AERAULIC PLANT

PRESSURE LOSSES AND SIZING

Michele De Carli

Giuseppe Emmi

Elisa Scalco

- **NEED TO SET PHYSICAL DIMENSION OF THE PIPES AND THE MACHINE THAT WILL PROVIDE THE MOVEMENT (FAN)**
- **To size any pipe, the air flow (G) will be needed as input**

$[m^3/s]$ $G = S \circ v$

$[m^2]$ S

$[m/s]$ v

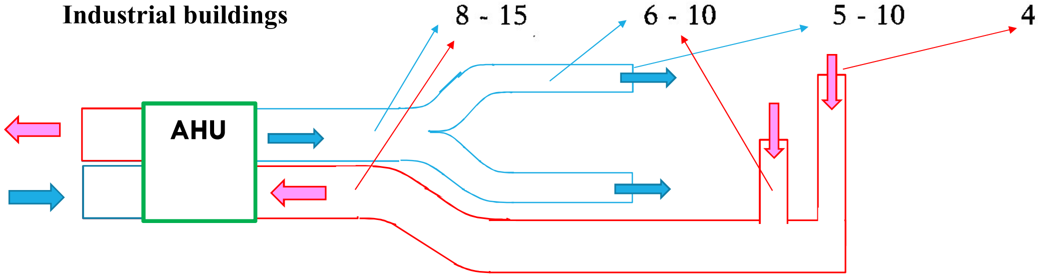
SMALL pipe size

PROS	CONS
Small dimension means small overall cost	High fluid velocity, must take into account vibrations and noise
Reduced necessary thechical space and easier positioning	High fluid-duct wall frictions, higher costs to keep the flow moving

Recommended air velocities in ducts

Air velocity [m/s]

	Main ducts	Secondary ducts	Air inlet	Air outlet
Residential	4 - 5	3 - 4	2 - 3	1,5 - 2
Public buildings, schools	5 - 8	4 - 6	3 - 5	2 - 3
Offices	8 - 11	6 - 8	5 - 8	3 - 4
Industrial buildings	8 - 15	6 - 10	5 - 10	4 - 10



To set a fluid in motion a pressure difference between inlet and outlet sections will be needed.

$\Delta P = \Delta P_k + \Delta P_p + \Delta P_f$

ΔP_k: kinetic energy variation

ΔP_p: potential energy variation

ΔP_f: friction pressure loss

Friction pressure loss (or pressure loss) is due to two components:

Localised pressure drop: occurs whenever flow meets discontinuity in its path

Continuous pressure drop: occurs because of fluid-wall interactions

CONTINUOUS PRESSURE DROP

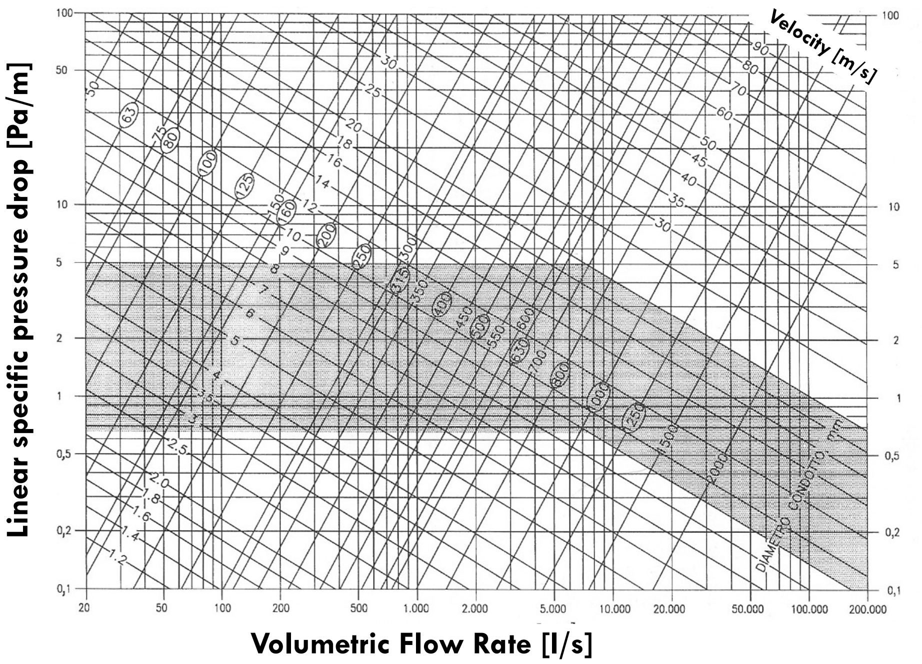
$$\frac{\Delta P_c}{L} = \frac{\rho\, v^2}{2}\frac{f}{D} \qquad [\frac{Pa}{m}]$$

- ρ fluid density $\left[\frac{\mathrm{kg}}{\mathrm{m}^3}\right]$
- v mean fluid velocity $\left[\frac{\mathrm{m}}{s}\right]$
- f friction factor [/]
- L pipe length [m]
- D pipe diameter [m]

The friction factor **f** is determined either analytically of via appropriate diagrams.
It depends on:

- Fluid density, viscosity and velocity
- Duct diameter and roughness

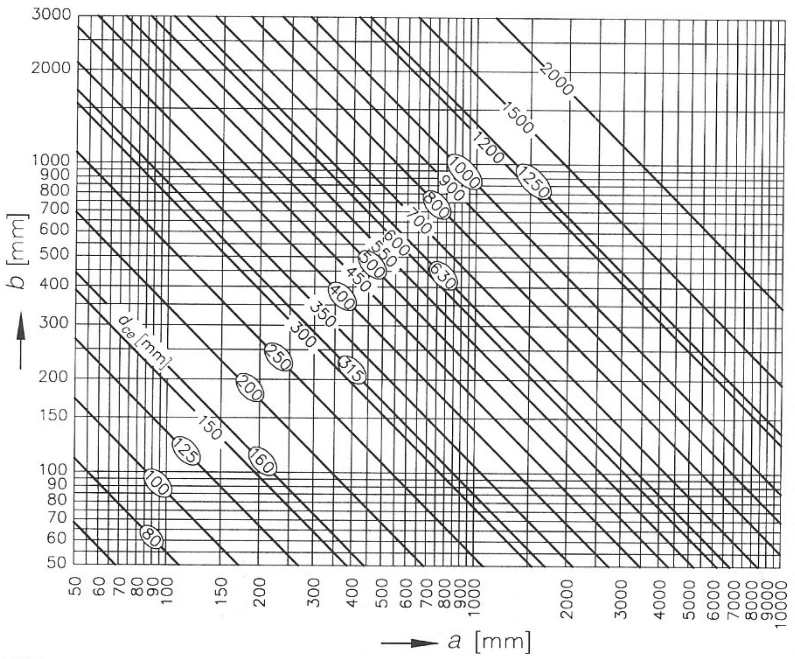
Diagram for distributed losses for quick choice for ε = 0.09 mm and ρ = 1.2 kg/m³



Standard diameters of the circular ducts according to UNI 10381-2

Dimensions of rectangular ducts equivalent to circular ducts standardized diameters:

$$d_{ce} = 1{,}30 \frac{(a \times b)^{0{,}625}}{(a + b)^{0{,}250}}$$



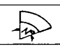
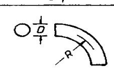
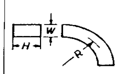
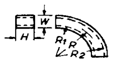
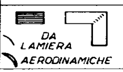
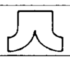
Standard diameters of the circular ducts according to UNI 10381-2

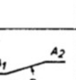
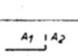
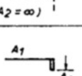
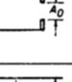
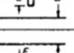
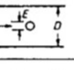
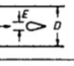
LOCALISED PRESSURE DROP

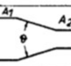
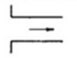
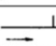
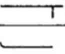
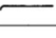
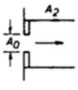
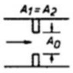
$$\Delta P_l = \frac{\rho\, v^2}{2}\xi \;\; \text{[Pa]}$$

- ρ fluid dencity $\left[\frac{\mathrm{kg}}{\mathrm{m}^3}\right]$
- v mean fluid velocity $\left[\frac{\mathrm{m}}{s}\right]$
- ξ localised p.d. coefficient [/]

ξ coefficient is established on the basis of the particular type of loss, usually tabulated for the most common circuit elements (curves, branches etc.)

TIPO	FIGURA	CARATTERISTICHE	PERDITA DI PRESSIONE C	L/D	L/W
CURVA A N°		RETTANGOLARE O ROTONDA; CON O SENZA ALETTE	N°/90 x PERDITA DI UNA CURVA UGUALE A 90°		
CURVA A 90° SEZIONE ROTONDA		GOMITO	1,30	65	
		R/D = 0,5	0,90		
		0,75	0,45	23	
		1,0	0,33	17	
		1,5	0,24	12	
		2,0	0,19	10	
CURVA A 90° SEZIONE RETTANGOLARE		H/W — R/W			
		0,25 — GOMITO	1,25		25
		0,25 — 0,5	1,25		25
		0,25 — 0,75	0,60		12
		0,25 — 1,0	0,37		7
		0,25 — 1,5	0,19		4
		0,5 — GOMITO	1,47		49
		0,5 — 0,5	1,10		40
		0,5 — 0,75	0,50		16
		0,5 — 1,0	0,28		9
		0,5 — 1,5	0,13		4
		1,0 — GOMITO	1,50		75
		1,0 — 0,5	1,00		50
		1,0 — 0,75	0,41		21
		1,0 — 1,0	0,22		11
		1,0 — 1,5	0,09		4,5
		4,0 — GOMITO	1,38		110
		4,0 — 0,5	0,96		65
		4,0 — 0,75	0,37		43
		4,0 — 1,0	0,19		17
		4,0 — 1,5	0,07		6
CURVA A 90° SEZIONE RETTANGOLARE CON DEFLETTORI		R/W — R1/W — R2/W			
		GOMITO — 0,5			28
		0,5 — 0,4	0,70		19
		0,7 — 0,6			12
		1,0 — 1,0	0,13		7,2
		1,5	0,12		
		GOMITO — 0,3 — 0,5			22
		0,5 — 0,2 — 0,4	0,45		16
		0,75 — 0,4 — 0,7	0,12		
		1,0 — 0,7 — 1,0	0,10		
		1,5 — 1,3 — 1,6	0,15		
GOMITO CON ALETTE		C = 0,10 ÷ 0,35 SECONDO LA COSTRUZIONE			
GOMITO A T CON ALETTE		CONSIDERARLO UGUALE AD UNA CURVA ANALOGA. PERDITA BASATA SULLA VELOCITA' IN ENTRATA			
T CURVILINEO					

TIPO	FIGURA	CARATTERISTICHE	COEFFICIENTE	
ESPANSIONE BRUSCA		A_1/A_2	C_1	C_2
		0,1	0,81	81
		0,2	0,64	16
		0,3	0,49	5
		0,4	0,36	2,25
		0,5	0,25	1,00
		0,6	0,16	0,45
		0,7	0,09	0,18
		0,8	0,04	0,06
		0,9	0,01	0,01
ESPANSIONE GRADUALE		θ	C_r	
		5°	0,17	
		7°	0,22	
		10°	0,28	
		20°	0,45	
		30°	0,59	
		40°	0,73	
EFFLUSSO BRUSCO		$A_1/A_2 = 0,0$	1,00	
ORIFIZIO DI EFFLUSSO A SPIGOLI VIVI		A_0/A_1	C_0	
		0,0	2,50	
		0,2	2,44	
		0,4	2,26	
		0,6	1,96	
		0,8	1,54	
		1,0	1,00	
SBARRA ATTRAVERSO IL CANALE		E/D	C	
		0,10	0,7	
		0,25	1,4	
		0,50	4,0	
TUBO ATTRAVERSO IL CANALE		E/D	C	
		0,10	0,20	
		0,25	0,55	
		0,50	2,0	
SBARRA A PROFILO AERODINAMICO ATTRAVERSO IL CANALE		E/D	C	
		0,10	0,07	
		0,25	0,23	
		0,50	0,90	

TIPO	FIGURA	CARATTERISTICHE	COEFFICIENTE
CONTRAZIONE BRUSCA SPIGOLI VIVI		A_2/A_1	C_2
		0,0	0,34
		0,2	0,32
		0,4	0,25
		0,6	0,16
		0,8	0,06
CONTRAZIONE GRADUALE		θ	
		30°	0,02
		45°	0,04
		60°	0,07
TRASFORMAZIONE AD AREA COSTANTE		$A_1 = A_2$	C
		θ ≤ 14°	0,15
INGRESSO A FLANGIA		A = ∞	C
			0,34
INGRESSO A CANALE		A = ∞	C
			0,85
INGRESSO GRADUALE		A = ∞	C
			0,03
ORIFIZIO DI INGRESSO A SPIGOLI VIVI		A_0/A_2	C_0
		0,0	2,50
		0,2	1,96
		0,4	1,39
		0,6	0,96
		0,8	0,61
		1,0	0,64
ORIFIZIO A SPIGOLI VIVI NEL CANALE		A_0/A	C_0
		0,0	2,50
		0,2	1,86
		0,4	1,21
		0,6	0,64
		0,8	0,20
		1,0	0,0

DISTRIBUTION LINE DESIGN

Step n 1

Set up network geometry and its location in the building. Fans and/or the AHU should be placed as cantered to the building as possible in order to restrict the network extension.

Check the weight of the equipment to check the static loads for the building structure.

Analyse the problem of noise and vibrations transmitted to the surroundings.

Step n 2

Decide the flow rate for each section of the plant according to the specifics needs of each room (both extraction and immission).

Step n 3

Choice of the pipes size of the whole plant.

Pressure losses determination (as sum of localised and continuous pressure drops)

The result will most certainly differ for the various sections of the plant; need to equalize the distribution network by adding calibration valves in specific points (main branches, terminals etc).

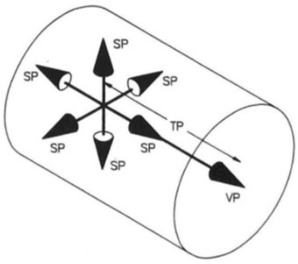
Step n 4

Choosing the appropriate operating machine (fan) that will provide the requested flow and supply the necessary head pressure to overcome the network pressure losses.

Fan

When dealing with ventilation, the fan has the duty to produce the pressure that will keep the flow moving while facing all the circuit resistances (pressure drops).

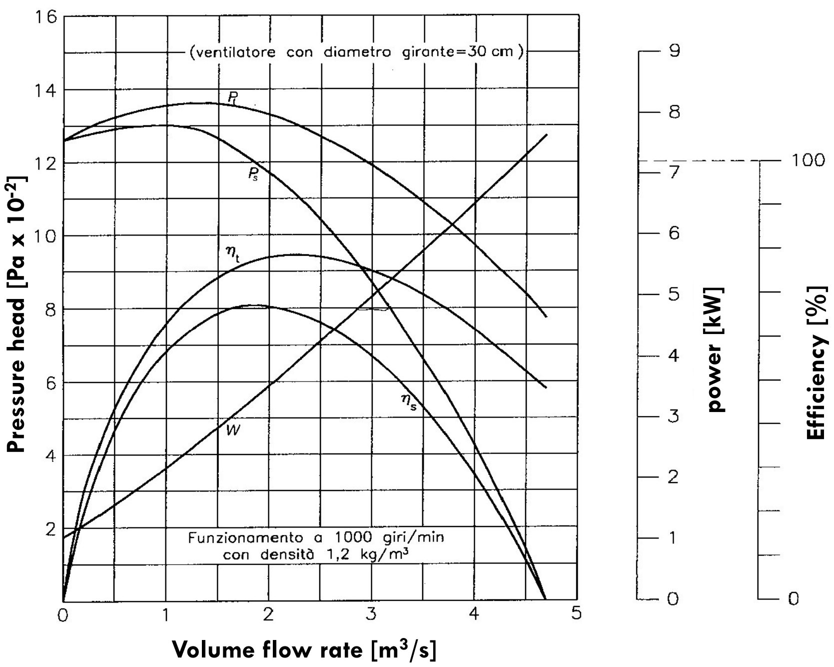
The fan produces the TOTAL PRESSURE which is the sum of two components:
- *Static pressure* (any direction)
- *Dynamic pressure* (always aligned with the flow)



TP: Total Pressure

SP: Static Pressure

VP: Dynamic Pressure



Static pressure

It is the pressure the flow will apply all over around the duct it is contained in.

It depends on the fan aerodynamic characteristics and acts equally in all directions; it does not depend on the fluid speed.

Taking the ambient pressure as a reference the static pressure will be:

POSITIVE if higher

NEGATIVE if lower

Static pressure provides the necessary energy to speed up the air from its quiet and to keep it moving while winning resistances due to friction and turbulence.

Dynamic Pressure

It is the fluid pressure due to its kinetic energy.

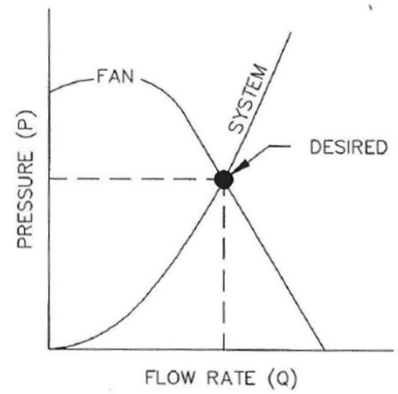
It is created at the cost of static pressure.

It acts in the same direction as the fluid motion and is always considered positive.

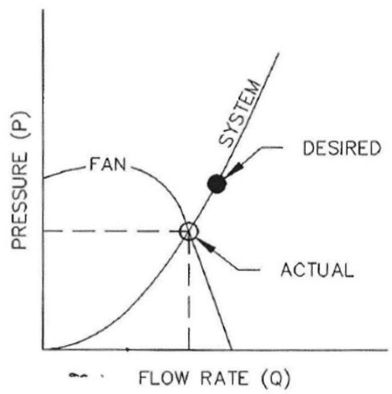
It is function of both speed and density of the fluid.

Suction system operating point

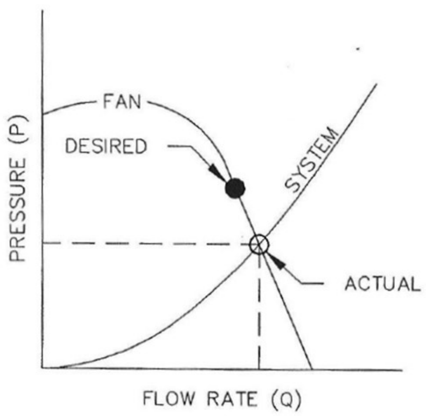
Fan curve → **The desired working point comes out of their intersection**
System curve



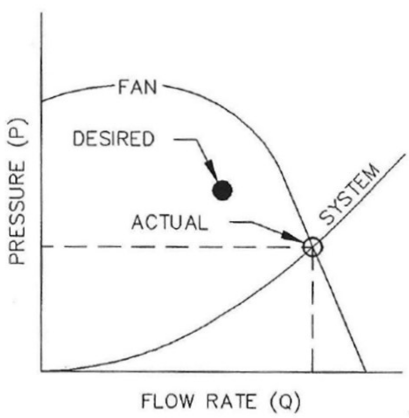
A. FAN AND SYSTEM MATCHED



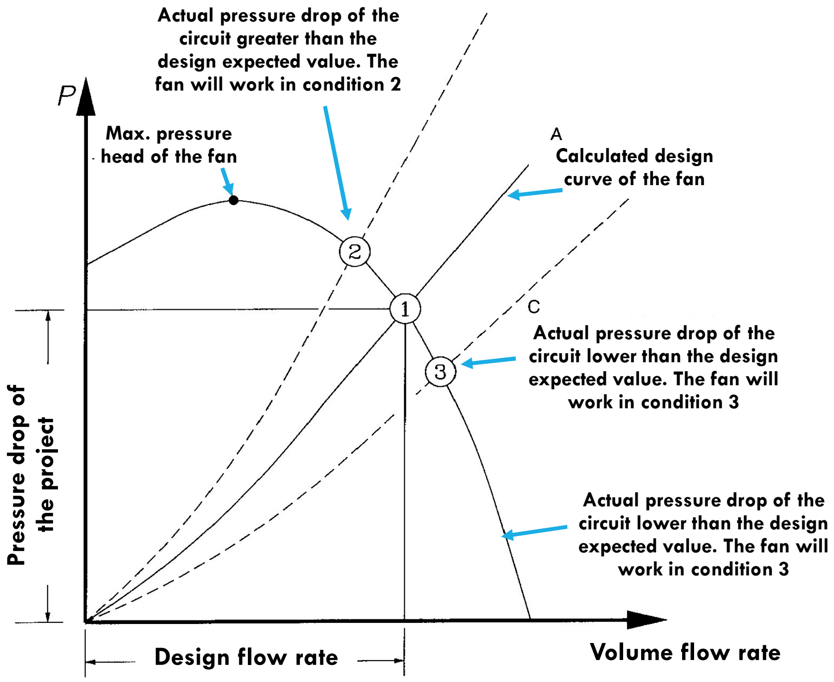
B. WRONG FAN.



C. WRONG SYSTEM.



D. BOTH FAN AND SYSTEM WRONG


Actual pressure drop of the circuit greater than the design expected value. The fan will work in condition 2
P
Max. pressure head of the fan
A
Calculated design curve of the fan
2
1
C
3
Actual pressure drop of the circuit lower than the design expected value. The fan will work in condition 3
Pressure drop of the project
Actual pressure drop of the circuit lower than the design expected value. The fan will work in condition 3
Design flow rate
Volume flow rate