Impellers

Impellers made by ebm-papst

Like pumps and compressors, fans and blowers belong to the category of aerodynamic and fluid work machines. A fan consists of an impeller, a drive motor and a housing for suspension and for guiding the air flow. The blades spaced along the circumference of the impeller are designed in such a way as to cause the flowing work medium to change direction, thus passing on pressure and speed energy.

ebm-papst construction designs

Depending on the geometrical shape of the impeller, there are different construction designs, with their names taken from the main flow direction in the impeller.

The most important designs are:

- Axial fans
- Centrifugal fans with backward curved blades
- Single or dual inlet centrifugal blowers with forward curved blades
- Diagonal (mixed flow) fans (a cross between axial and centrifugal fans)

Relevant fields of application of the various construction designs

The different ebm-papst fan and blower designs correspond to the different fields of application:

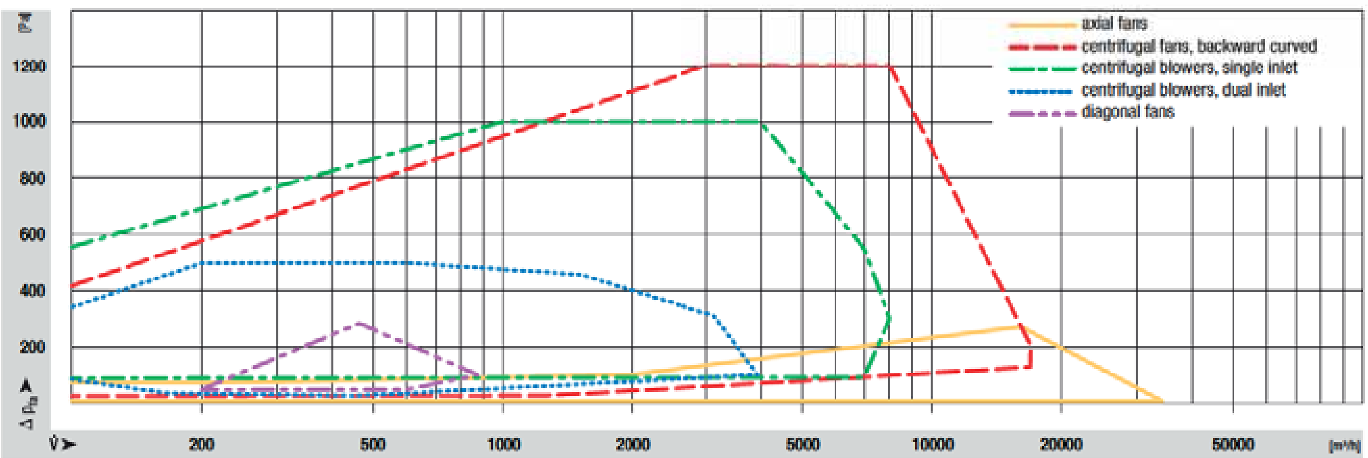
- Small back pressures: axial fans
- High back pressures: centrifugal fans with backward curved blades and single or dual inlet centrifugal blowers
- Threshold between axial and centrifugal fans: diagonal fans

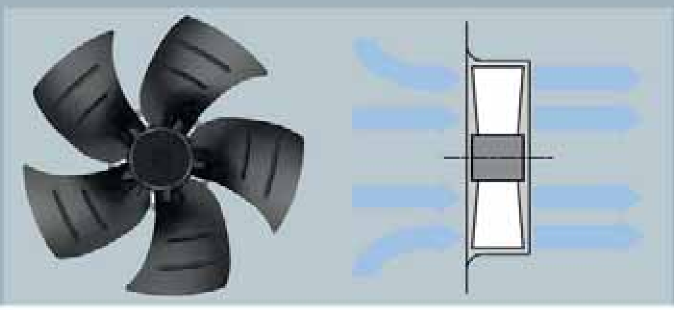
Application-specific selection parameters

When selecting an application-specific fan or blower, the main parameters to be taken into account are these:

- Air flow at given back pressure
- Constructional design
- Speed/rpm
- Impeller diameter
- Ambient conditions governing suction and exhaust side

Characteristic curves of the various designs





Axial fans

Operating range

To the right of the "saddle" (right part of the air performance curve):

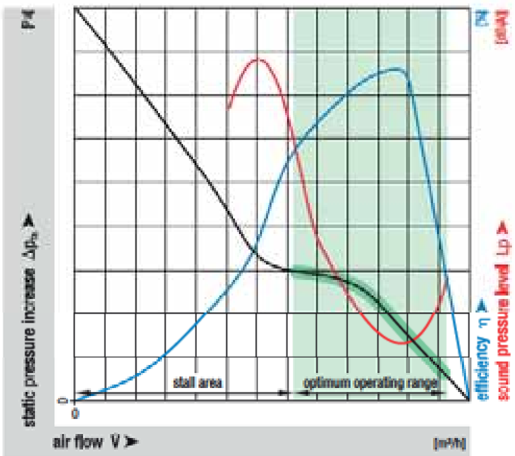
- Maximum efficiency
- Minimal noise

To the left of the "saddle" (left part of the air performance curve):

- Stall area
- Drop in efficiency
- Soaring noise

The optimum operating range of the fan is shaded in green in the curve given here.

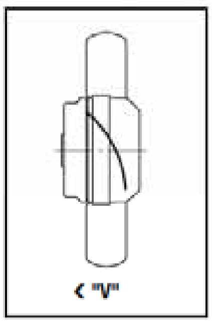
Noise / efficiency curve



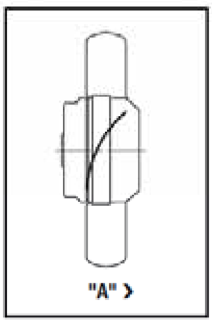
Direction of air flow

The direction of air flow is given as follows:

Direction of air flow "V"



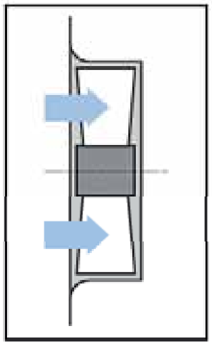
Direction of air flow "A"



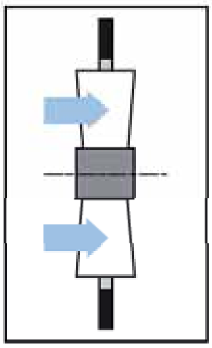
Effects when mounted in wall ring or in the aperture

Mounting the fan in a wall ring can significantly increase the air performance in the operating range.

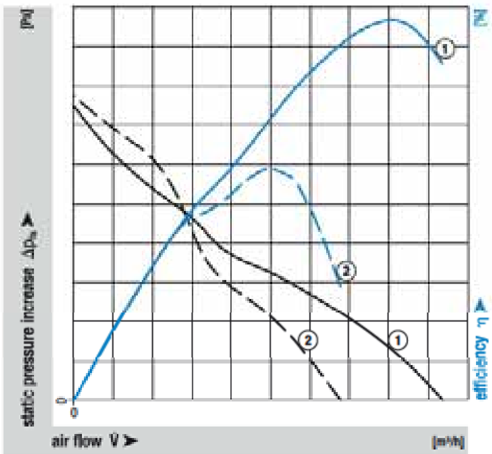
① Wall ring



② Aperture



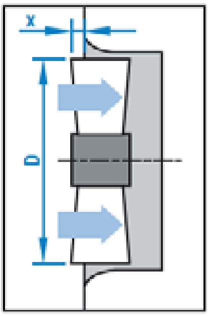
Curve



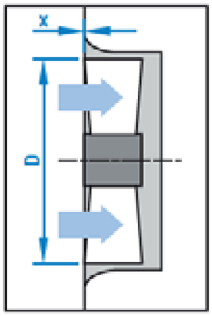
Effects with axial position in the wall ring

Axial position in the wall ring influences air performance and efficiency.

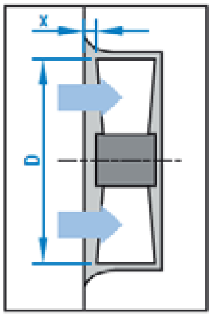
① Projecting on inlet side
x / D = 7 %



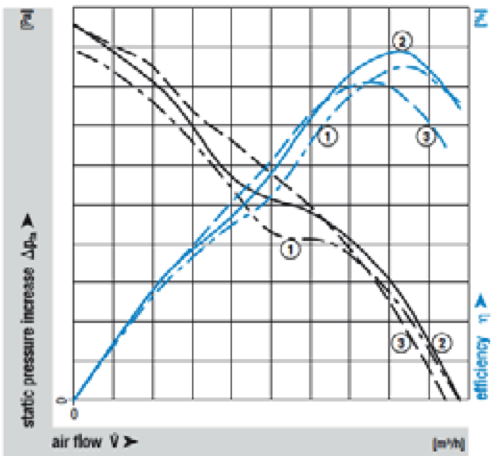
② Flush on inlet side
x / D = 0 %



③ Immersed on inlet side
x / D = -7 %



Curve



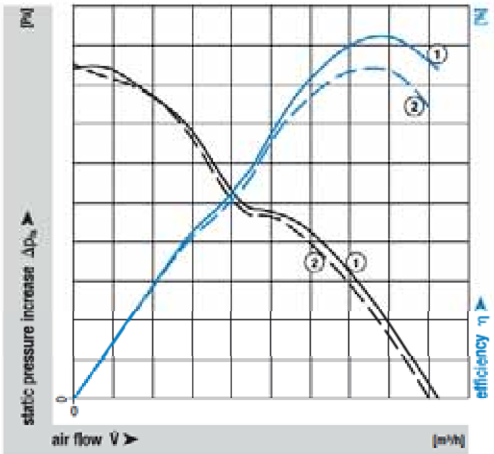
Effects with guard grilles

Mounting a guard grille reduces the air performance of the axial fan.

① Without guard grille

② With guard grille

Curve



The pressure drop in Pa can be roughly calculated according to the following equation:

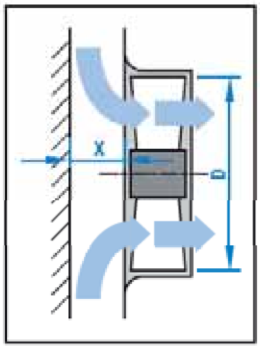
$$\Delta p_{GG} = \epsilon_{GG} \cdot 10^{-8} \cdot \dot{V}^2 \qquad \dot{V} \text{ in } [m^3/h]$$

For the guard grilles used at ebm-papst, the correction factor ϵ_{GG} can be used depending on the impeller diameter D from the table to the right.

Diameter D	Correction factor ϵ_{GG}
130	10000
143	6600
180	2550
200	1650
250	650
300	300
315	240
350	150
400	90
450	55
500	35
560	20
630	11
710	6
800	3
910	1.5
990	0.9

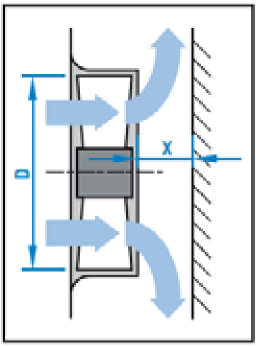
Effects of obstructions on the suction or exhaust side
Disturbances or obstructions on the suction or pressure side reduce the air performance of the axial fan.

Obstructions on the inlet side



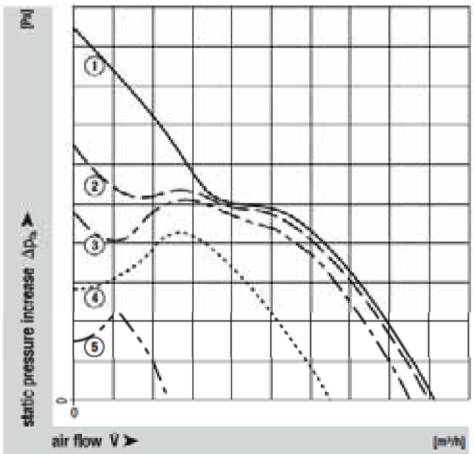
① x / D = ∞
② x / D = 35 %
③ x / D = 18 %
④ x / D = 9 %
⑤ x / D = 5 %

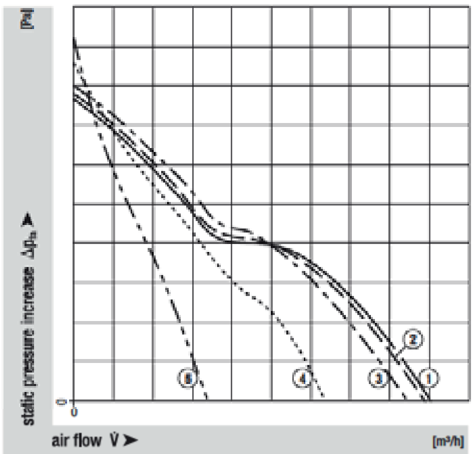
Obstructions on the exhaust side



① x / D = ∞
② x / D = 35 %
③ x / D = 18 %
④ x / D = 9 %
⑤ x / D = 5 %

Curve





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Centrifugal fans with backward curved blades

Operating range

Middle part of air performance curve:

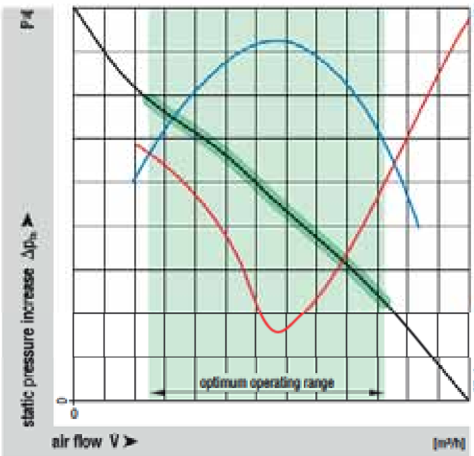
- Maximum efficiency
- Minimal noise

To the right and the left of the middle part of the air performance curve:

- Reduced efficiency
- Increasing noise

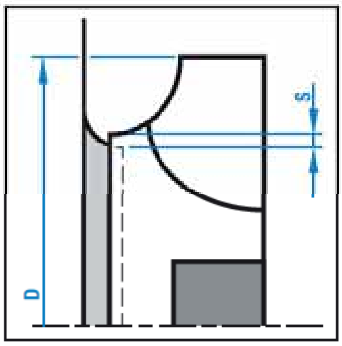
The optimum operating range of the fan is shaded in green in the curve given here.

Noise / efficiency curve



Effects of nozzle gap dimension

The centrifugal air gap between the inlet nozzle and impeller cover plate influences the air performance and efficiency of the centrifugal fan.

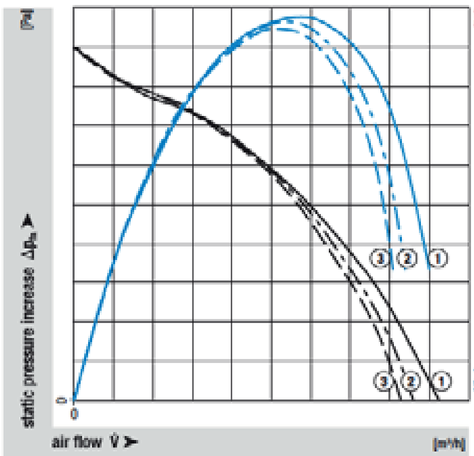


① s / D = 0.4 %

② s / D = 1.0 %

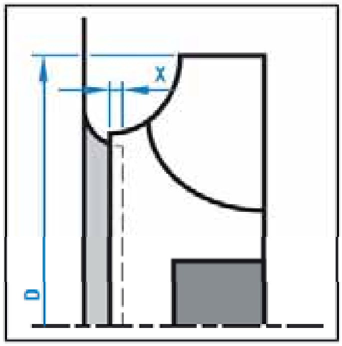
③ s / D = 1.4 %

Curve



Effects of overlapping dimension

The axial overlap between the inlet nozzle and impeller cover plate influences the air performance and efficiency of a centrifugal fan.

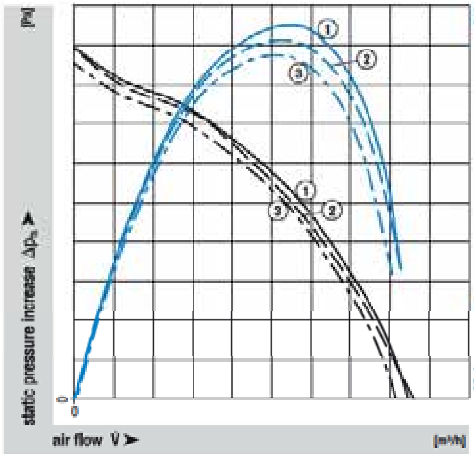


① x / D = 0.6 %

② x / D = 0 %

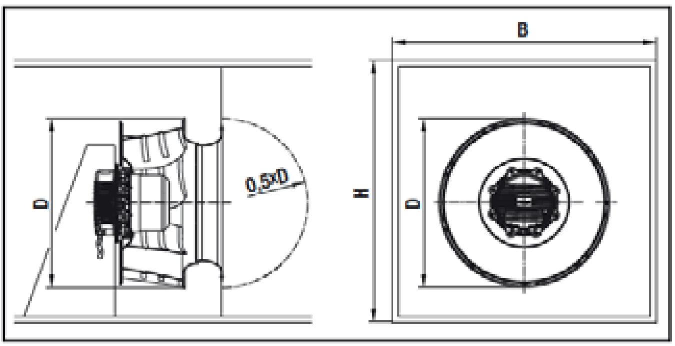
③ x / D = -0.8 %

Curve

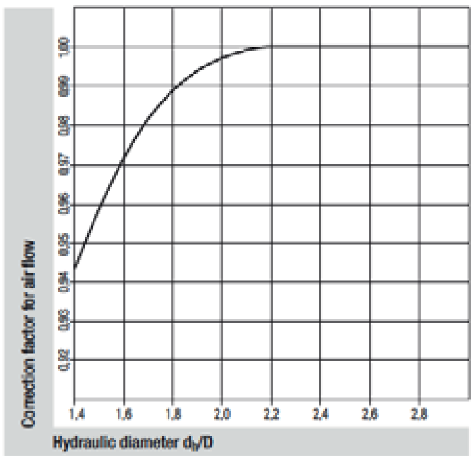


Effects of installation space

When mounting our product in a rectangular box, air performance might be reduced.



Curve



d_h = Hydraulic diameter

Formula: $d_h = 2 \times B \times H / (B + H)$

B = Width of box

H = Height of box

D = Outer diameter of the fan

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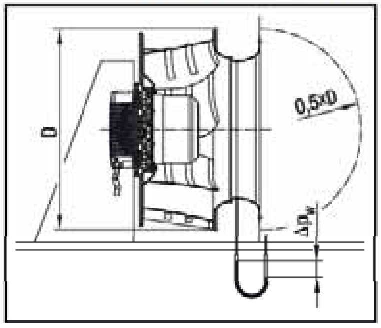
Air flow measurement for inlet nozzles with pressure-measuring point

The differential pressure approach compares the static pressure before the inlet nozzle with the static pressure inside the inlet nozzle.



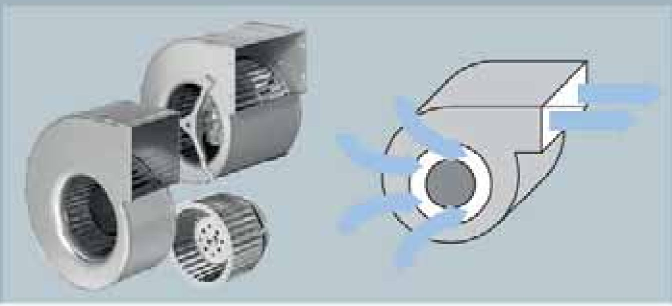
Air flow can be calculated on the basis of the differential pressure (difference in pressure of the static pressures) in keeping with the following equation:

$\dot{V} = k \cdot \sqrt{\Delta p_W}$ $\dot{V}$ in [m³/h] and Δp_W in [Pa]

If constant air flow control is used, then the nozzle pressure has to be kept constant: $\Delta p_W = \dot{V}^2 : k^2$

k takes into account the specific nozzle characteristics.

One or four pressure measuring points are spaced along the circumference of the inlet nozzle. Connection on the customer side is accomplished via a premounted T tube connector. This tube connector is suited for pneumatic hoses with an internal diameter of 4 mm.



Single and dual inlet centrifugal blowers with forward curved blades

The forward curved centrifugal impeller must always be operated inside a scroll housing.
A dual inlet centrifugal blower shows the same behaviour as two single inlet blowers operated in parallel: with size, speed and pressure being identical, double the air flow is achieved.

Operating range

Middle part of air performance curve:

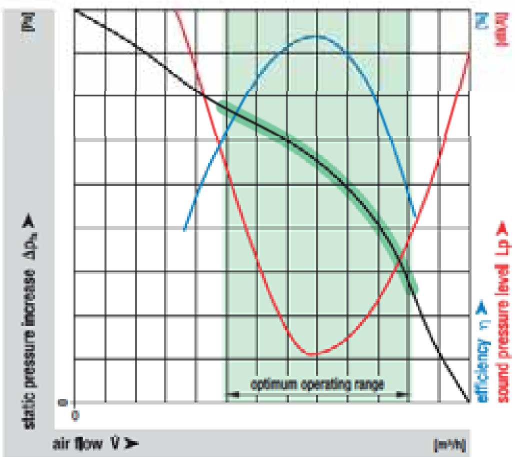
- Maximum efficiency
- Minimal noise
- higher performance density than with the backward curved centrifugal fan

To the right and the left of the middle part of the air performance curve:

- Reduced efficiency
- Increasing noise

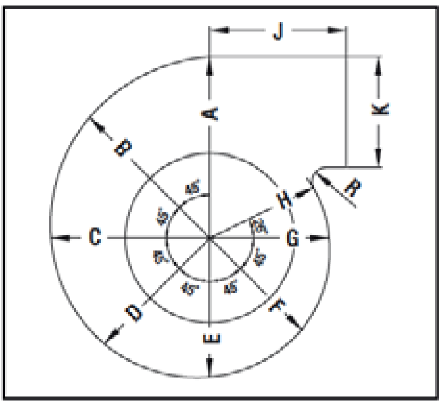
The optimum operating range of the fan is shaded in green in the curve given here.

Noise / efficiency curve



Dimensioning of the scroll

The dimensions of a typical scroll can be calculated with the following formulae, subject to the impeller diameter D:



A = 1.062 · D
B = 0.992 · D
C = 0.922 · D
D = 0.853 · D
E = 0.784 · D
F = 0.715 · D
G = 0.646 · D
H = 0.612 · D
J = 0.720 · D
K = 0.689 · D
R = 0.073 · D

Adjusting the dimensions to diminished mounting spaces is possible.

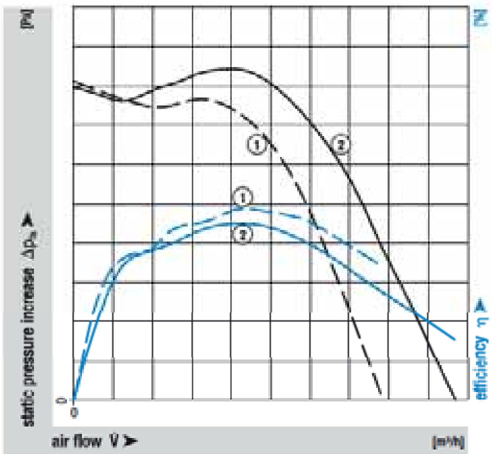
Effects of step diffusers

A diffuser mounted on the exhaust side with connected exhaust tunnel increases air performance and efficiency of the centrifugal blower.

① without step diffuser

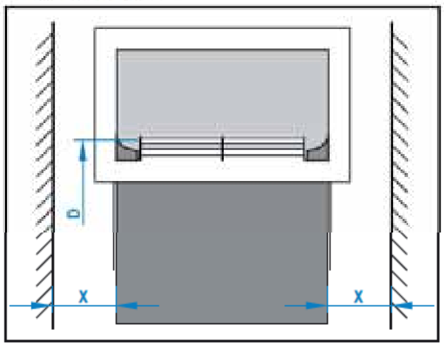
② with step diffuser

Curve



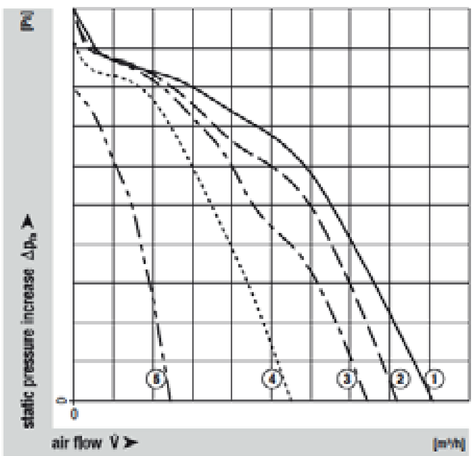
Effects of obstructions on the intake side

Obstructions on the air intake side reduce the air performance of the centrifugal blower.



① x / D = ∞
② x / D = 30 %
③ x / D = 23 %
④ x / D = 15 %
⑤ x / D = 7.5 %

Curve

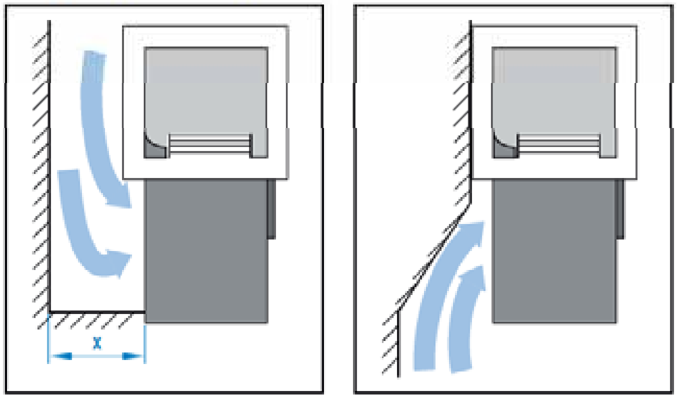


Effects caused by obstructions on the inlet side for constant air flow EC centrifugal blowers

Constant air flow is attained with unimpaired inflow only.

An obstructed (e. g. asymmetrical or partially blocked) air flow can have a significant effect on the curve behaviour and cause large deviations from a constant air flow curve.

<u>Examples of obstructed inflows</u>



Instructions for designing a sufficiently unobstructed inflow:

- The distance x between the blower intake and neighbouring walls or obstructions should be at least 25 % of the impeller diameter.
- Inflows with angular momentum or asymmetrical rotation should be avoided.
- The inflow can be made more uniform using resistances such as those from filters or grilles.

On request, we offer calibrated blower designs that incorporate a specific installation situation.

Diagonal fans (axial design)

Operating range

Directly to the right of the "saddle" (right part of the air performance curve):

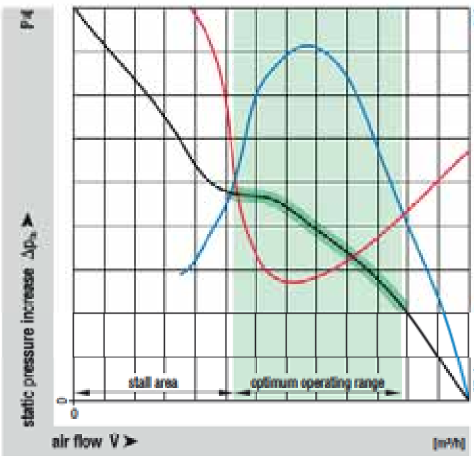
- Maximum efficiency
- Minimal noise

To the left of the "saddle" (left part of the air performance curve):

- Stall area
- Drop in efficiency
- Soaring noise

The saddle of the *diagonal / mixed flow fan is slightly higher than that* of the axial fan. This means that the technical ratings in the optimal operating range are better than those of the axial fan.
The optimum operating range of the fan is shaded in green in the curve given here.

Noise / efficiency curve



Mounting information

The conical housing (part of delivery) makes sure the necessary gap dimension is kept.

Effects

The effects of the diagonal / mixed flow fan are similar to those listed for the axial fan (p. 577-580).

Dimensioning / change in speed

Influence of speed n

A change in speed influences:

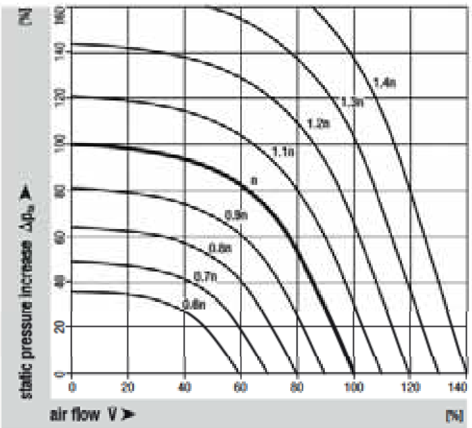
- Air flow $\dot{V}$

  $\dot{V} \sim n$
- Static pressure increase Δp_{fa}

  $\Delta p_{fa} \sim n^2$
- Requirement of energy P_1

  $P_1 \sim n^3$

Curve



Influence of the speed n on the sound level Lw

When the speed changes, the approximate sound level can be determined using the diagram to the right and the following formula:

$Lw_2 - Lw_1 = 50\ dB \cdot \log (n_2 : n_1)$

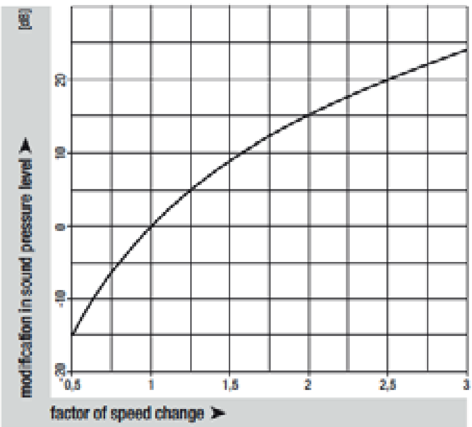
Lw_1 = Sound level after speed change

Lw_2 = Sound level before speed change

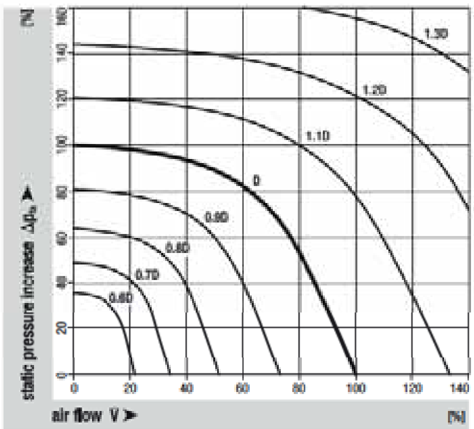
n_1 = Changed speed

n_2 = Starting speed

Curve



Curve



Influence of impeller diameter D

A change in impeller diameter influences:

- Air flow $\dot{V}$

  $\dot{V} \sim D^3$

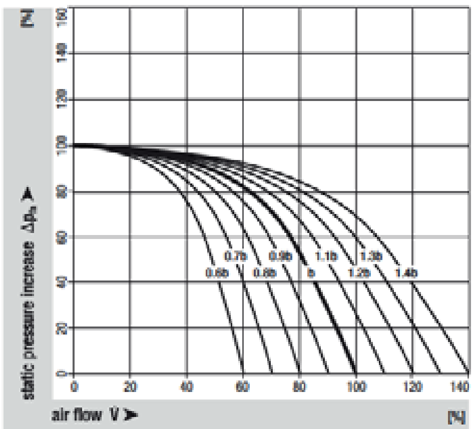
- Static pressure increase Δp_{fa}

  $\Delta p_{fa} \sim D^2$

- Requirement of energy P_1

  $P_1 \sim D^5$

Curve



Influence of width of air discharge b (only for centrifugal impellers)

A change in width of the air discharge influences, in approximation:

- Air flow $\dot{V}$

  $\dot{V} \sim b$

- Static pressure increase Δp_{fa}

  $\Delta p_{fa} = \text{const}$

- Requirement of energy P_1

  $P_1 \sim b$