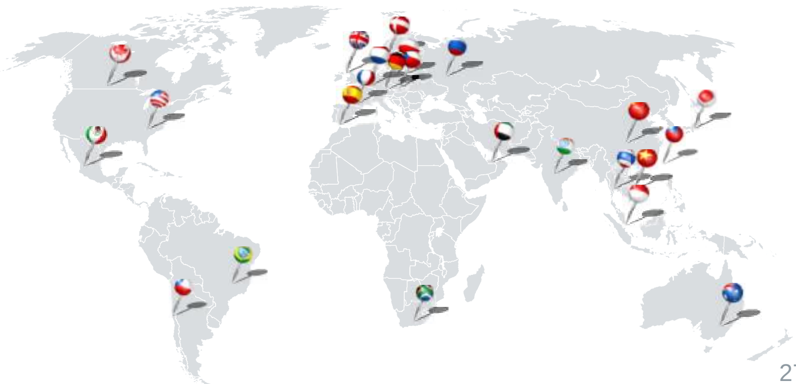
Howden Netherlands – Cooling Fans

Desmond de Haan – Area Manager

Revolving Around You™

STORK®

1955	**Ventilatoren Stork Hengelo** starts production of aluminum Cooling Fans
1960	The company adopts Fiberglass Reinforced Polyester for its Cooling Fans
1989	Howden takes a majority interest in the fan division of Stork
1992	Ventilatoren Stork Hengelo is acquired 100% by Howden and the company name changes to **Ventilatoren Sirocco Howden (VSH)**
2006	The company is renamed “Howden Netherlands” (HNL)



Specific features of Howden Cooling Fans

High air flow volume: to 3000 m^3/s (6.5M ACFM)
Low pressure drop : 350 Pa (1.5” WG)

Large diameter : 0,7 up to 21 m (3-60’)

Temperature
Standard : - 20 to 65 °C (-5 to 150F)
Optional : - 60 to 135 °C (-75 to 275° F)

Air Cooled Heat Exchanger
A.C.H.E

Air Cooled Condenser
A.C.C.

Mechanical Draft
Cooling Tower
C.T.

Retrofit

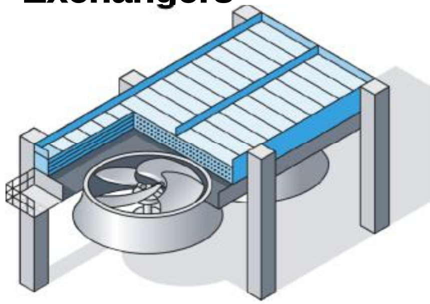
What is Retrofit?

More airflow = more cooling capacity

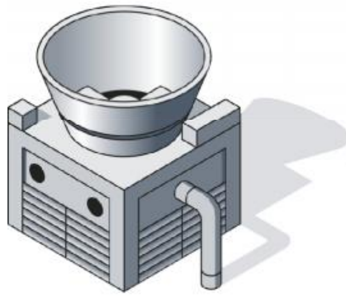
With retrofit we mean replacing a cooling fan in an existing cooling system for the purpose of:

- **Plant Performance**
- **Efficiency**
- **Noise reduction**

Air-cooled Heat Exchangers



Cooling Towers

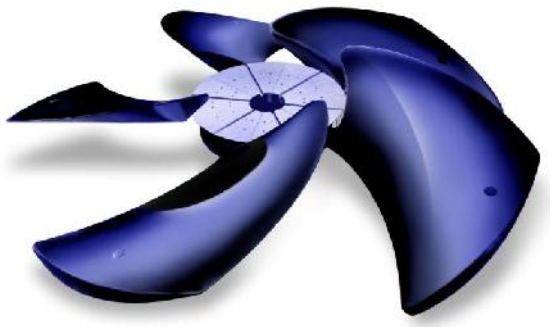


Air-cooled Condensers

Retrofit possibilities are strongly enhanced by the use of **(Ultra) Low noise fans.**

FPX

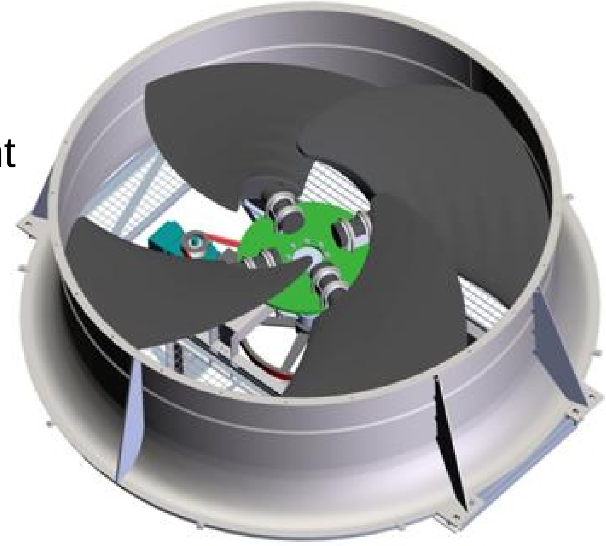
SXT

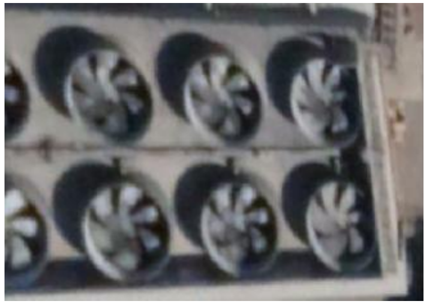


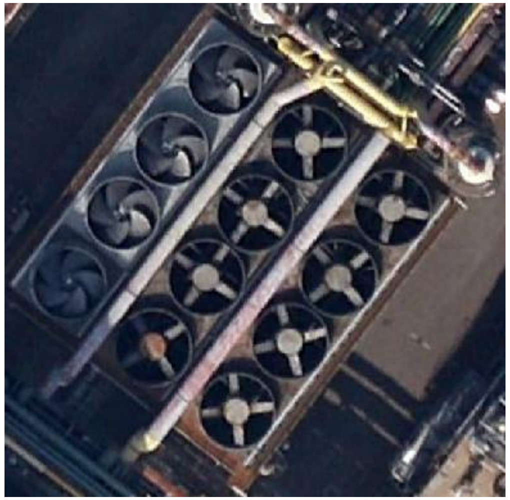
SX

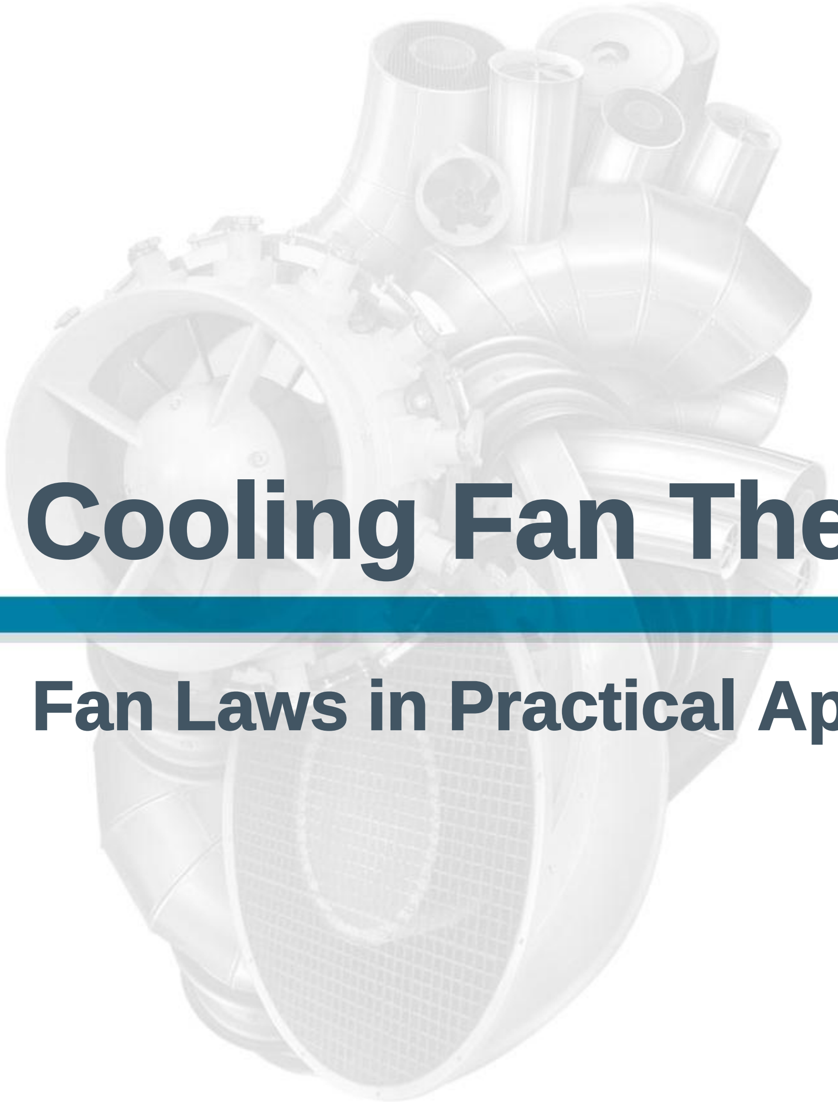
Specific advantages of a cooling fan retrofit:

- Capacity can be increased quickly and easily on same footprint
- Sound emission (noise) reductions, crucial in field noise
- Efficiency increases
- The upgrade can be arranged in stages, no down time
- Low investment, short return on investment
- Possibility to prove the concept and ROI





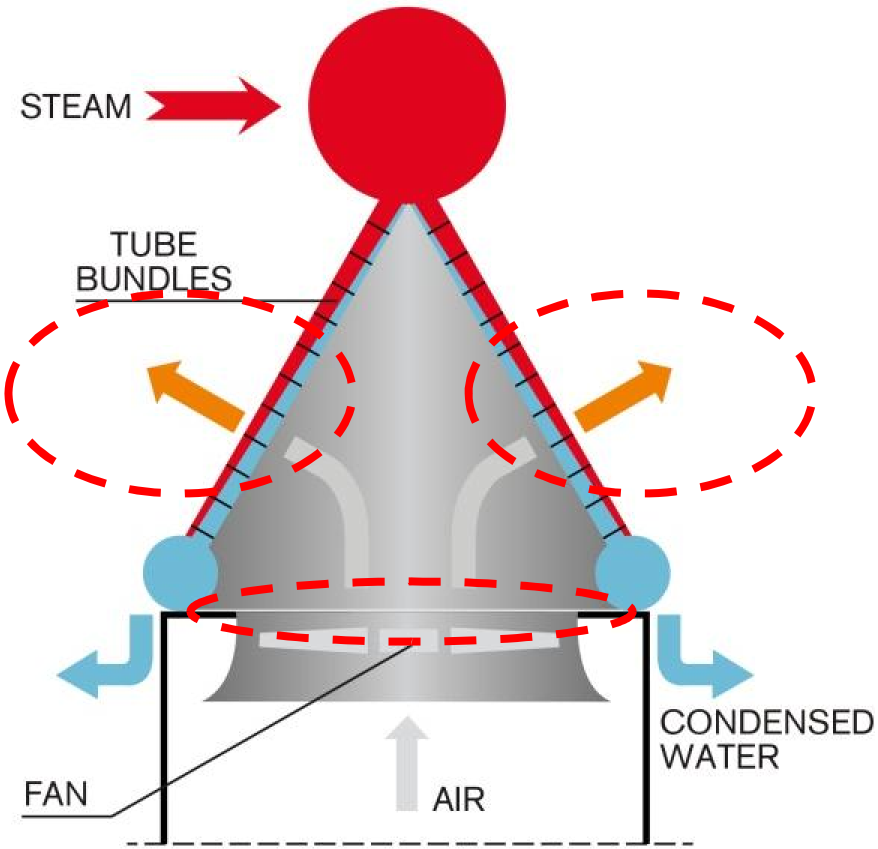




Cooling Fan Theory

Fan Laws in Practical Applications

System resistance



Resistance

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Fan Power (P)

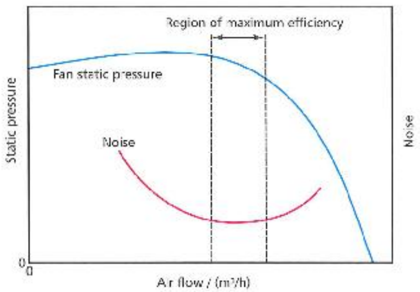
- A fan is a mechanical device converting mechanical input power into aerodynamic power
- Aerodynamic power is the product between flow and pressure
- Cooling Fans are designed to provide large air volumes at low static pressure rises

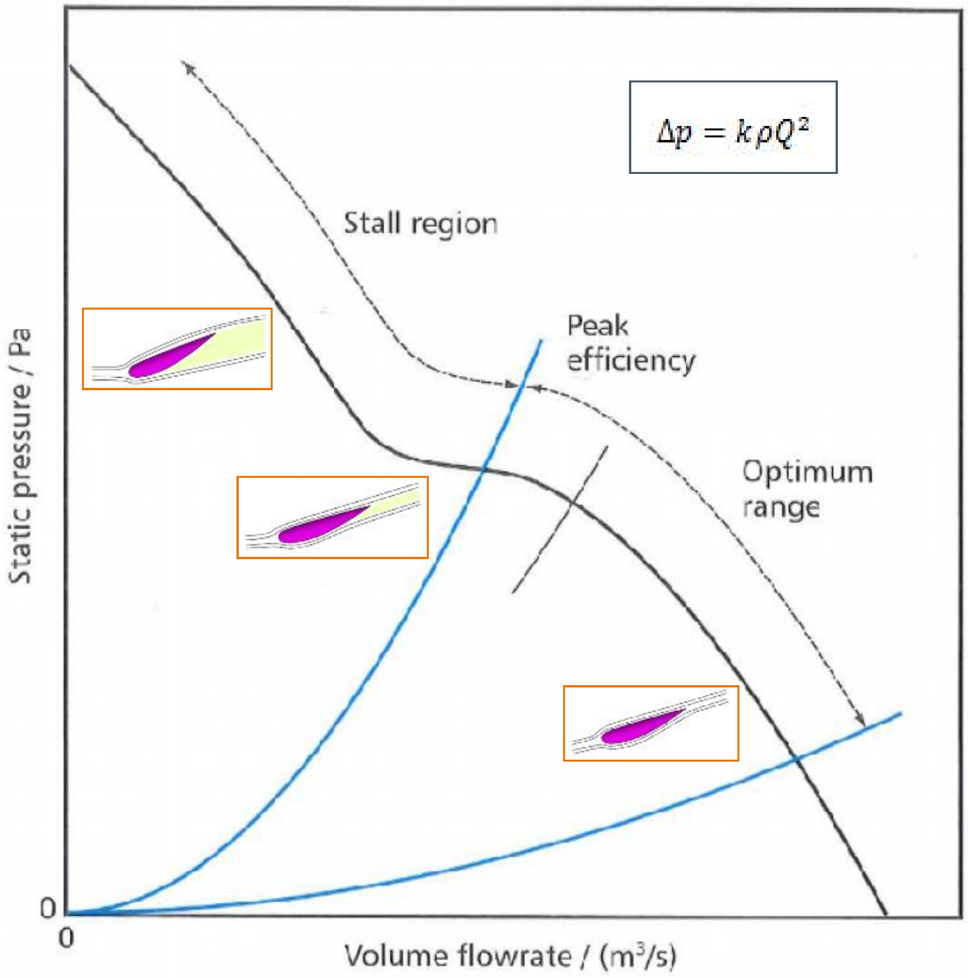
$$P_{aero} = (Q \times P_{stat}) / \eta_{stat}$$

$$P_{aero} = (Q \times P_{tot}) / \eta_{tot}$$

System Resistance and Fan Curves

- System resistance line
- Fan curve
- Stall Area
- Static Pressure $\boldsymbol{P_{stat}}$ in ***Pa***





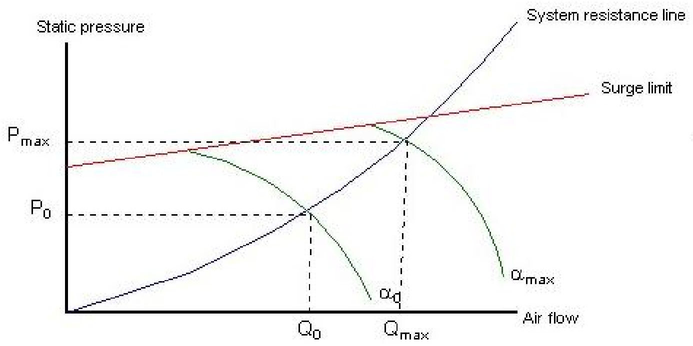
$$P_{tot\ fan} = P_{stat} + P_{dyn}$$

$$P_{tot\ fan} = k\,\rho\,^2Q^2 + \tfrac{1}{2}\rho V$$

Pressure an Volume Margin

Pressure Margin API 661

"Fan selection at design conditions shall ensure that at constant speed the fan can provide by an increase in blade angle a 10 percent increase in airflow and a corresponding pressure increase. Since this requirement is to prevent stall and inefficient operation of the fan, the resulting increased power requirement need not govern the driver rating."



API pressure margin:

$$\frac{P_{max}-P_0}{P_0}.100\%$$

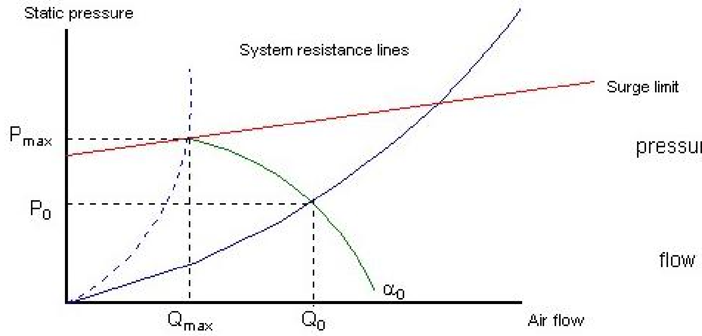
API flow margin:

$$\frac{Q_{max}-Q_0}{Q_0}.100\%$$

Pressure Margin Constant Blade Angle

Pressure margin value the fan can make for the set blade angle before stalling. This is a more realistic approach as pollution of the cooling unit with time will cause an increase in system resistance; the blade angle will not be adjusted.

This assessment is preferred by Howden!



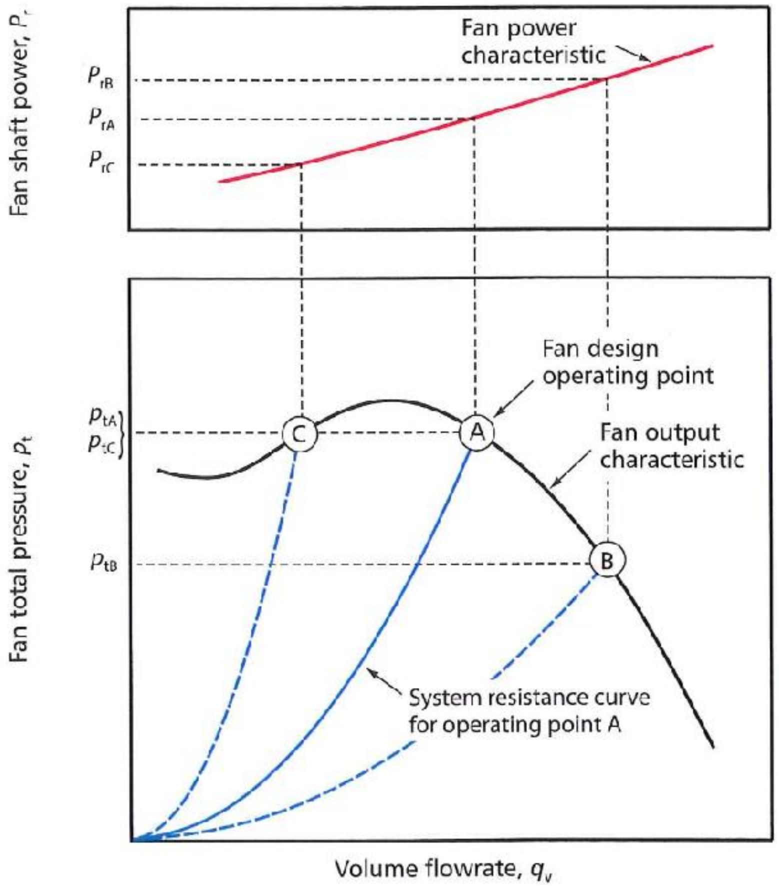
pressure margin at selected blade angle α_0:

$$\frac{P_{max}-P_0}{P_0}.100\%$$

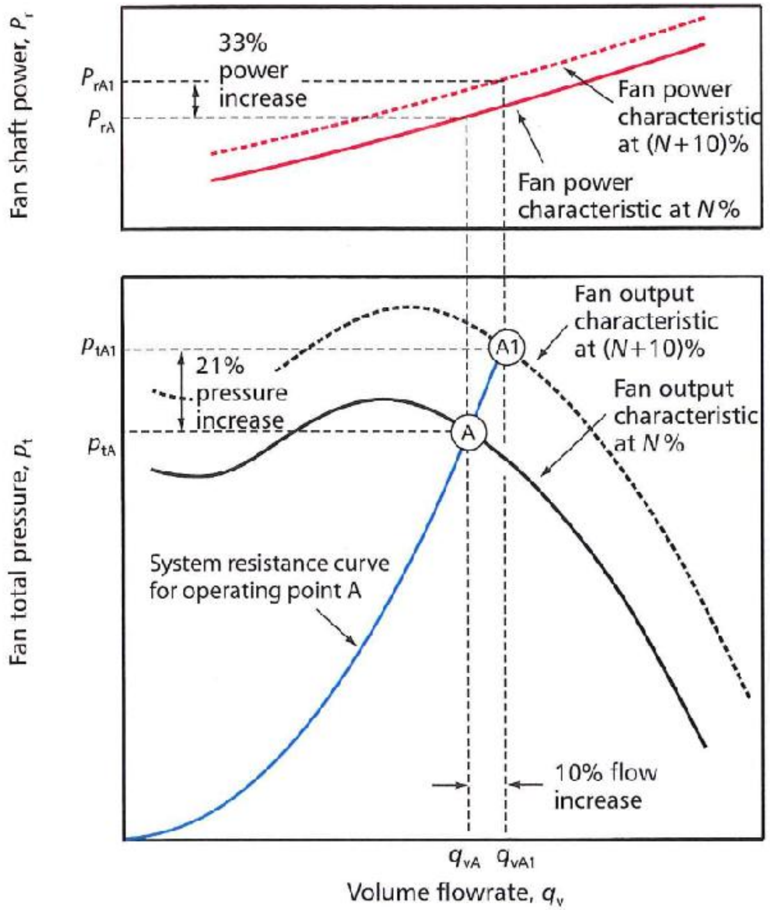
flow margin at selected blade angle α_0:

$$\frac{Q_{max}-Q_0}{Q_0}.100\%$$

Practical Facts of the Combined Fan Curves and System Laws (1)

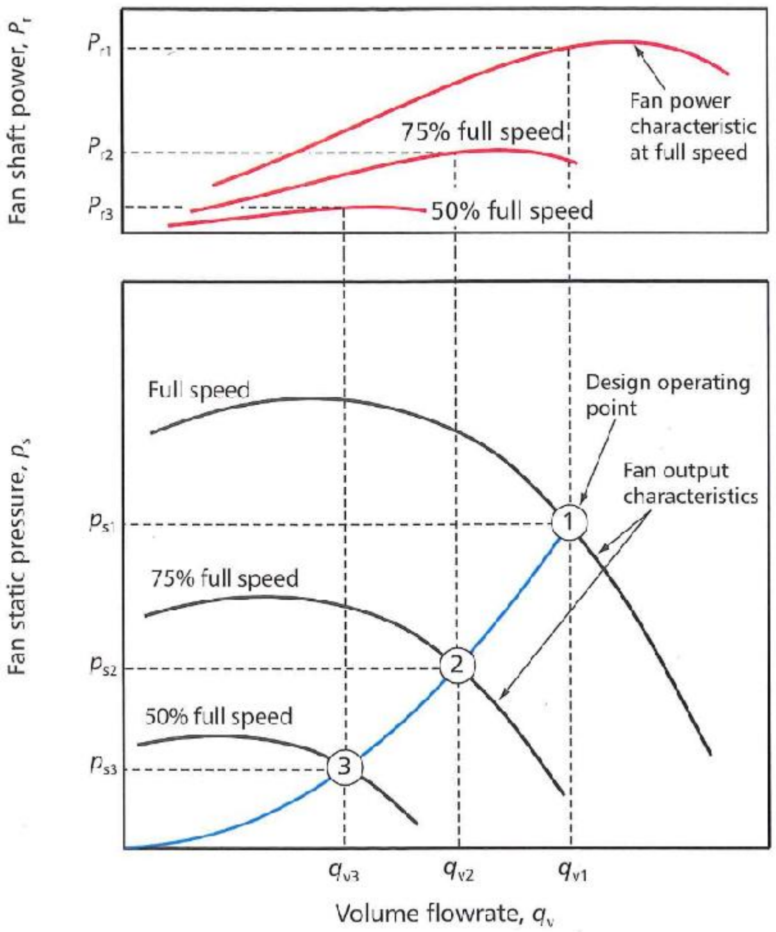


Change in Resistance Curve

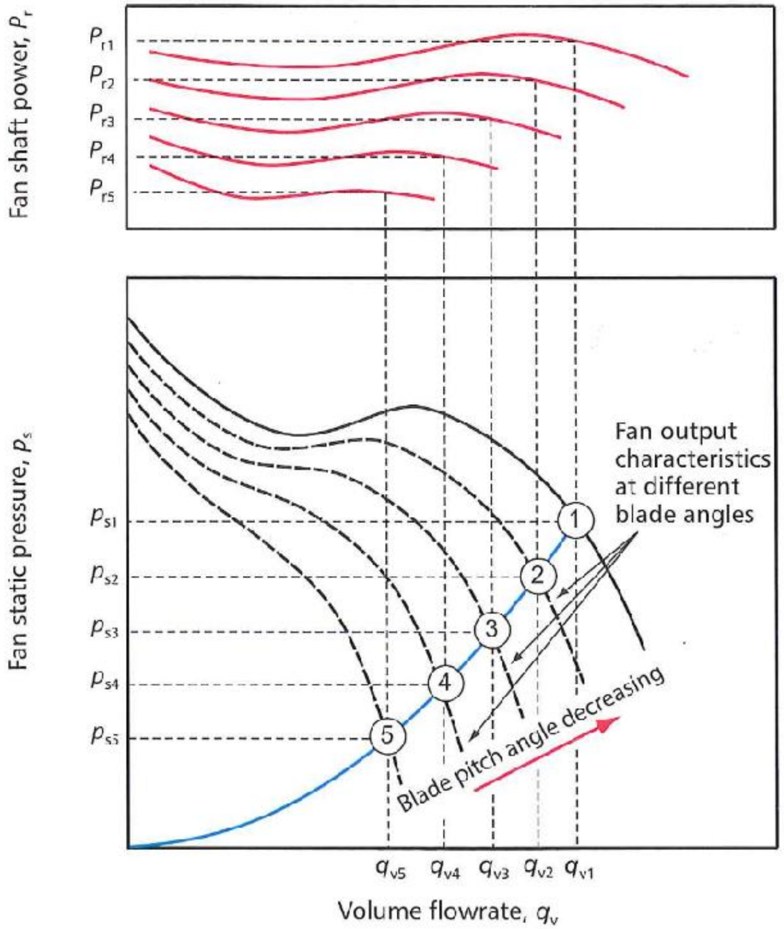


Change in Fan Speed

Practical Facts of the Combined Fan Curves and System Laws (2)



Change in Speed

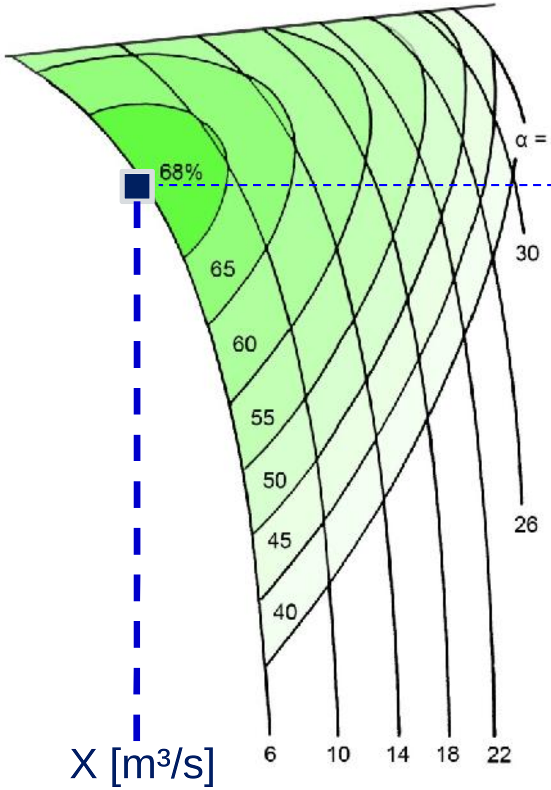


Change in Blade Pitch

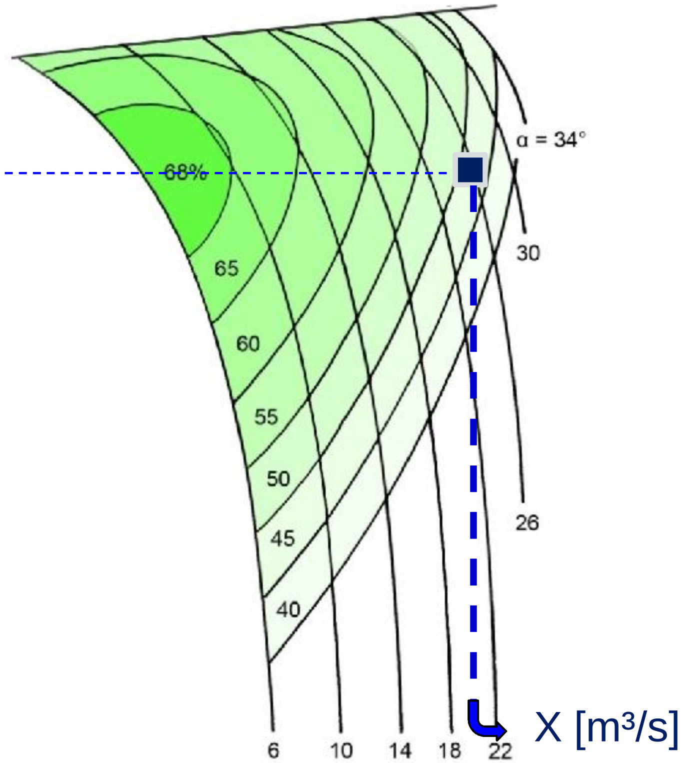
Fan Sizing – Fan Diameter

Big impeller

Small impeller



Y [Pa]



Big impeller =
small pitch - low $p_{dyn.}$ - high static efficiency –
low power consumption - low noise –
higher CAPEX.

Small impeller =
big pitch - high $p_{dyn.}$ - low static efficiency –
high power consumption - high noise -
Low CAPEX

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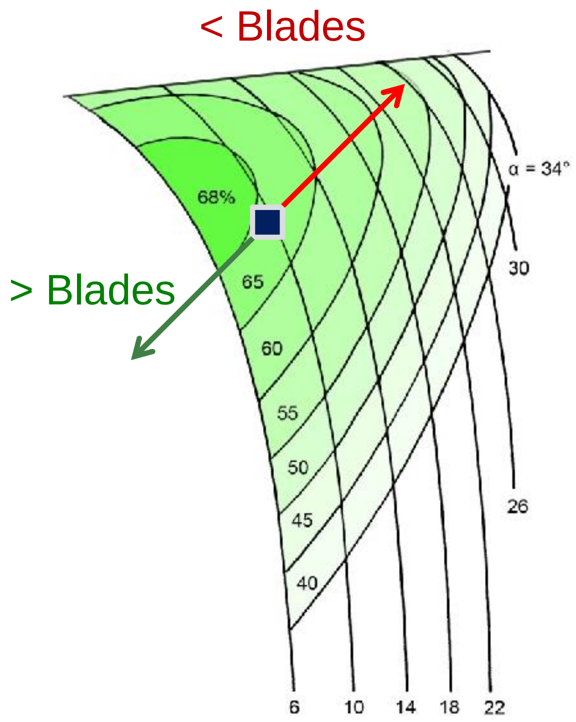
Fan Sizing – Number of Blades



Input data

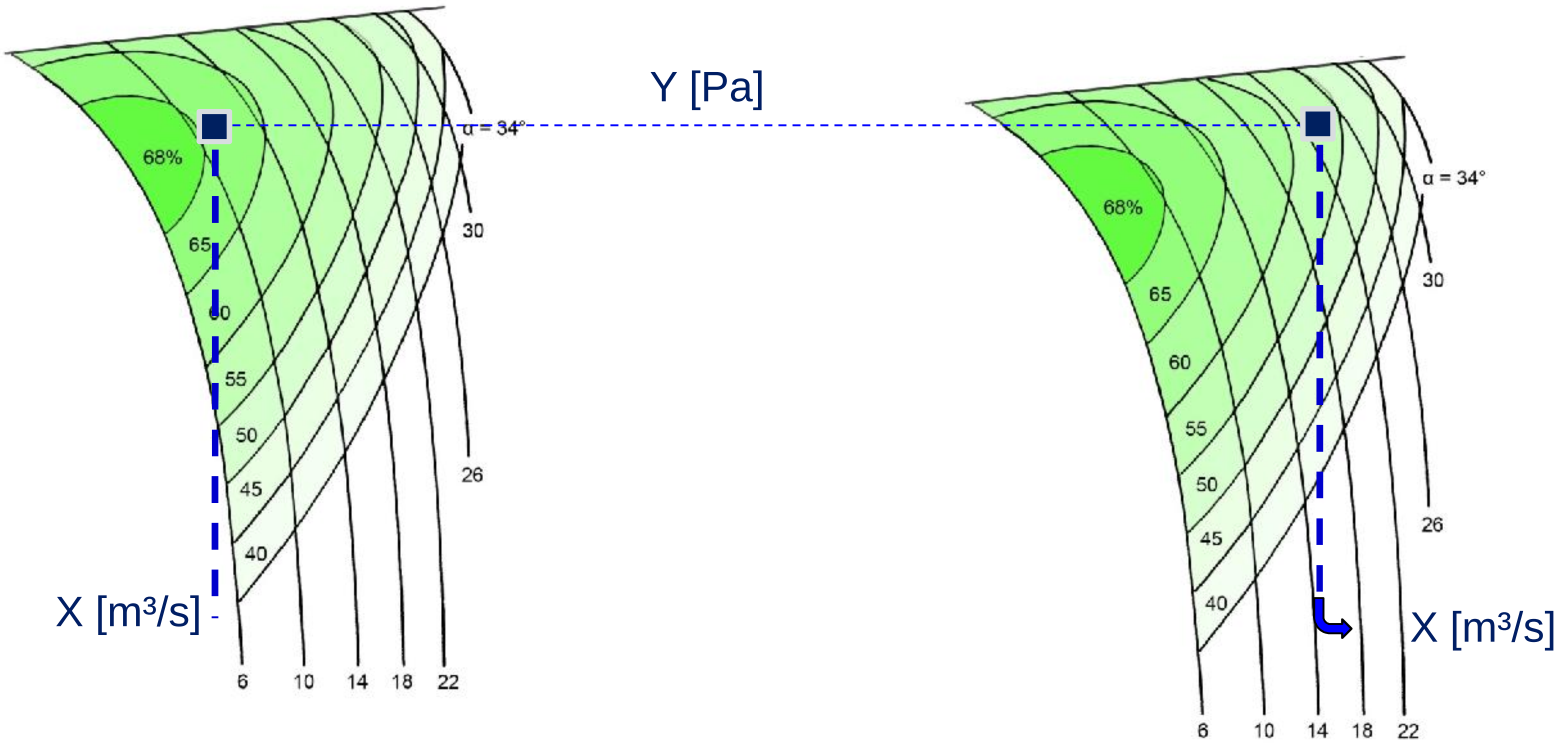
Application	: Cooling tower			
Air flow	: 150,0	[m^3/s]	Installation type	: Induced Draught
Static pressure	: 150,0	[Pa]	Mounting orientation	: vertical shaft; hub at inlet
Inlet temperature	: 20,0	[°C]	Fan inlet shape	: Bell, L/D = 0.15
Air density	: 1,200	[kg/m^3]	No diffusor present	
Fan diameter	: 14 [ft]		No obstacles present	
Fan blade type	: ELF			
Blade number	: All possible			
Fan tip speed	: 45,0	[m/s]		
Fan clearance	: 0,01	(2S/FanDia)		
Crosswind	: 0,0	[m/s]		

Selection results

Fan type	Tip speed [m/s]	RPM [min^-1]	Blade angle [°]	Static efficiency [%]	Total efficiency [%]	Fan shaft power [kW]	pressure margin [%]	Air flow margin [%]	Total PWL [dB(A)]	Cf	Cp
14 ELF 4	45,0	201,4	23,5	56,2	79,9	40,1	22,4	10,6	95,0	0,233	0,123
14 ELF 5	45,0	201,4	20,9	56,9	81,0	39,5	36,3	16,8	95,0	0,233	0,123
14 ELF 6	45,0	201,4	19,1	57,3	81,5	39,3	49,2	22,1	95,0	0,233	0,123
14 ELF 7	45,0	201,4	18,2	59,5	84,7	37,8	57,2	25,4	95,0	0,233	0,123

Fan Sizing – Speed

High speed **Low speed**



High speed = smaller pitch - higher efficiency - lower power consumption - higher noise

Low speed = big pitch - low efficiency - high power consumption - low noise – higher risk for stall

Fan Laws (1/2)

Q = Volume in m³/sec

N = Speed in rpm

D = Diameter in meter

p = Air Density in kg/m3

H = Static Pressure in Pa

$$\frac{Q}{Q_r} = \left(\frac{N}{N_r}\right)\left(\frac{D}{D_r}\right)^3$$

$$\frac{P}{P_r} = \left(\frac{N}{N_r}\right)^2\left(\frac{D}{D_r}\right)^2\left(\frac{p}{p_r}\right)$$

Key essential to know for making fan assessments!

$$\frac{H}{H_r} = \left(\frac{N}{N_r}\right)^3\left(\frac{D}{D_r}\right)^5\left(\frac{p}{p_r}\right)$$

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Fan Laws (2/2)

Volume: $$\frac{Q_2}{Q_1} = \frac{n_2}{n_1}$$

Pressure: $$\frac{p_2}{p_1} = \left(\frac{n_2}{n_1}\right)^2$$

Abs. Power: $$\frac{P_{Fan2}}{P_{Fan1}} = \left(\frac{n_2}{n_1}\right)^3$$

Noise: $$\Delta PWL = 60LOG\left(\frac{n_2}{n_1}\right)$$

Q *Volume flow*

n *Fan speed*

p *Static pressure*

P *Power consumption*

PWL *Sound power level*

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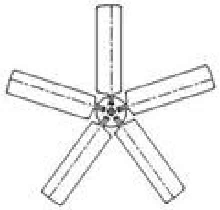
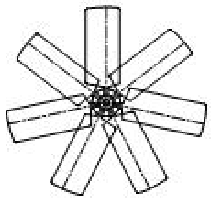
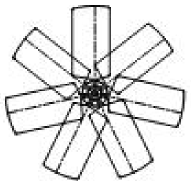
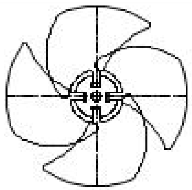
Choice of Fan Type with respect to Noise

Various Cooling fan options for an identical duty point.

Fan Diameter 8 meter
280 m³/sec
110 Pa

Difference in Noise generation
up to 15 dB(A)

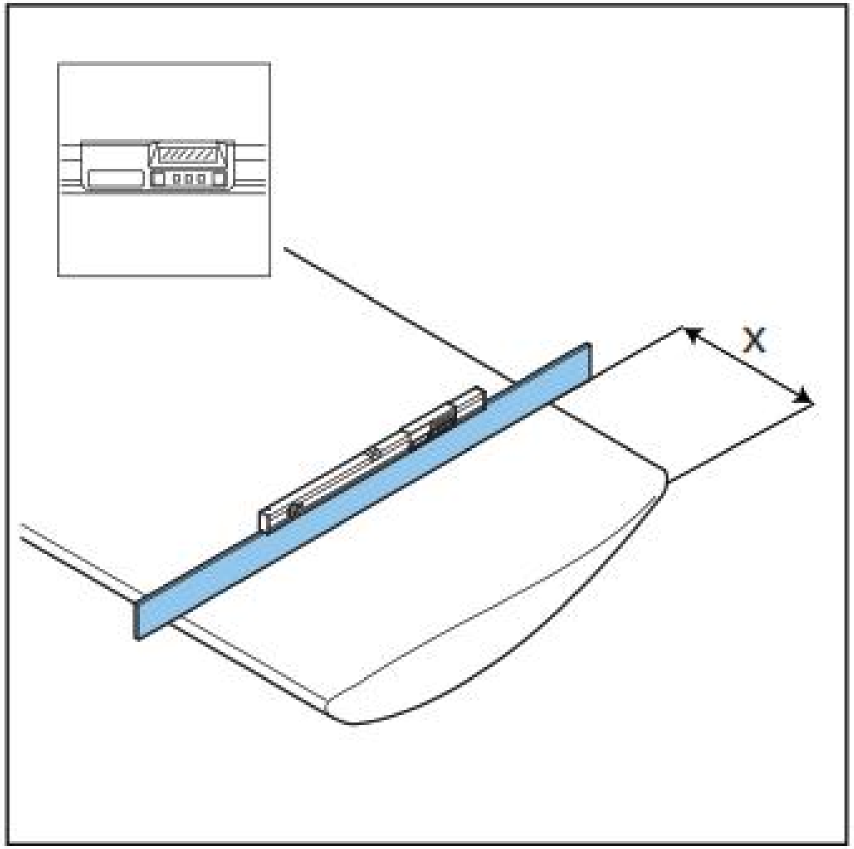
Shape	Noise reduction	Solidity	RPM	Tipspeed	PWL	▲ dB (A)
	Standard	0,11	117	52	101	-
	Low-noise	0,33	80	36	93	-7,5
	Very low-noise	0,52	72	32	90	-10,5
	Ultra low-noise	0,71	72	32	86	-15

Troubleshooting

Adjustment of the blade angle

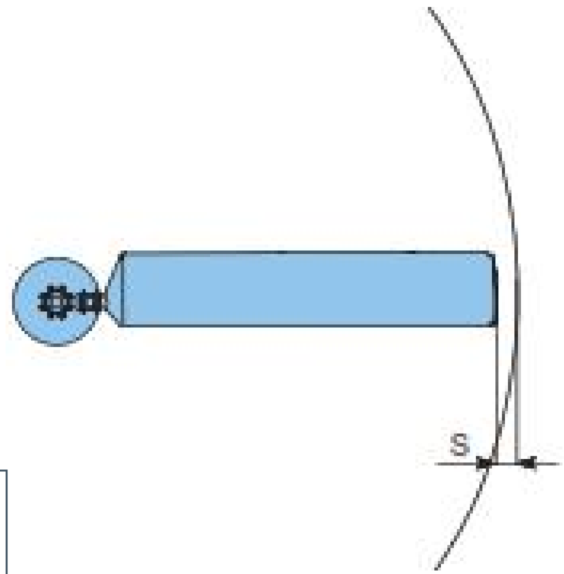
Adjust blade angle

1. Place a straight edge, which is at least as long as the profile width, on top of the discharge side of the blade at about 50 mm (2 inches) from the blade profile end (distance X).
2. Place the inclinometer on top of the straight edge.
3. Lift the blade at the tip and rotate the blade around its axis until the desired angle is set within a maximum tolerance of ± 0.5 degrees.



Fan Blade Tip Clearance

The tip clearance is the distance between the blade tip and the impeller casing. Howden recommends a tip clearance according to the applicable fan selection sheet. In general, the tip clearance is not constant around the impeller casing. This is because the impeller casing is not exactly circular.



CAUTION
The tip clearance must never be less than 0.25% of the impeller diameter!

Determine longest blade

1. Measure the tip clearance (S) of all blades at a fixed point in the fan casing.
2. Determine the longest blade.

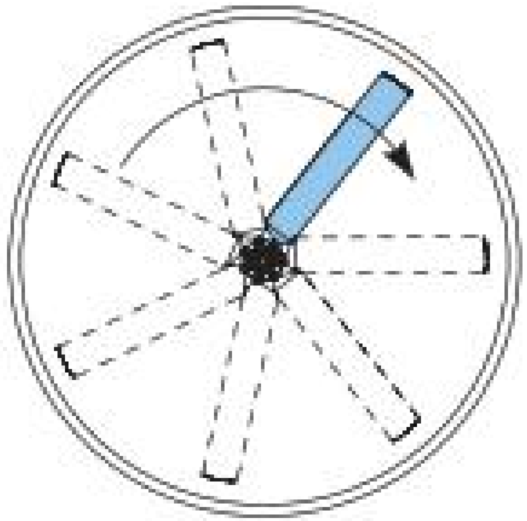
CAUTION
Do not measure at a split of the casing.

Measure tip clearance longest blade

1. Slowy rotate the impeller manually to the various measuring points.
2. Measure the tip clearance of the longest blade at the various measuring points. The number of measuring points = 12.

Note
If the the minimum tip clearance is too small, there are two options:

- *The impeller shaft is not correctly centered. Refer to 5.1.3.*
- *Reducing the impeller diameter. Refer to 5.5.2.*



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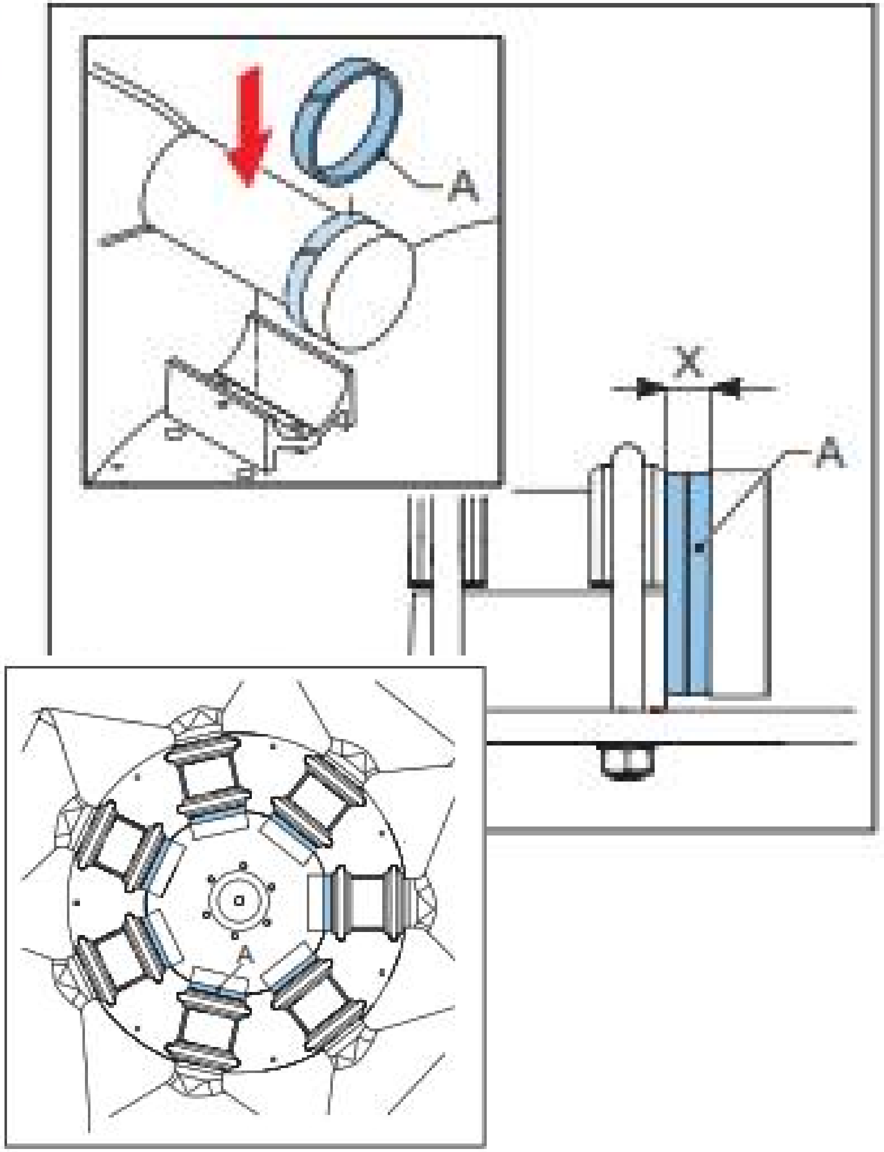
Install spacer rings

1. Install one or more spacer rings (A) between the blade stem collars and the lower clamping pieces.

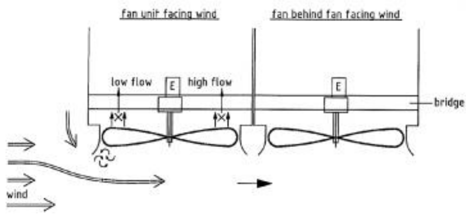
Note
The total thickness of spacer rings per blade equals the reduction in radius (= diameter/2) that is necessary to get enough tip clearance.

WARNING
The total thickness of the rings (X) must not exceed the value given in Table 1: "Maximum total thickness of the spacer rings".

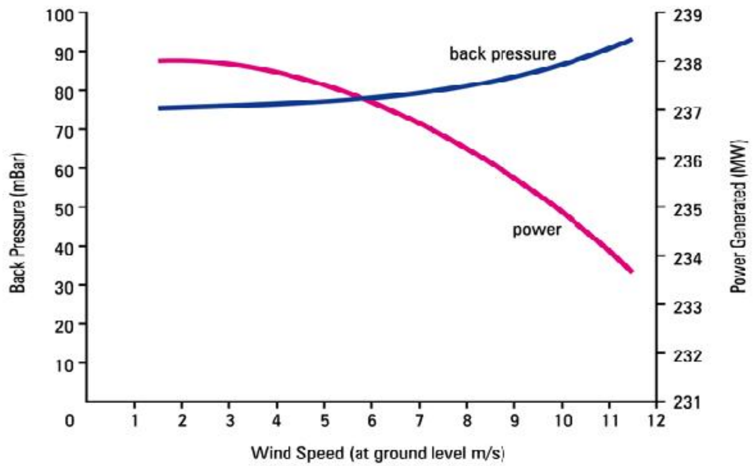


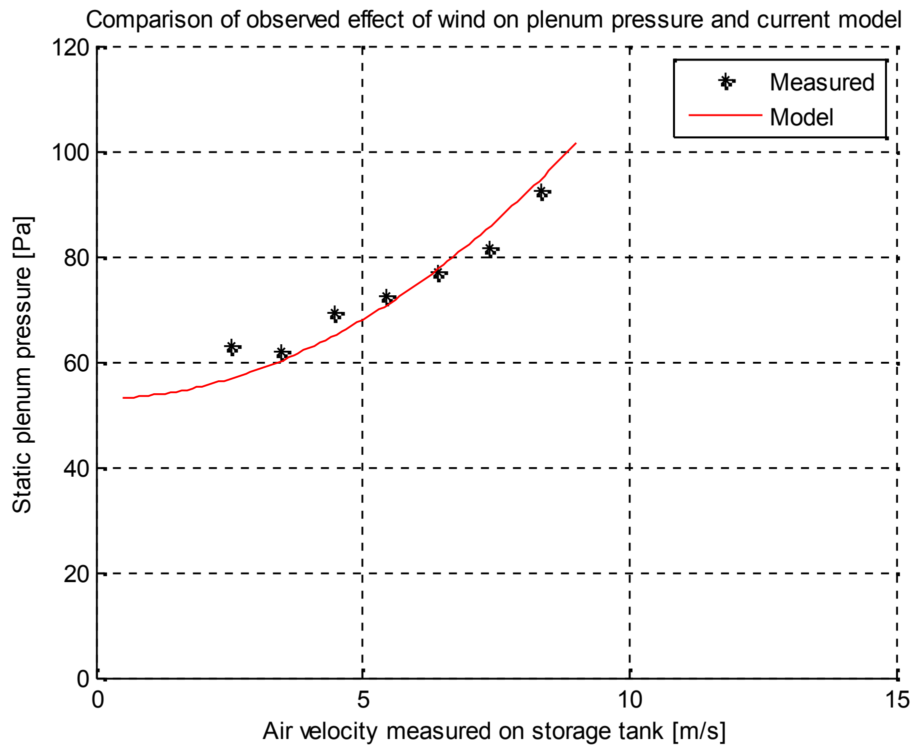
Effects of Wind on FD fan

- Adds resistance and pressure loss
- Causes loss in fan performance
- Causes increased loading on the fan blades
- Recirculation (hot exhaust air flow back into the fan inlet)
- Reduced thermal performance



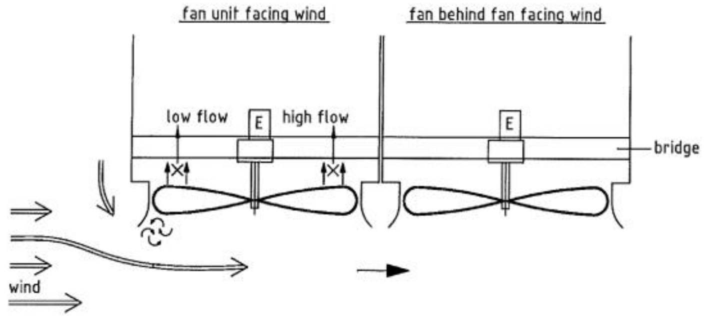
$$\Delta p_{wind} = \frac{1}{2}\rho v_{wind}^{2}$$

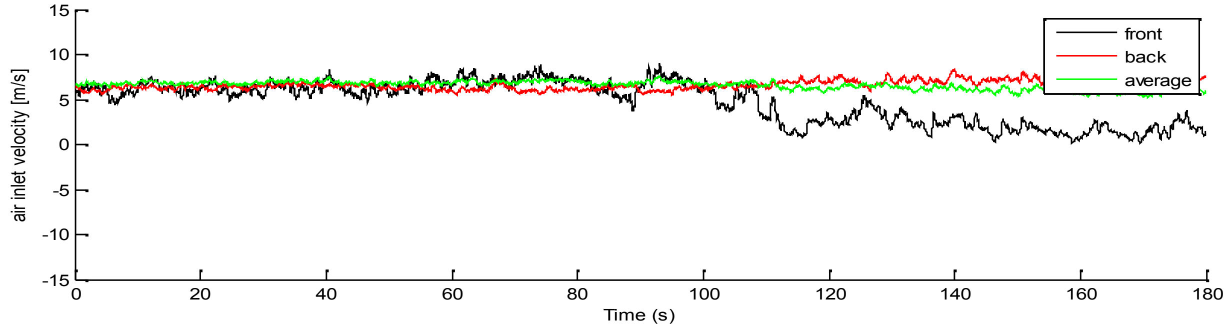


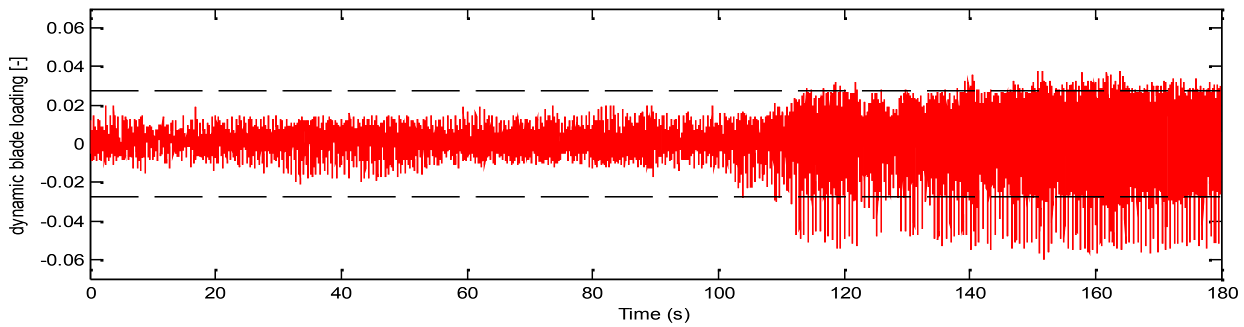


Non-uniform Inlet Flow due to Wind

- Separation from the inlet bell
- Local reduction air inlet velocity
- Causes additional loading of the fan blades







Tips for making a good fan selection and assessment (1)

- Set the flow / diameter ratio to 7-11 m/sec air speed
- Choose application and possible recovery effects
- Set the air density
- Determine the pressure and obstacle influences (Noise and Pressure Loss)
- Set inlet shape
- Determine the desired pressure margin
- Check for mechanical frequency excitations
- Specify the maximum PWL of the fan

Fan Data 36DVM8:

Type:	36DVM8
Diameter:	36 ft
Blades:	8
Blade angle:	21,3 °
Fan Static Efficiency:	59 %
Mass:	1952 kg
Moment of inertia:	15573 kg.m²

Input data -

Application Data:

Application:	Air Cooled Condensor
Draught:	Forced Draught
Mounting orientation:	Vertical shaft; hub at inlet
Inlet shape:	Bell, L=0.15D
Duct height:	0,0 m
Tip clearance:	0,35 %
Diffuser:	n.a.
Obstacles:	
Inlet frontal area:	0,10
Inlet obstacle distance:	0,15
Outlet frontal area:	0,10
Outlet obstacle distance:	0,15
Crosswind:	0,0 m/s
Resistance exponent:	2

Input data -

Operating Conditions:

Airflow:	686,1 m³/s
Pressure recovery:	0%
Static pressure:	94,0 Pa

Recovery:	0,0 Pa	Outlet obstacles:	0,0 Pa
Inlet shape:	0,0 Pa	Diffuser:	0,0 Pa
Inlet obstacles:	0,0 Pa	Crosswinds:	0,0 Pa
Inlet height:	0,0 Pa		

Fan Static Pressure:	94,0 Pa	
Fan speed:	55,5 rpm	
Tip speed:	31,9 m/s	
Fan shaft power:	110,1 kW	
Fan shaft torque	18958 Nm	
Airflow margin:	10,2 [1]	-27,5 [2]
Pressure margin:	21,4 [1]	30,8 [2]

1) according to API 2) at selected blade angle

Air density:	1,200 kg/m³
Inlet temperature:	25,0 °C
Axial thrust:	11715 N
Force loss of 1 / 2 blade(s):	15355 N / 28373 N
Imbalance (ISO 1940/1 G6.3):	71 N
Fan rotation frequency:	0,9 Hz
Fan operating natural freq:	3,4 Hz
Blade passing frequency:	7,4 Hz

Input data -

Acoustical Data:

Lw(A) fan:	91,0 dB(A)
Inlet shape:	0,0 dB(A)
Inlet obstacles:	0,8 dB(A)
Outlet obstacles:	0,4 dB(A)
Lw(A) fan total:	92,2 dB(A)

Tolerance on Lw(A) fan total ± 2 dB

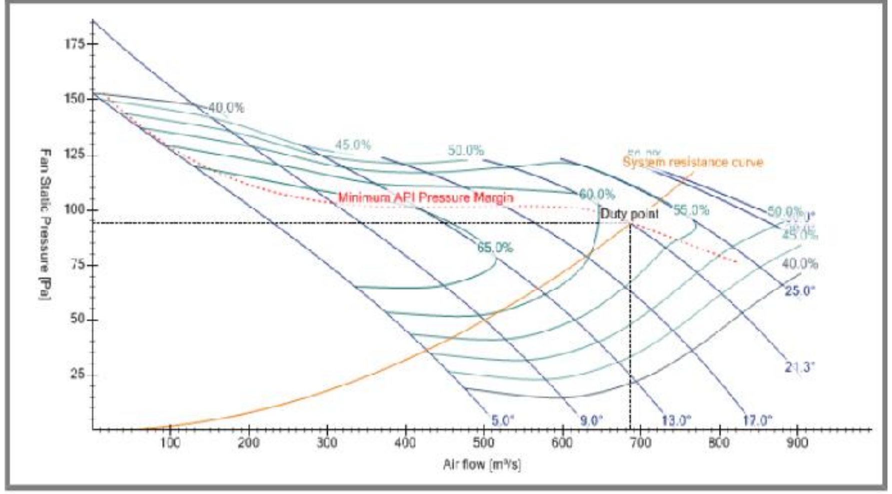
Fan sound power spectrum:

Octave [Hz]	PWL [dB]	PWL [dB(A)]	Tolerance [dB]
63	96,1	69,9	5
125	96,1	80,0	3
250	92,1	83,5	2
500	89,1	85,9	2
1000	86,1	86,1	2
2000	78,1	79,3	2
4000	74,1	75,1	2
8000	70,1	69,0	2

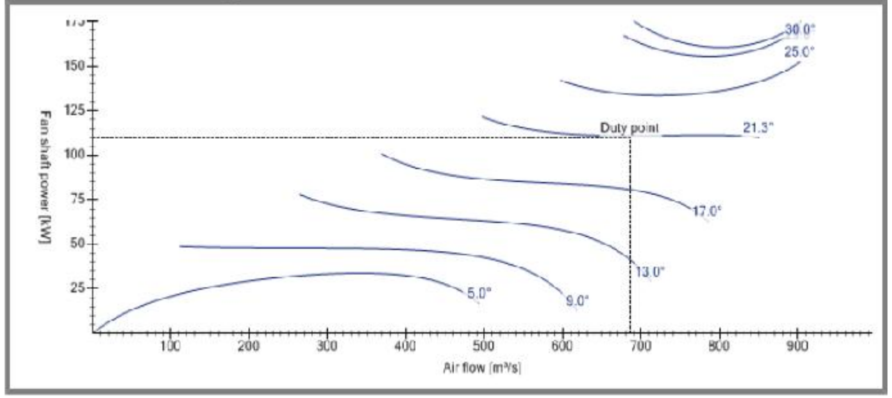
Lp(A) 1m beside inlet:	63,1 dB(A)
Lp(A) 1m below inlet at 45°:	65,8 dB(A)
Lp(A) 1m below inlet:	71,0 dB(A)
Lp(A) 1m above cooler:	67,7 dB(A)

Tips for making a good fan selection and assessment (2)

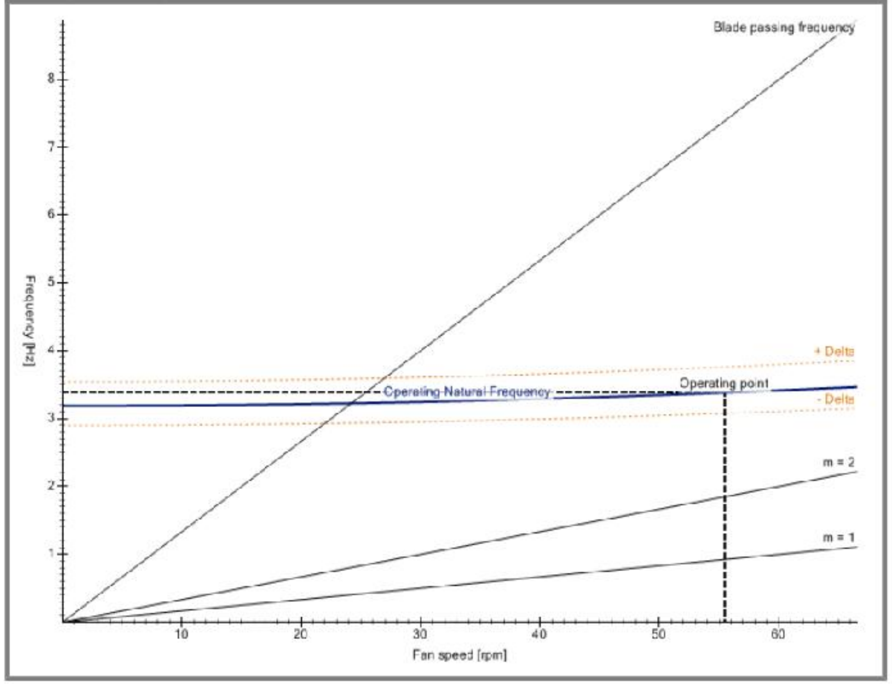
Performance Graph:



Fan Shaft Power Graph:



Campbell Diagram:

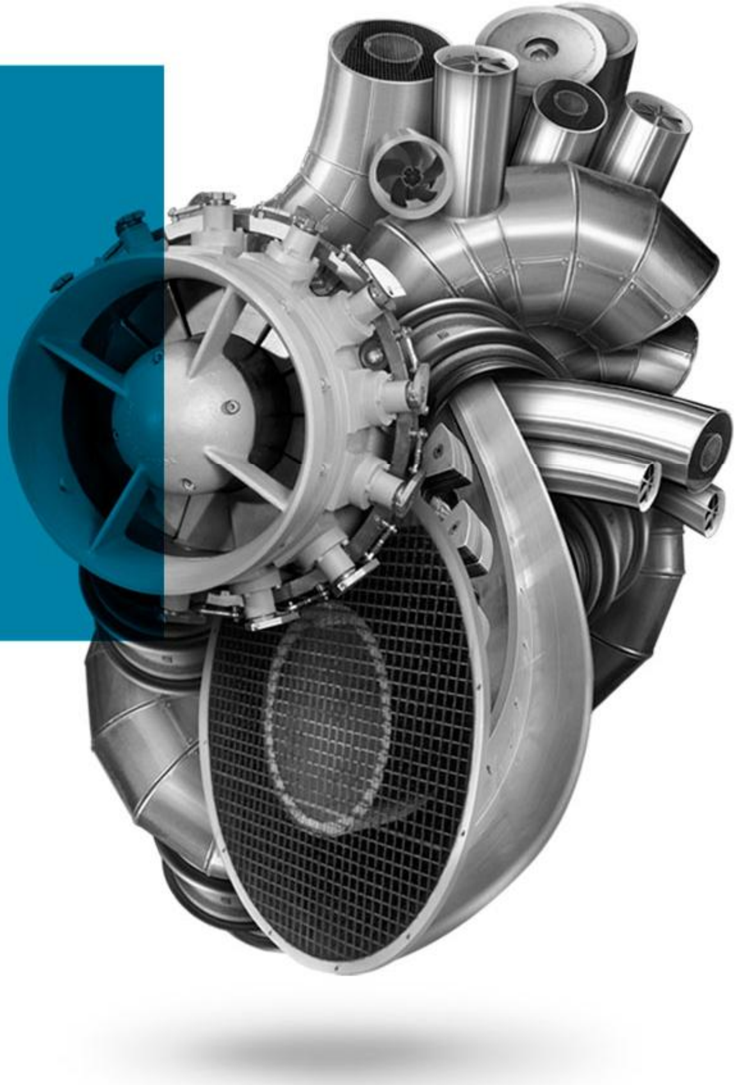


Ethos

Our Vision: To be the world's leading application engineer, providing lifetime solutions in air and gas handling.
Our Brand Promise: Our supportive people and our leading engineering combine to deliver the best long-term value for our customers.
Our Values:
Customers Talk, We Listen
The Best Team Wins
Continuous Improvement (Kaizen) is Our Way of Life
Innovation Defines Our Future
We Compete for Shareholders Based On Our Performance
Revolving Around You™
Howden

Howden

At the heart of your operations



Questions?

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