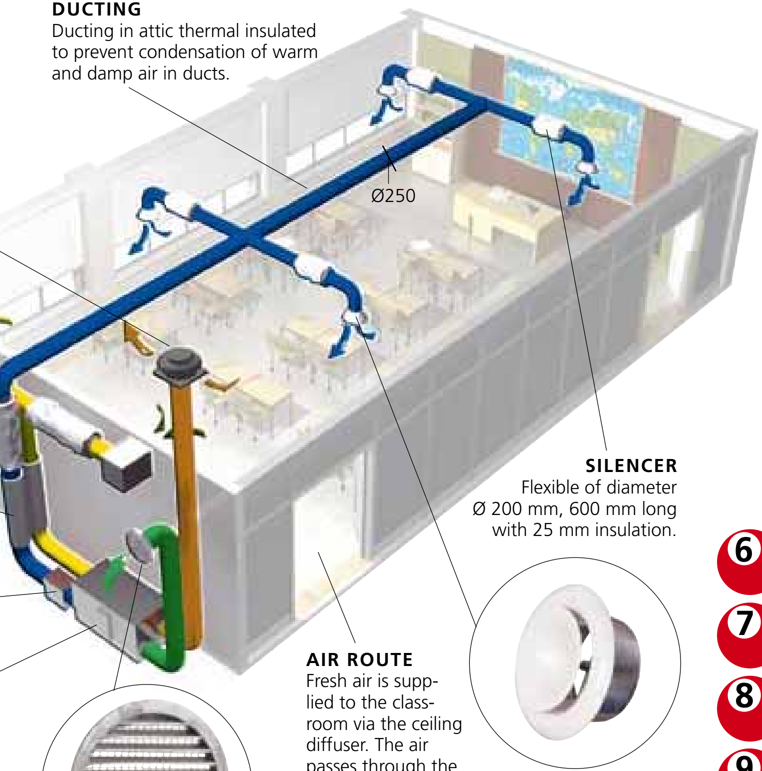
SILENCERS
Of diameter Ø 250 mm, in steel sheet 1200 mm long with 100 mm insulation and flexible silencer 600 mm long with 25 mm insulation.



HEATING COIL
Duct-mounted heating coil. Cooling coils are also available for installation in ducts if needed. HERU® has a control system for regulation.

ENERGY RECOVERY UNIT
HERU®180 S for installation in separate area, warm or cold, e.g. in attic or storage room.

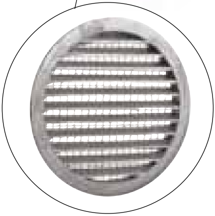
DUCTING
Ducting in attic thermal insulated to prevent condensation of warm and damp air in ducts.



SILENCER
Flexible of diameter Ø 200 mm, 600 mm long with 25 mm insulation.

AIR ROUTE
Fresh air is supplied to the classroom via the ceiling diffuser. The air passes through the room and is removed via the exhaust air diffuser.

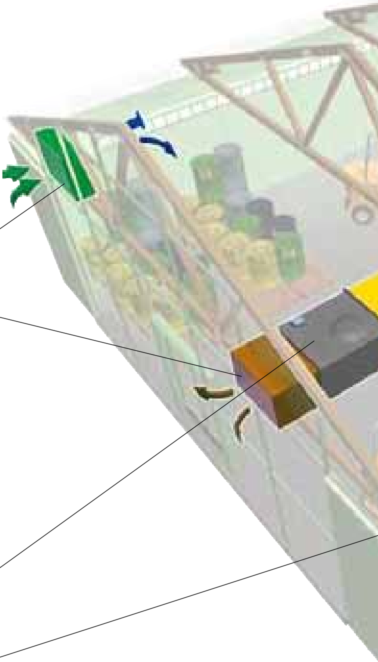
SUPPLY AIR DIFFUSERS
Supply air via adjustable ceiling diffusers evenly distributed for draught-free air supply, and with adjustable distribution pattern.



LOUVRE
Intake of outdoor air via louvre YG 315.

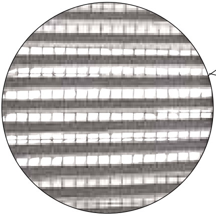
WORKSHOP/STORAGE ROOM, EXHAUST AIR WITH THE REQUIREMENTS OF EXPLOSION PROOF ATEX CERTIFIED FANS

120 m² with airflow 1200 l/s.



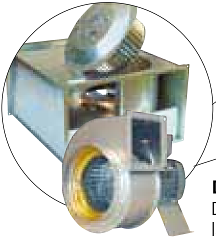
BASE FLOW

Airflow depends on concentration and type of gas.
With large amounts of solvents, approx. 10 l/s x m².



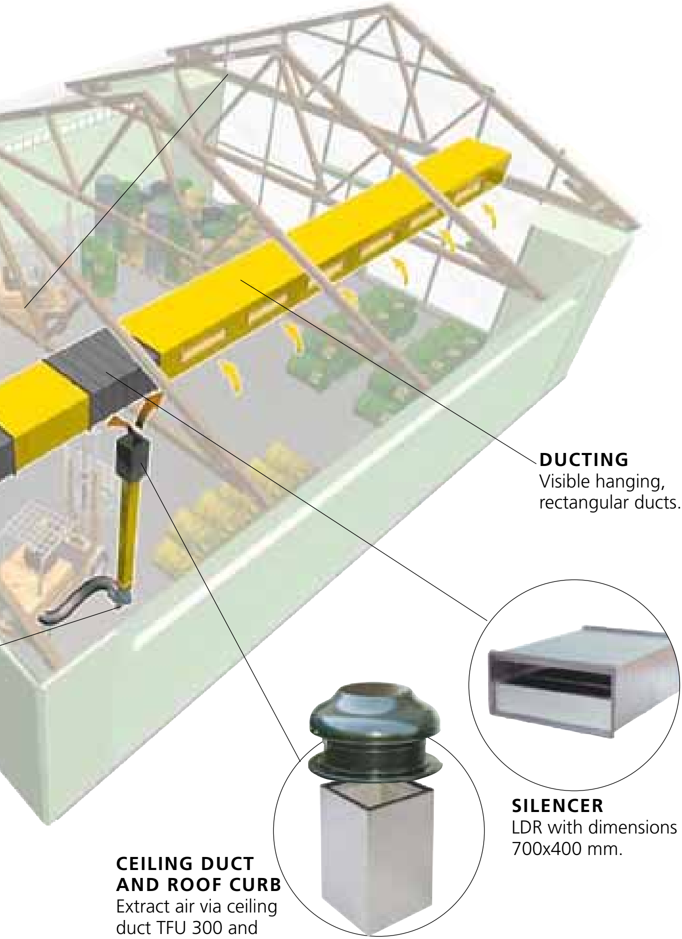
LOUVRE

Intake of fresh air via louvre, 1000x500 mm.



DUCT FANS

Duct fan RKX 700x400 B3 is intended for larger airflows and central exhaust ducts.
RFTX 140 A is a centrifugal fan suitable for point extraction of explosive gases, e.g. for forklift charging stations. It is connected to the forklift by a flexible hose. The fan starts when the charging unit is started

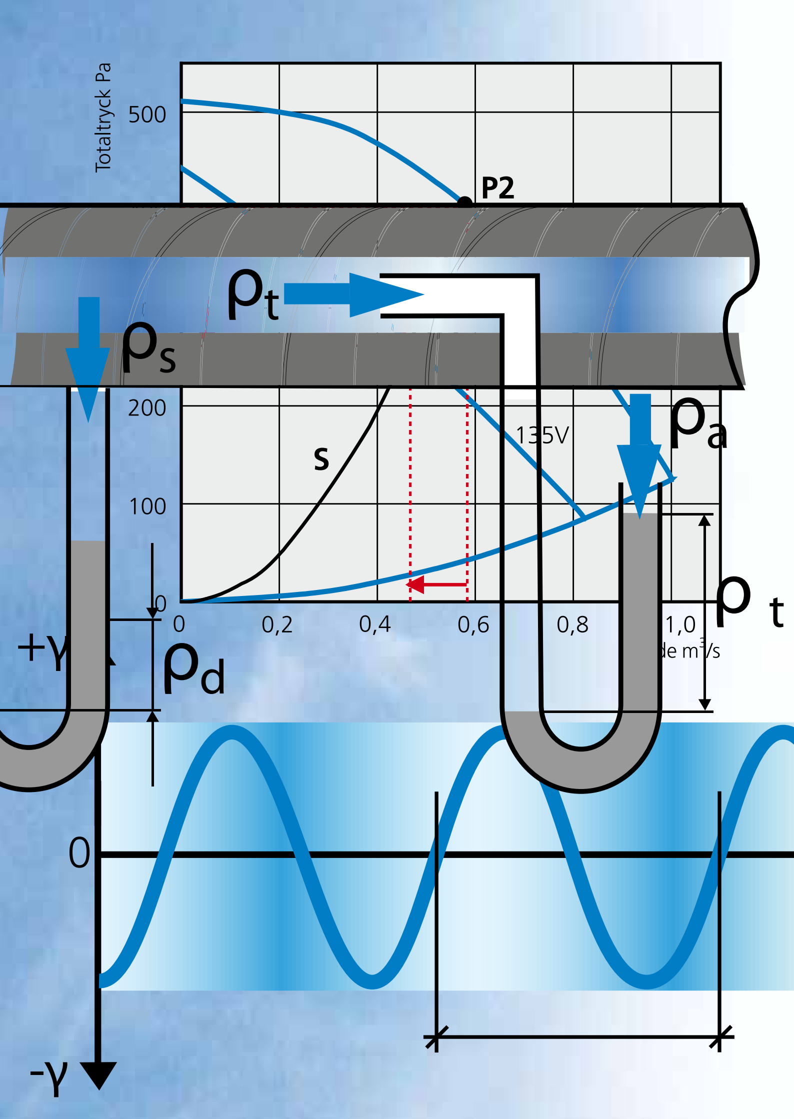


DUCTING
Visible hanging, rectangular ducts.

SILENCER
LDR with dimensions 700x400 mm.

CEILING DUCT AND ROOF CURB
Extract air via ceiling duct TFU 300 and roof curb TH 300.

step by step



Totaltryck Pa
500
P2
ρt
ρs
ρa
200
135V
s
100
0
0
0,2
0,4
0,6
0,8
1,0
ρ t
de m³/s
+γ
ρd
0
-γ

READING CATALOGUE DATA

Fan catalogues contain a great deal of information. If you choose a fan from a catalogue, it is important to understand how this information should be used to ensure that you receive the product that you are expecting.

It is also important to know what standards have been used to compile the measurement data. This is particularly important if you would like to compare fans from different manufacturers, as the results may vary depending on the measuring standards used.

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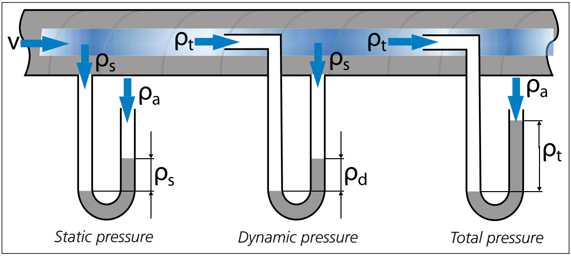
PRESSURE/FLOW DIAGRAMS AND ELECTRICAL DATA

When choosing a fan, you must first find out the maximum volume of air the fan can transport. Then you have to determine what pressure drop the fan will overcome at this flow. Using this data, you can then choose the fan size in the model you have decided on.

DIAGRAM FOR MEASURING PRESSURE IN DUCTS



DYNAMIC/STATIC PRESSURE

A fan's pressure is the work the fan performs in addition to supplying a specific flow.

A fan's pressure can be presented as total pressure or static pressure.

Static pressure is the pressure that in the duct works at right angles to the duct wall in relation to the pressure outside the duct.

Dynamic pressure works in the duct's longitudinal direction and is dependent on, among other thing, the air velocity in the duct. It is the static current pressure that is dimensioned when choosing a fan for a system. It is the static pressure drop that is calculated for the duct system during the pressure drop calculation.

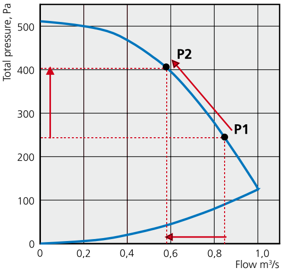
The static pressure added to the dynamic pressure is the fan's total pressure.

The dynamic pressure, *Pd*, is calculated as follows:

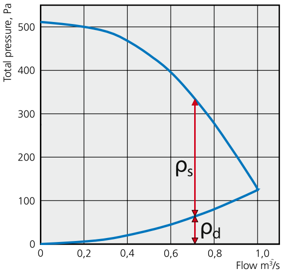
$Pd = \rho * v^2/2$

ρ = air density, kg/m³

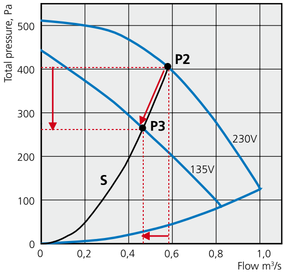
v = air velocity, m/s



The diagram shows the **fan capacity** *at various points according to the pressure created by ductwork system.*
The digram shows the pressure in Pascals (Pa) on the vertical axis and flow in cubic metres/ seconds (m³/s) on the horizontal axis.
The point on the diagram that shows the current flow and pressure is called the **fan's working point***, which is indicated in this example by* **P***.*
As pressure is increased in the system, the working point will move along the fan curve and a lower flow will be obtained. Working point **P1** *is moved to* **P2***.*



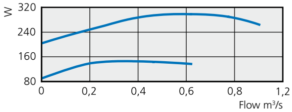
Most of our fan diagrams show total pressure in Pascals (Pa).
*Total pressure (**Pt**) = Static (**Ps**) + Dynamic pressure (**Pd**).*
The static pressure is the pressure of the fan compared to the atmospheric pressure. It is this pressure that must overcome the pressure losses of the ventilation system.
The dynamic pressure is a calculated pressure that arises at the outlet of the fan, and is mostly due to air velocity. The dynamic pressure thus describes how the fan is working. The dynamic pressure is presented with a curve, starting at 0, that increases with increased flow. A high dynamic pressure can, with incorrect duct connection, produce a high pressure drop.



***The system line** (**S**)) describes the total character of the ventilation system (ducts, silencers, dampers, diffusers, etc.).*
Along this system line, the working point moves from **P2** *to* **P3** *as the rotation speed (voltage) is changed.*
Distinct voltage steps with e.g. a transformer, 135 V and 230 V, in this example, produces different fan diagrams, "rotation speed diagrams".

POWER/FLOW DIAGRAMS

Once you have chosen a fan, the power/flow diagram will show you the amount of power the fan will consume at a certain flow, which will assist you in choosing an energy-efficient alternative.

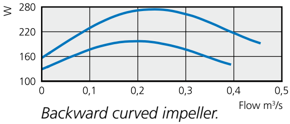


The electrical equipment, such as rotation speed regulators and fan circuit breakers, must be dimensioned according to technical data/rating, which will specify maximum power consumption (input) and operating current consumption within the permitted working area.

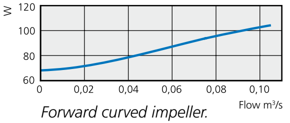
If the current consumption is higher than the rated current, the motor will be overloaded, which considerably shortens the motor's service life. If the winding temperature is too high, the motor's overheating protection will be activated and the motor will stop.

We always specify the motor's input power, but there are fan manufacturers who incorrectly give the motor's output power instead. You should therefore also compare current consumption figures from different fan manufacturers.

At start-up, current consumption is higher than rated current for a short time. This is called starting current.



Backward curved impeller.

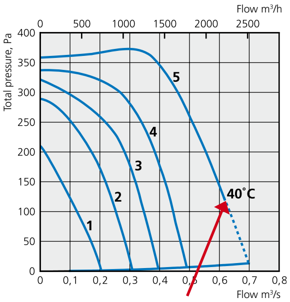


Forward curved impeller.

Fans with large impellers have longer starting current times. Fans with F-wheels have the highest current consumption at low pressures, and fans with B-wheels have the highest current consumption in the middle of the curve.

At high current consumption, the most heat is generated in the motors. This heat must be cooled away so that the motor's service life is not affected. Most of our fans have their motors located in the airstream and are cooled by this airstream. If the air that moves past the motor is too warm, it will not sufficiently cool the motor. For this reason, the highest recommended ambient/air temperatures for the fan are provided. If the fan is used at higher temperatures, its service life will be shortened considerably and the fan's overheating protection will activate.

The temperatures are shown in the curve at the pressure and flow where the ambient temperature is lowest. The



motor can handle higher temperatures at other pressures and flows. Motors with F-wheels, for example, are used at higher pressures.

SOUND

The sound level that we experience is the intensity of the pressure fluctuations that the sound consists of. Pressure fluctuations can be measured and given in Pascals, **Pa**, and are called **sound pressure**.

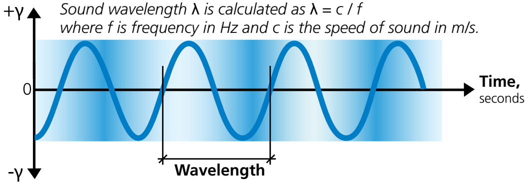
The lowest sound that the human ear can register is a pressure difference of 0.00002 Pa (hearing threshold). The highest pressure is 20 Pa (pain threshold).

To make it easier to report sound levels, a logarithmic scale is used instead of Pascals. This scale is called Bell, or more commonly, **decibel**, and is abbreviated **dB**. The decibel scale ranges from 0 dB (hearing threshold) to 120 dB (pain threshold). One advantage of this is that the human ear registers sound levels logarithmically, which means that a difference of 1 dB is perceived equally across the entire scale. An increase of 6 dB equals a doubling of sound pressure, but an increase of 10 dB is required for us to perceive this increase as having doubled.

The human ear can discern a 3 dB difference in sound pressure.

WAVELENGTH FOR A PURE TONE

Sound wavelength λ is calculated as λ = c / f
where f is frequency in Hz and c is the speed of sound in m/s.



Octave band	Middle frequency Hz	Band limits Hz	Wavelength m
1	63	44-88	5.396
2	125	88-177	2.720
3	250	177-354	1.360
4	500	354-707	0.680
5	1000	707-1410	0.340
6	2000	1410-2830	0.170
7	4000	2830-5660	0.085
8	8000	5660-11300	0.043

SOUND DATA

In our catalogues, we give the **sound power level Lw(A)** and **sound pressure level Lp(A)** for sound in ducts and sound that is transmitted to the surroundings (through the fan casing).

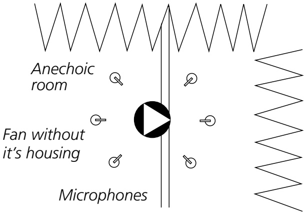
Values are measured in accordance with ISO 3741 for sound transmitted to the surroundings from the fans, or ISO 5136 for measurements of sound power level to the ducts.

Note that measurements conducted according to another standard may differ from the measurement data in these ISO standards.

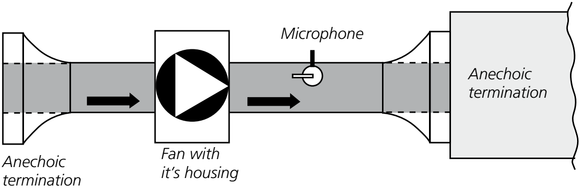
We conduct sound measurements according to the ISO method, in which the fan is measured in its casing to provide the most realistic values.

Measurements conducted on free-standing fans without casing result in lower sound levels.

In Application of Manufacturers' Sound Data, industry organization ASHRAE in the US states that: *"Measurements conducted on free-standing fans have 5-10 dB lower sound levels in octave bands from 250 Hz, and lower sound levels than fans in fan casing."*



AMCA method: *Measurement conducted on free-standing fan in fully soundproofed room. Results in lower sound levels.*

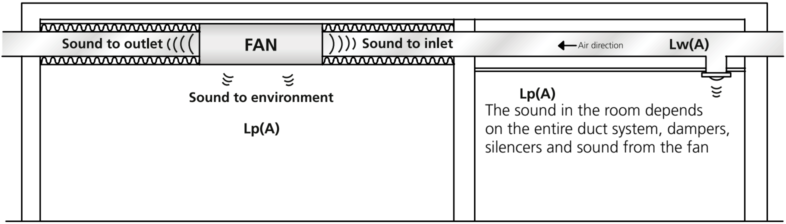


ISO method: *Measurements conducted inside a duct with specified design and non-reflecting connection. Measurements and calculations conducted in 1/1 octave band.*

MEASUREMENT INACCURACY

In conjunction with the preparation of its measuring method for sound power levels in ducts, ISO analyzed inaccuracy in various octave bands (90% reliability).

Octave band Hz	63	125	250	500
Inaccuracy dB	+–5,0	+–3,4	+–2,6	+–2,6
Octave band Hz	1000	2000	4000	8000
Inaccuracy dB	+–2,6	+–2,9	+–3,6	+–5,0



SOUND POWER LEVEL

Sound power level, **Lw(A)**, is used to calculate the sound generated from the entire ventilation system. The system consists of components such as dampers, ducts, diffusers, grilles, etc., all of which contribute to the total sound power for the entire system.

The sound power level is a calculated value that specifies the source intensity or the acoustic power emitted; it does not indicate how strongly the sound is perceived.

Sound power level is reported in **octave bands 63-8000 Hz** and as a logarithmic composite sum **Lw(A)tot**.

SOUND PRESSURE LEVEL

Sound pressure level, **Lp**, indicates how the sound is perceived. It is calculated in relation to a reference sound pressure, **P,** which is the hearing threshold, as follows:

$$Lp = 10 \log (P/P_0)^2 \quad Lp = 20 \log P/P_0 \quad \text{Där } P_0 = 2 \times 10^{-5} \text{ (Pa)}$$

Sound pressure varies according to distance and direction from the source of the sound. The acoustic properties of the surroundings also affect sound pressure.

The sound pressure level is presented for a normally soundproofed room with an equivalent absorption area of 20 m².

A difference of 7 dB corresponds to a distance of roughly 3 m to the sound source with semi-spherical propagation of sound.

In an attempt to simulate how the human ear perceives the sound at the different frequencies, it is weighted (corrected in the octave band) to weighting curve **A** which is presented as **Lp(A)** and by the unit **dB(A)**.

Tabell A-filter

Frequency	**63**	**125**	**250**	**500**	**1000**	**2000**	**4000**	**8000**
Measured sound pressure level Lp dB	50	46	30	25	20	18	15	15
A filter	-26	-16	-9	-3	0	+1	+1	-1
A-weighted sound pressure level Lp(A) dB	24	30	21	22	20	19	16	14

The **dB** scale is logarithmic and following the logarithmic addition of the above sound pressure levels, the total is 32,5 dB(A).

dBtot = 10 * log [10^(dB 1/10) + 10^(dB 2/10)]

$$Lp = 10 \times \lg (10^{Lp1/10} + 10^{Lp2/10} \ldots\ldots\ldots + 10^{LpX/10})$$

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step by step

CALCULATION EXAMPLES

Here are a few examples of various types of calculations in the area of ventilation.

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PRESSURE DROP CALCULATION

In order to be able to choose the right fan, you must know what conditions the fan will be working under.

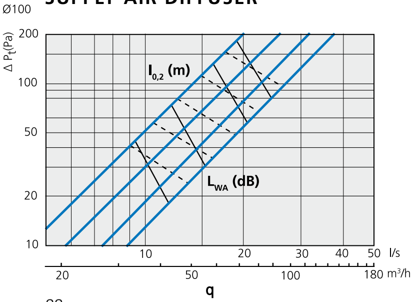
The first thing you have to know is the **flow**. Once you know the flow, then you must calculate **pressure drop**. These two criteria determine the fan's working point, and will form the basis for your decision on what type of fan to choose.

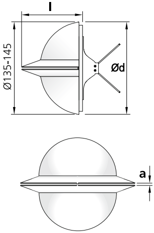
A pressure drop calculation must be made based on a plan of the duct system.

The pressure drop in the duct system consists of the pressure drop that occurs when the air passes the various components such as ducts, bends, grilles, dampers, heaters and diffusers.

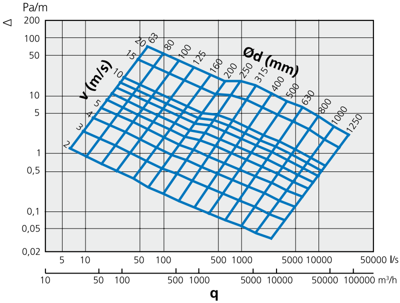
Here follows a few examples of pressure drop in supply air diffusers, ducts and duct components:

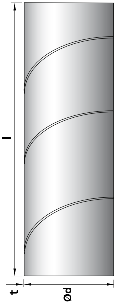
SUPPLY AIR DIFFUSER



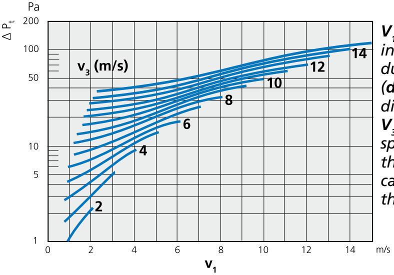


STRAIGHT SPIRAL DUCT

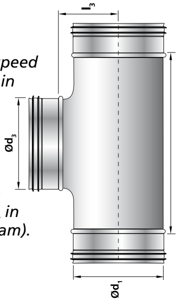




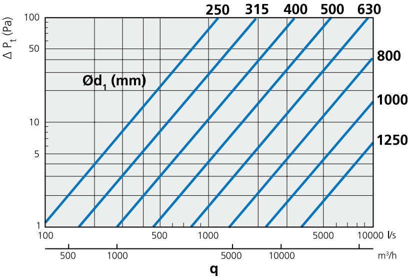
T-SECTION

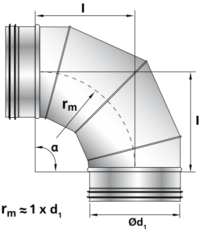


V_1 is the speed in the main duct (d_1 in the diagram) V_3 is the speed in the bifurcation (d_3 in the diagram).



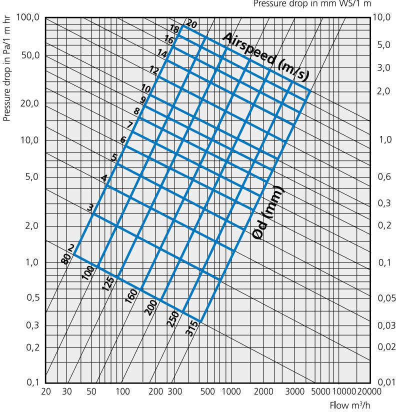
90° BEND





$r_m \approx 1 \times d_1$

FLEXIBLE DUCT



Pressure drop for flexible duct. Note that the diagram applies for ducts that are straight and fully stretched!

Example of pressure drop calculation of an exhaust air system consisting of four 15 l/s exhaust air diffusers, ducting to an exhaust air fan with silencer, and to the outdoors via an outer wall grille.

These calculations have been made to clarify the differences produced if each individual component is dimensioned according to the applicable flow.

A duct system optimized for low pressure drop.

Component	**Type**	**Flow l/s**	**Speed m/s**	**Pressure drop Pa**
Outer wall grille	YGC 200	60	2,00	20
Reducer	RCFU 200-160	60		3
Duct	D=160 L=3 m	60	3,00	3 x 0,6 = 1,8
Bend	2 st 90°	60	3,00	2 x 5,0 = 10
Fan				
Duct	D=160 L=4 m		3,00	4 x 0,6 = 2,4
Silencer	SLCU 160 1200 100	60	3,00	1
T-section	TCPU 160 125	45/15	2,24	0
Duct	D=160 L=2 m	45	2,24	2 x 0,5 = 1
T-section	TCPU 160 125	30/15	2,45	0
Reduction	160 125	30	2,45	3
Duct	D=125 L=2 m	30	2,45	0,7
T-section	TCPU 125 125	15/15	1,22	
Duct	125 L=2 m	15	1,22	2 x 0,5 = 1
Bend 90°	BKU 125 90	15	1,22	1
Diffuser	KVB 125	15		25
				Total 68,9 Pa

A duct system that has not been accounted for pressure drop over the components, particularly diffusers and louvres.

Component	**Type**	**Flow l/s**	**Speed m/s**	**Pressure drop Pa**
Outer wall grille	YGC 160	60	3,00	50
Duct	D=160 L=3 m	60	3,00	3 x 0,6 = 1,8
Bend	2 st 90°	60	3,00	2*5=10
Fan				
Duct	D=160 L=4 m		3,00	4 x 0,6 = 2,4
Silencer	SLCU 160 1200 100	60	3,00	1
T-section	TCPU 160 100	45/15		0
Reduction	160 125	45		0
Duct	D=125 L=2 m	45	3,67	2 x 0,5 = 1
T-section	TCPU 125 100	30/15	2,45	0
Reduction	125 100	30	3,82	3
Duct	D=100 L=2 m	30	3,82	2 x 2,0 = 4
T-section	TCPU 100 100	15/15	1,91	0
Duct	100 L=2 m	15	1,91	2 x 0,5 = 1
Bend 90°	BKU 100 90	15	1,91	2
Diffuser	KVB 125	15		70
				Total 146,2 Pa

Using the above calculations, a fan is chosen from the ”Fan Selection Programme”.

In the first example, **CK 125 A** which takes 40 W, is suggested.

In the second example, **CK 125 C** med 62 W.

At continual operation, the difference in power is 8760 h x 0,022 kW = 193 kWh in savings every year using CK 125 A (10 years = 1930 x SEK 1.20 = SEK 2316).

Below is an example of what happens when you begin by choosing the fan according to the curve in the catalogue based on an “estimated” pressure drop.

In this case, a **CK 125 C** 60 l/s at approx. 160 Pa. A duct system is then built according to the fan’s connection dimensions.

This shows that the desired flow will not be achieved – it will only be approx. 40 l/s at this pressure drop.

Of course, this system will also generate higher sound levels.

A duct system with no pressure drop calculation.

Component	Type	Flow l/s	Speed m/s	Pressure drop Pa
Outer wall grille	YGC 125	60	4,90	125
Duct	D=125 L=3 m	60	4,90	3 x 2,5 = 7,5
Bend	BU 2 st 90°	60	4,90	2 x7,0 = 14
Fan	CK 125 C			
Duct	D=125 L=4 m		4,90	4 x 2,5 = 10
Silencer	SLCU 125 1200 100	60	4,90	4
T-section	TCPU 125 100	45/15	3,67	0,5
Duct	D=125 L=2 m	45	3,67	2 x 1,5 = 3
T-section	TCPU 125 100	30/15	2,65	0
Reduction	125 100	30	3,82	2
Duct	D=100 L=2 m	30	3,82	2 x 2,0 = 4
T-section	TCPU 100 100	15/15	3,82	0
Duct	125 L=2 m	15	1,91	2 x 0,5 = 1
Bend 90°	BKU 100 90	15	1,91	1
Diffuser	KVB 100	15		70
				Total 242 Pa

SOUND CALCULATIONS

The sound power level, **Lw,** specifies the source intensity or the acoustic power emitted; it does not indicate how strongly the sound is perceived.

Sound power is a calculated value based on measured sound pressure.

The sound power level of the fan/system and the sound generation and sound reduction of individual components must be known to be able to conduct a sound calculation of a ventilation system.

The reason for using sound power level is that these values are not dependent on distance, direction and location. The system consists of components such as dampers, ducts, diffusers, grilles, etc., all of which contribute to the total sound power for the entire system.

Sound power level is reported in octave bands 63-8000 Hz and as a logarithmic composite and A-weighted sum **Lw(A)tot**.

In an attempt to simulate how the human ear perceives the sound, it is customarily weighted (corrected in the octave band) to weighting curve A, which is presented as **Lw(A)** and by the unit **dB(A)**.

Other units, dB(B) and dB(C), are also used, with other values for weighting sound data.

Frequency Hz	A filter (dB)	B filter (dB)	C filter (dB)
63	-26.2	-9.3	-0.8
125	-16.1	-4.2	-0.2
250	-8.6	-1.3	0.0
500	-3.2	-0.3	0.0
1000	0.0	0.0	0.0
2000	+1.2	-0.1	-0.2
4000	+1.0	-0.7	-0.8
8000	-1.1	-2.9	-3.0

SOUND CALCULATION EXAMPLES

Information is taken from the product catalogue on the sound power level **Lw(A)** of the sound source, e.g.:

Fan	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Tot
LwA	50,00	58,20	59,70	60,20	53,39	47,00	35,50	35,50	**65,32**

Note that fan sound varies according to pressure and flow.

The duct system must be calculated in terms of attenuation and sound generation. Sound data is listed in manufacturer catalogues.

Example below:
Silencer SLCU 100, connection 160, 1200 mm long.
Duct and duct components spiral ducts.
Five T-sections with equal flows in each branch.
Diffuser CTVK 100, 12 l/s 8 mm gap.

	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Silencer	-8,00	-12,00	-27,00	-32,00	-46,00	-50,00	-28,00	-20,00
Duct T-section	-7,00	-7,00	-7,00	-7,00	-7,00	-7,00	-7,00	-7,00
Bend	0,00	0,00	0,00	-0,50	-1,00	-2,00	-3,00	-3,00
Diffuser generation	22,00	17,00	17,00	20,00	20,00	17,00	14,00	10,00
Diffuser reduction	-24,00	-20,00	-18,00	-12,00	-10,00	-10,00	-10,00	-10,00
Totals	**-17,00**	**-22,00**	**-35,00**	**-31,50**	**-44,00**	**-52,00**	**-34,00**	**-30,00**

Result:

	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	Tot LwA
LwA Fan	50,00	58,20	59,70	60,20	53,39	47,00	35,50	35,50	**65,32**
Duct system	-17,00	-22,00	-35,00	-31,50	-44,00	-52,00	-34,00	-30,00	
Totals	33,00	36,20	24,70	28,70	12,00	1,30	13,00	5,50	**38,60**

How this is perceived in the room (LpA) depends on the room's sound properties and size, where the diffuser is located in the room, and the distance to the diffuser.

CALCULATING SOUND PRESSURE LEVEL

The sound pressure level of the room is calculated using the following formula:

$$Lp = Lw + 10 \, Log \, (Q/4\pi \, r^2 + 4/A)$$

A = Equivalent absorption area of room, m^2
Q = Propagation type
Q = 1 is spherical propagation
Q = 2 is semi-spherical propagation
Q = 4 is quarter-spherical propagation

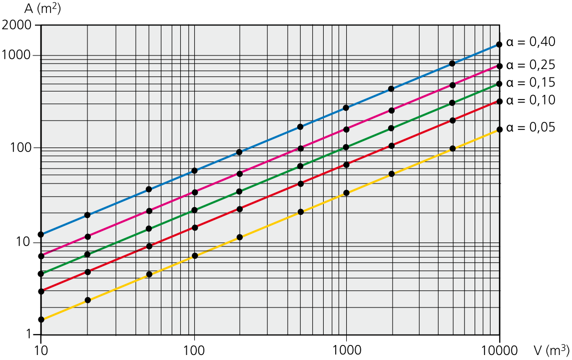
Absorption area **A** depends on the acoustic characteristics of the room, taking into account the room's total volume, nature of surfaces and interior fittings.

Absorption area is calculated as **A = S*αm** where **S** is the room's overall limitation area and **αm** is the average absorption factor for the total limitation area.

The following reference values for average absorption factor can be used:

Very soundproofed room	0,40
Soundproofed room	0,25
Normal room	0,15
Hard room	0,10
Very hard room	0,05

The following table can be used once the equivalent absorption area has been calculated using the room's volume and average absorption factor.



A 20 m^2 room with a ceiling height of 2.6 m gives the volume **V**= 52 m^3, a soundproofed room α=0,25 gives a room absorption area of about 20 m^2.

With 20 m^2 equivalent absorption area **A,** distance **r** to the diffuser 3 m, and diffuser placement **Q,** in the centre of the ceiling, the calculation will be:

Lp = 38,6 + 10 Log (2/(4*3,14*9) + 4/20)
Lp = 38,6 + -6,621558307
Lp = 31,978
Lp = 32 dB(A)

In this room then, we perceive the sound as 32 dBA.

If the room is equipped with several diffusers or pronounced background noise, those sources of sound will be added logarithmically to this sound.

If the sound sources have the same sound level, the table below can be used for the equation.

Two similar sound sources in the same room increases the sound level by dB.

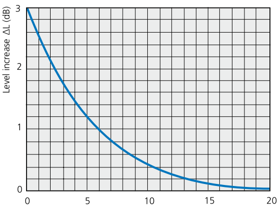
Number of similar sound sources	Total sound level increase
2	3 dB
3	5 dB
4	6 dB
5	7 dB
6	8 dB
7	9 dB

ADDITION OF TWO DIFFERENT LEVELS

If the difference in the sound level is 5 dBA, then 1.2 dBA is added to the louder of these two sound levels.

The sound pressure level in free fields (e.g. from a roof fan) is calculated as follows:

Lp =Lw + 10 Log Q/ 4πr²



With Lw(A) tot at 63 dB(A), this gives a free field, at a distance of 5 metres and semi-spherical propagation, of:

Lp(A) = 63 + 10 Log 2/4π 5²
= 63-22 = 41 dB(A)

At 10 metres:

Lp(A) = 63 + 10 Log 2/4π 5²
= 63-28 = 35 dB(A)

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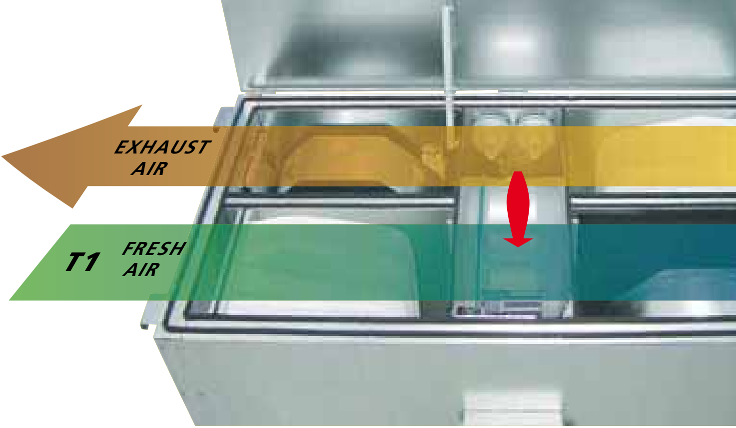


ENERGY CALCUATION / ENERGY SAVINGS

It is highly advantageous to keep an eye on energy consumption, as energy costs can become considerable over time, even if the difference doesn't seem significant at the moment.

It is important not only to consider the energy consumption of the fan, but also operating times, type of control equipment, supply air temperature, post-heating and heat recovery.

FAN POWER

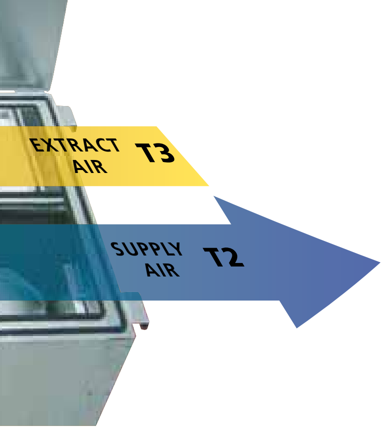
Fan power is measured in watts (W) or kilowatts (kW) and energy consumption is measured in kilowatt-hours.

SFP, Specific Fan Power, indicates the fan's energy consumption for a specific airflow. It is specified in **kW/m³/s** or **W/l/s**. A low SFP indicates low energy usage, but it does not say anything about the pressure at which the SFP value applies.

NOTE: It's the supplied power to the fan's motor that is calculated.

A 0.1 kW fan operating continuously (24 h/day) uses in one year:
0,1 kW x 8700 h = 870 kWh
At a price of SEK 1.20/kWh annual operating costs total SEK1044.

A fan with lower power and/or a system with a lower pressure drop, which also leads to lower power needs, will naturally decrease costs.



Fan efficiency depends on several factors: Motor efficiency, impeller efficiency and the aerodynamic design of the fan casing. If the fan has a belt drive, its efficiency will also be a factor.

OPERATING TIME

In many types of premises, airflow can be reduced when there is no activity in the room. This can be accomplished with a timer that switches from high to low flow.

Flow can also be demand-controlled with carbon dioxide sensors, motion detectors or moisture sensors that permit the fan to run on low speed (lower power) when the ventilation need is lower.

HEATING/COOLING RECOVERY

The greatest energy savings is achieved by recovering the energy from the exhaust air instead of just letting it be released outdoors.

In energy recovery, the warm exhaust air heats up a wheel of corrugated aluminium (rotating heat exchanger). The heated part of the wheel then rotates over to the "cold" side to warm up the outdoor air before it is sent on to the serviced areas.

Another method is to let the warm exhaust air emit its heat to the outdoor air through a rigid aluminium plate (plate heat exchanger). Cooling recovery of course uses this process in reverse.

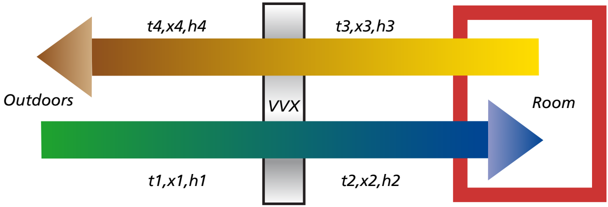
A ventilation system's recovery capability is often specified in temperature efficiency rate. This is calculated as **T2-T1/T3-T1** and is the temperature efficiency rate of the supply air, where T2 is the supply air temperature, T1 is the outdoor temperature and T3 is the extract air temperature.

A good heat exchanger utilizes 80-85% of the energy in the exhaust air.

HEAT EXCHANGER EFFICIENCY

Temperature efficiency (**η**) is a measurement that indicates how much of the heat is recovered.

This is calculated as follows: **η t= t2-t1 / t3-t1** (temperature efficiency of supply air).



Supply air temperature=**18°C**
Fresh air temperature = **-5°C**
Extract air temperature = **22°C**

Gives: **η t= 18 - -5 / 22 - -5 = 0,85 = 85%**

Moisture efficiency is calculated in the same way:
ηx = x2-x1 / x3-x1

and enthalpic efficiency:
h2-h1 / h3-h1

Enthalpic efficiency occurs in connection with heat recovery from warm air and indicates the efficiency for heat exchangers, taking into account the chemical energy content of the air and the air humidity.

AN ENERGY CALCULATION EXAMPLE:

Outdoor temperature +6°C in central Sweden
(daily average annual temperature):

Exhaust air temperature: 22°C
Δ T = Temperature difference: 22-6 = 16°C
Q = Airflow: 100 l/s = 0,1 m^3/s
Operating hours/year = 8760 h
c_p – Specific heating capacity at constant pressure (J/kgK) = 1
$\dot{m}$ = Mass flow = **Q** x ρ (kg/s = m^3/s x kg x m^3)
ρ - Density (kg/m^3) = 1,2

Formula for energy: $$Q = \dot{m}_1 c_{p1} \Delta T_1$$

The *expelled* heat from exhaust air ventilation without heat recovery:

0,1 x 1,2 x 1 x 16 x 8760 = 16 819 kWh/year

At a heat recovery rate of 85%, the supply air temperature will be:

19,6°C Δ T (19,6-6)= 13,6 K

The *recovered* energy will be:

0,1 x 1,2 x 1 x 13,6 x 8760 = 14 296 kWh/year

which is the same as the gain compared with just regular exhaust air ventilation.

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DEFINITION OF EFFICIENCY FOR FANS

Impeller efficiency:

$$\eta_r = \frac{P_u}{P_r} \times 100\%$$

Fan's total efficiency:

$$\eta_e = \frac{P_u}{P_e} \times 100\%$$

where P_u is theoretical power according to:

$$P_u = \frac{q \times \Delta p_t \text{ kW}}{1\,000}$$

where **q** is given in m^3/s and $\mathbf{\Delta p_1}$ in Pa.

$\mathbf{P_r}$= Actual power of impeller
$\mathbf{P_e}$= Actual power of fan (input).

The efficiency of the impeller is the theoretical power in relation to actual power.

The efficiency for a backward curved impeller is 70-80% and for a forward curved impeller, 50-60%.

The total efficiency of the fan is the theoretical power in relation to the input power (from the electrical grid), which is dependent on the:
Aerodynamic properties of the fan casing,
impeller efficiency
x motor efficiency
x belt drive efficiency
x control equipment efficiency.

To achieve a good efficiency, all components in the chain must be optimized. A belt drive, for example, has an efficiency rate of 88-95% and a direct drive of 100%.

FAN LAWS (AFFINITY LAWS)

$$\frac{V_1}{V_2} = \frac{n_1}{n_2} \qquad \frac{H_1}{H_2} = \frac{n_1^2}{n_2^2} \qquad \frac{P_1}{P_2} = \frac{n_1^3}{n_2^3}$$

***V**=flow (l/s) **n**=rotation speed (rpm) **H**=pressure drop (Pa) **P**=power (Watt)*

These laws provide a theoretical link between the **power (P)**, **pressure drop (H)** and **rotation speed (n)** of the fan.

Affinity laws apply if the **efficiency (η)** and the **density (ρ)** are constant.

1: The ratio between one flow **V_1** and a new flow **V_2** is equal to the ratio between current rotation speed **n_1** and the new rotation speed **n_2**.

If the flow is doubled, the rotation speed must also be doubled. Air quantity is, in other words, directly proportional to rotation speed.

2: The ratio between a fan's available pressure **H_1** and the new pressure **H_2** is equal to the ratio between the current rotation speed **n_1** squared and the new rotation speed **n_2** squared.

A few examples:
If the rotation speed is doubled from 1400 rpm to 2800 rpm, the pressure increases from 150 Pa to 600 Pa. At half this rotation speed (700 rpm), the available pressure is decreased to 37.5 Pa.

3: The ratio between one power **P_1** and the new power **P_2** is equal to the ratio between the current rotation speed cubed and the new rotation speed cubed.

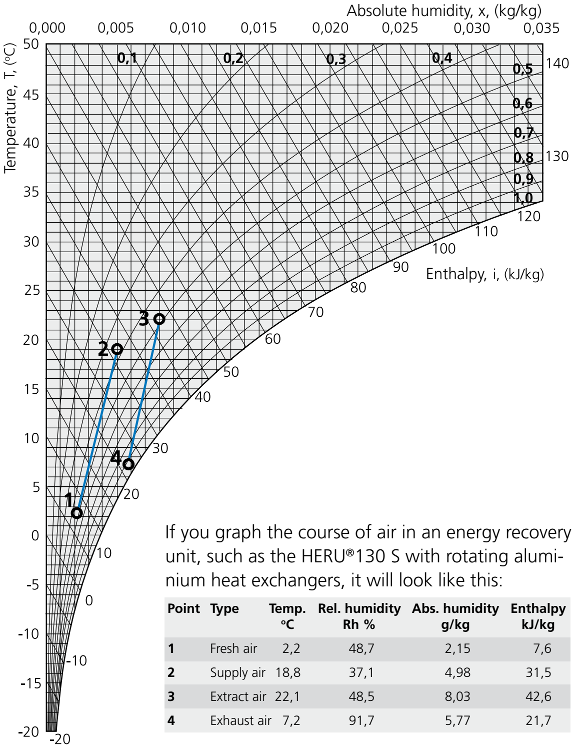
A few examples:
If the current power is 250 W, the new power will be 2,000 W when the rotation speed is doubled.

The power decreases to 31.25 W when the rotation speed is halved, and the available pressure decreases from 150 Pa to 37.5 Pa.

If the pressure must be increased from 150 Pa to 200 Pa, the rotation speed must be increased from 1400 rpm to 1616 rpm. At this increase in rotation speed, power increases from 250 W to 384 W!

MOLLIER DIAGRAM

Mollier diagrams show what happens during different air handling applications, such as humidification/dehumidification, heating/cooling, etc., and what happens with the energy content in the air during these applications.



If you graph the course of air in an energy recovery unit, such as the HERU®130 S with rotating aluminium heat exchangers, it will look like this:

Point	Type	Temp. °C	Rel. humidity Rh %	Abs. humidity g/kg	Enthalpy kJ/kg
1	Fresh air	2,2	48,7	2,15	7,6
2	Supply air	18,8	37,1	4,98	31,5
3	Extract air	22,1	48,5	8,03	42,6
4	Exhaust air	7,2	91,7	5,77	21,7

From the moment that air comes into the unit (*point* ***1****, outdoor air*), the *supply air* is heated from 2.2°C to 18.8°C to *point* ***2***.

This point is located farther up in the diagram because the temperature scale is on the left side of the chart, and because the air is humidified somewhat, it moves a bit to the right. The scale for absolute humidity is shown at the top of the diagram.

The relative humidity decreases, however, from 48.7% to 37.1%. This is represented by the bow-shaped lines with values from 0.1 to 1.0.

Enthalpy increases from 7.6 kJ/kg to 13.5 kJ/kg. This scale is shown at the bottom edge of the diagram.

ENTHALPY

Indicates the energy content in the air, also taking into account the chemically-bound energy (air containing a lot of water vapour has a higher enthalpy than dry air at a given temperature).

ABSOLUTE HUMIDITY

This value indicates how much moisture there is in grams per kilograms of air.

RELATIVE HUMIDITY

Indicates how much moisture there is in the air in percent of maximum possible moisture.

When Rh=100%, the moisture in the air becomes free-falling water droplets.

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Conclusion

GUIDELINES AND TROUBLESHOOTING

1. Fan problem	How is it electrically installed? Has the correct wiring diagram been used? Has the correct capacitor been used? Has the correct motor been used?	Single phase/3-phase delta/star.
	Distance to inlet cone?	Dependent on type of impeller, Forward durved impeller always +, 2-8 mm. Backward durved impeller can have - or even + (when swung-out) -5 to + 7-8 mm.
	Damaged impeller	Gives off vibrations, must be replaced.
	Controls	Check what types of controls are used.
	Overheated	Circuit breaker has cut power, determine why (wrong environment for fan?).
	Dirt	A dirty fan will not function correctly. Clean the fan and install a filter.
2. Low/high flow	Is the fan designed for this flow and pressure?	The system and the fan must be constructed for the desired flow.
	Points 1 and 3	Fan problems and bad duct system cause flow rates to be too low.
	Flow adjustment	The flow must be measured and adjusted to match the projected flow. If the flow is too high, the first step is to reduce the fan speed or switch to a smaller fan.
3. Duct system	Sharp bends in the system	Is the flexible hose sufficiently stretched? No bends directly after the fan.
	Air velocity in duct	Max 3 m/s in single-family home ventilation systems, max 5 m/s in other systems.
	Air speed in damper/diffuser	See manufacturer catalogue for flow/pressure data.
	Duct system sealing	Spiral ducts are best. Duct fittings with rubber seals are best.
4. Noise	Points 1,2 and 3	Problems with the fan, adjustments not performed properly, and bad duct systems generate noise.
	Silencers	In environments where people work or live, silencers are always desirable.
	Thyristors (stepless transformers)	These can generate noise if the speed is set too low.
	Damper with high pressure drop	Dampers generate noise. It may be necessary to place silencers after them.
	Where is the fan located?	The fan always transmits sound to the surrounding areas. Can the fan be placed somewhere else?

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Conclusion

GLOSSARY FAN TERMS

AC motor: Electric motor for alternating current, most common type is the asynchronous motor.

Affinity Laws (fan laws): Indicate proportional ratios between a fan's rotation speed, airflow, air velocity, pressure and power needs.

Air adjustment: Adjustment of air diffuser and damper to projected airflow in a ventilation system.

Air change rate: Measurement of air change determined by the ratio between airflow to or from a room and its volume.

Airflow: Indicates the volume flow of air per time unit - litres per second, l/s.(q=v A).

Air handling: Handling of air by filtering, heating or cooling.

Air pollutants: Harmful and undesirable substances or organisms in air.

Air speed: Measured in m/s. Indicates air speed in e.g.duct.

ATEX: The European quality and safety standard for explosion-proof fans.

Axial fan: A fan where the air passes straight through the fan wheel (axial airstream).

B-wheel: A fan wheel with backward-curved impellers.

Balanced ventilation: System in which both exhaust and supply airflows are the same.

Carbon dioxide: Formed during combustion of hydrocarbons, human respiration, etc. Abbreviated CO_2.

Centrifugal fan: A fan where the air stream is angled 90°, the supply air enters in an axial direction and leaves the fan wheel in a radial direction.

Collecting efficiency: A measure of the efficiency of the filter.

Constant flow: To control the fan's airflow/speed or pressure with a control unit via a sensor.

Damper: Used in ventilation ducts to regulate airflow.

Density: Or a specific gravity, measurement of the substance density. E.g. kg/m^3.

Displacement ventilation: Supply air is supplied to a room at low air speed, and then heated by the surrounding and rises.

Dynamic pressure: Kinetic energy is calculated density x speed squared, divided by 2. $\rho \cdot v2/2$. The pressure works with duct direction (flow).

EC motor: Electronically commutated, a motor that, thanks to electronically controlled optimized field winding, leading to better efficiency compared to a standard AC motor.

Effekt: Work per time unit, indicates in Watt or J/s (Joule/second).

Energy: Indicates in Wh (watt-hours) or kWh (kilowatt-hours). If the fan uses 40 W and operates in 100 hours the energy consumption is 4000 Wh or 4 kWh.

Energy recovery: Normally achieved in a ventilation system with a rotating heat exchanger, plate exchanger or cross-flow exchanger, or in some other form of liquid-connected heat exchanger. How much that is recovered depends on the type of heat exchanger.

Enthalpy: Indicates the total energy content in the air, both heat and moisture.

Evaporative cooling: Energy is consumed from the surroundings when water vaporize. This process is used to cool e.g. a rotating heat exchanger, which in turn cools the outside air that passes. Approx. 3-4°C.

Exhaust air: Air that is directed away from a room.

Exhaust air diffuser: Removes damp and used air from the room. For placement in ceilings or walls. The diffuser is adjustable for right airflow.

Exhaust air ventilation system: Ventilation system with fan-controlled exhaust airflow.

Exhaust and supply air ventilation system: Ventilation system with fan-controlled and adjustable supply and exhaust airflows.

Exhaust and supply air ventilation system with energy recovery: Ventilation system with fan-controlled exhaust and supply airflows, where the heat from the exhaust air is recovered to heat the supply air.

External rotor motor: An engine where the rotor consists of permanent magnets that rotate around the stator comprising windings.

Extract air: Exhaust air that is expelled outdoors.

F-wheel: A fan wheel with forward curved impellers.

Filter: Used in ventilation systems, etc. to remove particles from the air. Various classes available.

Frequency control: A control equipment where the frequency of the alternating current can be change. A lower frequency gives a lower air speed and a lower airflow. Normally, the frequency of power supply in Europe is 50 Hz.

Fresh air: Air from or in the outdoors.

General (comfort) ventilation: Ventilation for handling impurities in the air from people, construction materials, furniture, fixtures, etc.

Heat recovery: Normally achieved in a ventilation system with a rotating heat exchanger, plate exchanger or cross-flow exchanger, or in some other form of liquid-connected heat exchanger. How much that is recovered depends on the type of heat exchanger.

Hygroscopic rotor: Recovers both sensible (temperature change) as latent (energy bound in the moisture) heat.

Impeller (fan wheel): The part of the fan that actuates air. There are different types of impellers for different purposes.

Infrasound: Inaudible sound at low frequencies, under 20 Hz.

Insulation: Available in various classes and materials for fireproofing, sound, heat, condensation, etc.

Kilowatt, kW: = 1000 Watt

Mixing ventilation systems: Entails dilution of the air in the room with a high supply air speed.

Natural ventilation system: Ventilation achieved through thermal lifts when the temperature in a vertical exhaust air duct is higher than the outdoor temperature.

Non-hygroscopic rotor: Recovers only sensible heat (temperature change).

PPM: Part per million. 1000 ppm means that 0.1% of the air consists of carbon dioxide, CO_2.

Pulser: Used to pulse out voltage to an electric heater in a duct system, etc. The pulser ”regulating” the power on the heater.

Radon: Inert gas formed during the disintegration of the radioactive element radium. Comes from construction materials (e.g. autoclaved concrete), the ground and water.

Recirculating air: Air that is circulated in a room or air that is returned to the same room that it was taken from.

Recuperative heat exchanger: Heat exchanger that transfer heat from the warm side (exhaust air) to the cold side (supply air) by directing the heat through the wall that separates the two media, type plate/cross-flow heat exchangers.

Regenerative heat exchanger: A rotating heat exchanger that transfer heat and moisture från exhaust air to supply air.

Relative air humidity: The moisture content of air in % of the maximum amount of moisture the air can contain at a certain temperature.

Room hygrostat: Used to start and stop a fan to regulate the humidity in a room.

Room thermostat: Used to start and stop a fan to regulate the temperature in a room.

SFP: Specific fan power. A measurement of the fan’s energy consumption in relation to airflow, $kW/m^3/s$. A lower value is better than a higher value.

Silencer: Used to muffle sound from the fan and air in a ventilation system. A silencer consists of a pipe or a box made of galvanized sheet steel that is insulated on the inside. The sound attenuation depends on the length of the silencer and the thickness of the insulation.

Static pressure: The difference between the static pressure in the duct and the atmosphere. The static pressure works perpendicular to the duct wall and is the pressure the fan must be dimensioned after.

Supply air: Clean air that is supplied to a room.

Supply air diffuser: Brings fresh air to the room. For placement in ceilings or walls. The diffuser is adjustable for right airflow.

System curve: Shows how the ventilation system's flow varies with the voltage.

Tangential fan (cross-flow)**:** Air is drawn into the fan and pressurized and ejected with a direction change of 90 °. Low built-in height and low pressure makes it useful for built-in cooling/heating components.

Temperature efficiency: A measurement of the heat recovery efficiency in % depending on the temperature difference between the temperature of the supply and fresh air.

Thyristor: Stepless voltage regulation of e.g. a fan. The thyristor "chops up" the alternating current sine wave, and release only a part of the wave to the fan when downregulation. The thyristor can, because of this, create a noise of the fan.

Total pressure, Pt: A fan's energy gains create a total pressure which is composed of static pressure and dynamic pressure. The static pressure is therefore the total pressure minus the dynamic pressure.

Transferred air: Air that is transferred from one room to another.

Transformer: Voltage regulation of e.g. a fan in fixed "steps", normally five. Lower voltage results in lower speed and hence lower flow.

Ventilation ducts: Normally galvanized and available in circular spiral or rectangular design.

A FEW FINAL WORDS...

Our objective with this book was to highlight the importance of good ventilation and to show what is required to achieve it.

It is said that a chain is never better than its weakest link, and this is also very true of ventilation systems.

It cannot be emphasized enough that each system must be planned and designed with flow, sound and operating costs, and that the components must then be selected based on these factors. But good planning and design and good components aren't enough on their own. It is also essential that the system and all components are installed correctly and adjusted to match the estimated flow.

*For a throughout high standard ventilation system, all links in the chain – **Planning, Design, Components, Installation** and last but not least, **Adjustment,** must be considered.*

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