Reminder Vacuum basis

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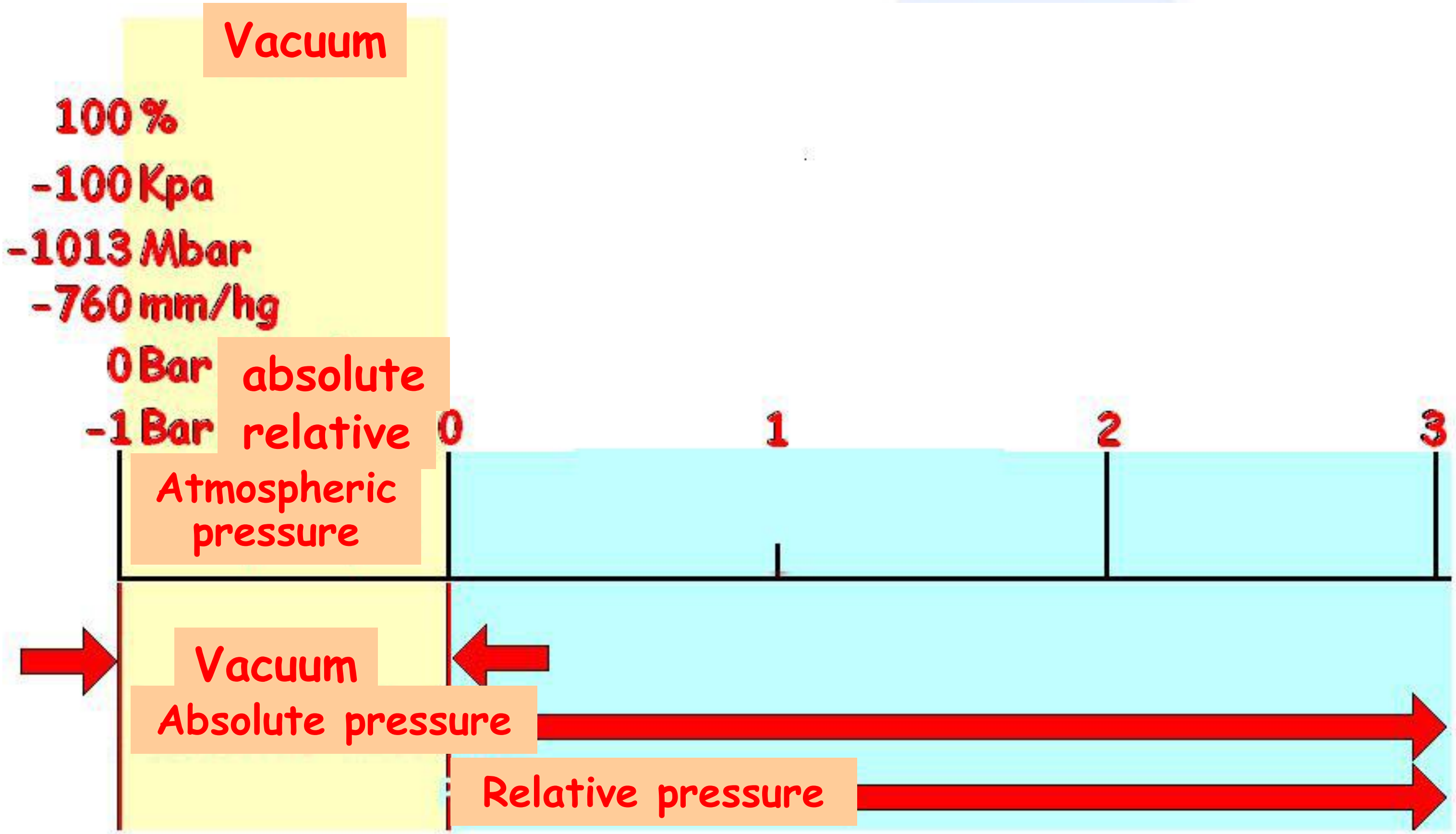
To create VACUUM means therefore to eliminate the air in a given volume and in which, if it is collected with the external environment, only the atmospheric pressure is present (which is on average -1013 mbar on the sea level).

Consequently the maximum vacuum level reachable, by referring to the relative pressure, will be therefore -1013 mbar.

Even if in some laboratory applications, vacuum levels extremely close to the absolute 0 may be reached, (the record, obtained in an experimental apparatus, is of 1/100 of billionth of billionth of the atmospheric pressure), industrial vacuum is normally limited, according to technology used, at a variable value of 0,5 at 100/150 residual mbar compared to the absolute vacuum.

Measurement units



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Conversion chart vacuum / pressure

Pression résiduelle absolue		Vide relatif				
Mbar	Bar	Pourcentage	Bar	Mbar	mm/hg	Kpa
1000	1,013	0%	0	0	0	0
900	0,912	10%	-0,101	-101	-76	-10,1
800	0,811	20%	-0,203	-203	-152	-20,3
700	0,709	30%	-0,304	-304	-228	-30,4
600	0,608	40%	-0,405	-405	-304	-40,5
500	0,507	50%	-0,507	-507	-380	-50,7
400	0,405	60%	-0,608	-608	-456	-60,8
300	0,304	70%	-0,709	-709	-532	-70,9
200	0,203	80%	-0,811	-811	-608	-81,1
100	0,101	90%	-0,912	-912	-684	-91,2
0	0	100%	-1,013	-1013	-760	-101,3

Main questions

To handle a product :

⇒ What do I need to handle it : Flow or vacuum ?

⇒ Pneumatic or electrical power supply required ?

⇒ which additional function requested

- Commands
- Vacuum switch
- Saving air function
- safety in case of emergency stop …

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Elements of a vacuum network

1/ Vacuum generator

2/ Vacuum cup

3/ Vacuum network

These 3 criteria are linked together and when one of these element is not the right one, it reduced dramatically all the advantages of the 2 other even if they are perfectly determined and calibrated.

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Vacuum generator

Requirements to handle a seal product:

⇒ Maximum reachable vacuum rate : 90% (we can easily reach it working on a non porous product),

⇒ Shortest evacuation time Vs time cycle,

⇒ As close as possible of the cups,

⇒ All functions included,

⇒ Savings (initial and operative costs and maintenance),

⇒ Reduced noise level.

Selecting a vacuum generator

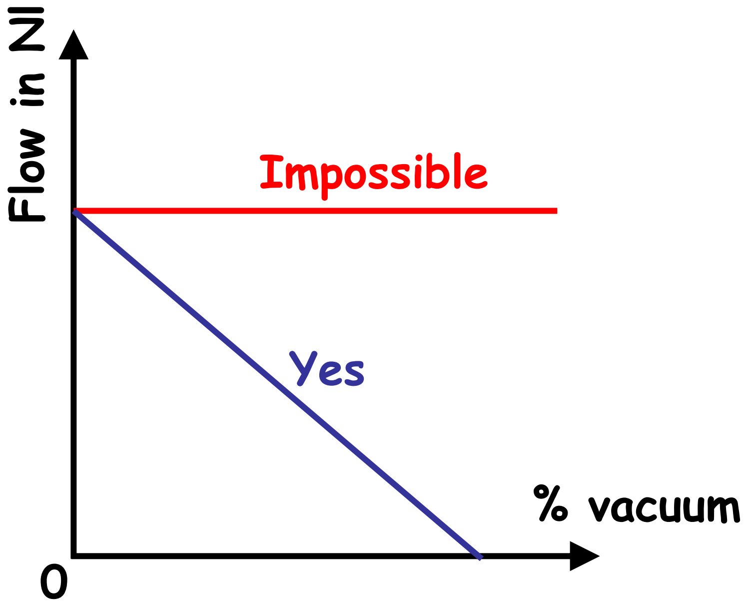
To select a vacuum generator, you must define the most important result for your application:

✓ **Vacuum**

✓ **Flow rate**

Indeed, it is not possible to have a constant flow rate with the installation of vacuum...

...You have to choose between pneumatic and electric power and to select the more suitable technology.



	•Power	
	•Pneumatic	•Electric
•Vacuum •(80%)	•Mono-stage ejector	•Electric vacuum pumps
•Flow rate •(20%)	•Multi-stage •Air amplifier	•Suction turbines

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Selecting a vacuum generator

The vacuum force is convenient for lots of industrial applications, but high suction flow rates can also be interesting. The flow rate is mainly used in large-scale or rapid applications.

•Vacuum %	•Main industrial applications
•< 20%	•Ventilation
•20÷40%	•Vacuum carrying
•40÷90%	•Product handling (with or without suction cups)
•>90%	•Controlled atmosphere working

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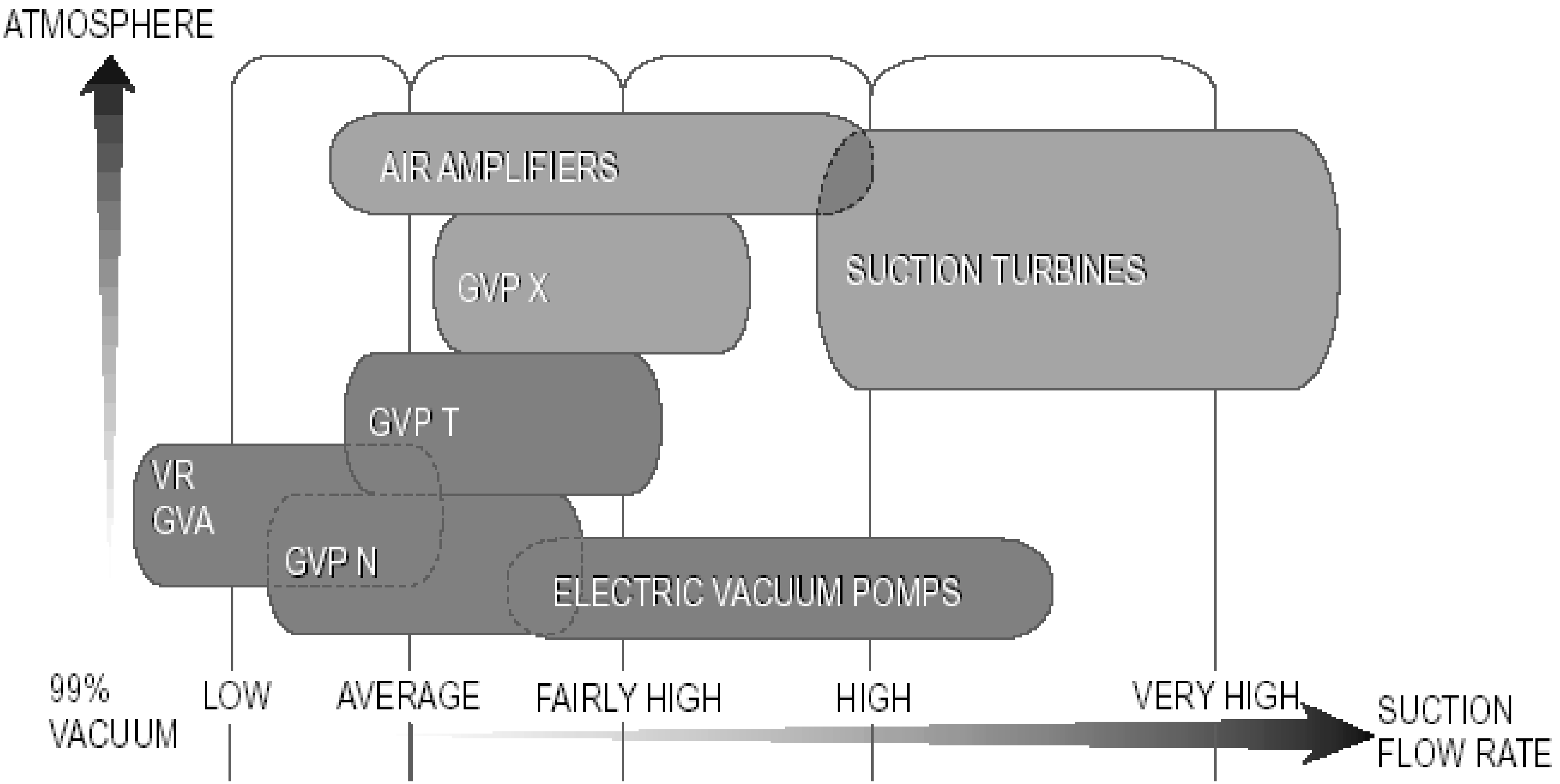
Selecting a vacuum generator



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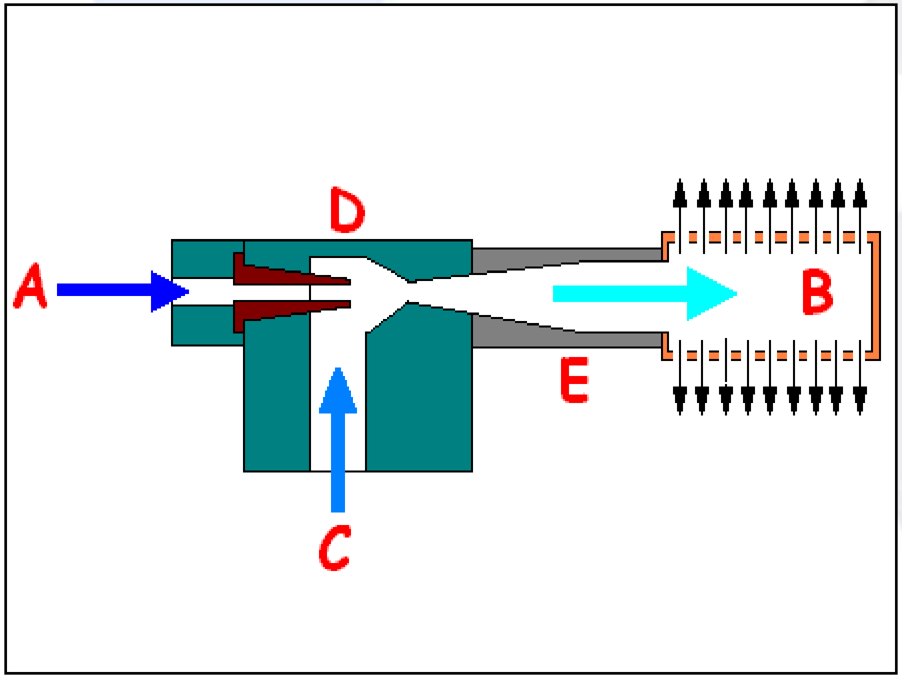
Venturi Effect

The air which is compressed in A (filtered and non-lubricated) is blown through nozzle D and its speed is increased. It then passes through the mixer E before escaping into the silencer B.

Vacuum is the result of negative pressure contained in the chamber surrounding the nozzle D.
The air that is, therefore, drawn in via C follows the same route and passes into the silencer B.



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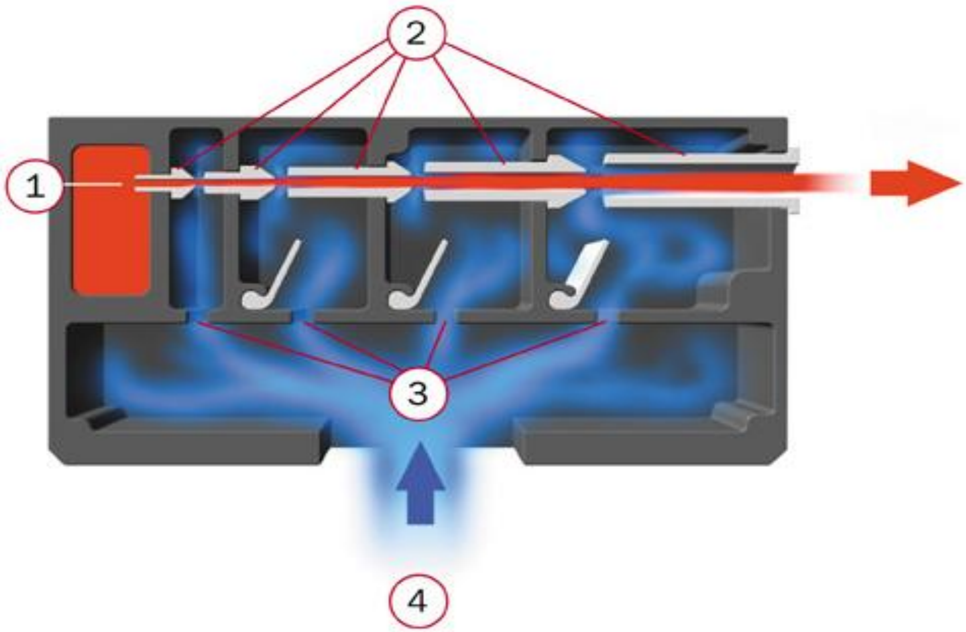
Multistage ejectors

The maximum vacuum level we can reach with a multi-stage ejector is 95%.
The vacuum flow can be increased using a multi-stage ejector.
This technology adds the flow of different nozzles used in series and shuts down one after the other while the vacuum level increases



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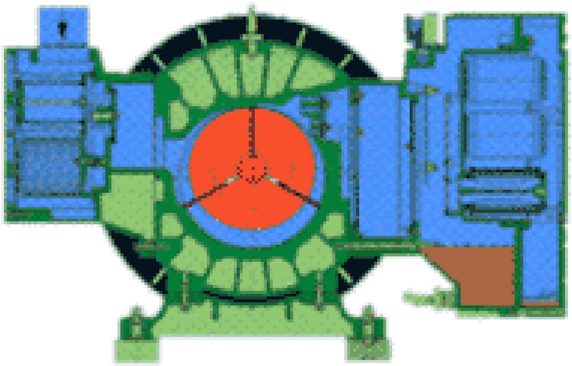
Multistage ejectors

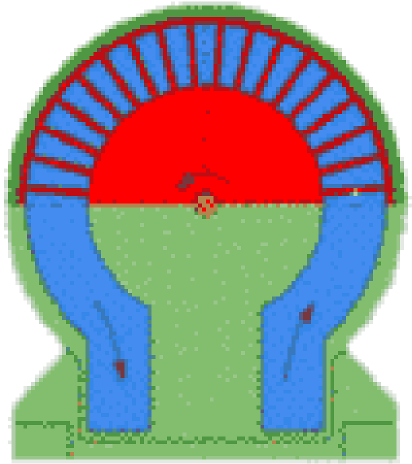
The use of such a technology is adapted under a 50% vacuum level because after that limit, the nozzles shut down one after the other. Up to, that vacuum level, the flow decreases quickly and finally the vacuum is generated by the smallest nozzle. It means that the evacuation time for one liter will be longer than with a monostage.

In the same time, changing the mixer, we can obtain a new vacuum/flow report. That solution is also used for mono-stage and that is why we have developped a 75% range (T version) or a 50% range (X version).

Vacuum pumps and blowers



pumps



blowers

Vacuum flow is always expressed in l/mn

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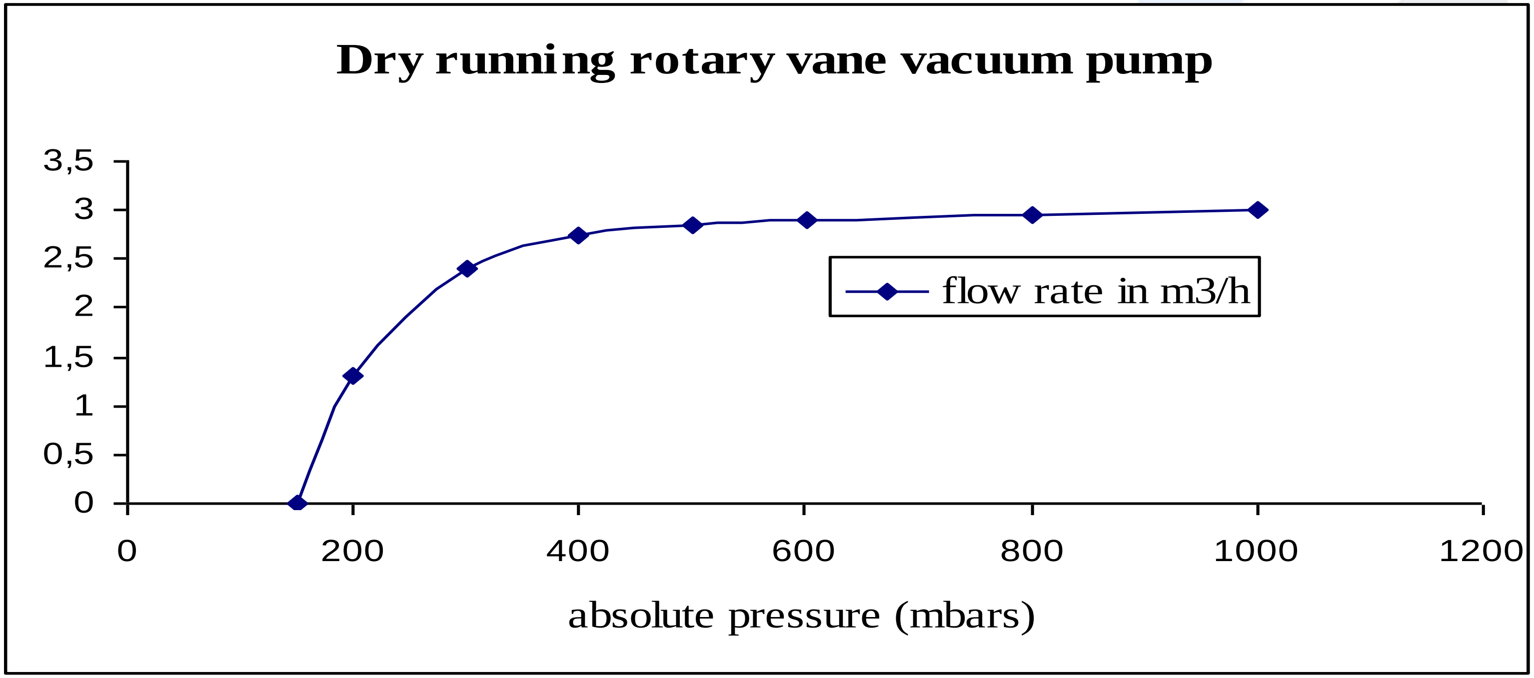
Vacuum pumps and blowers

Dry running rotary vane vacuum pump

pressure in mbars	150	200	300	400	500	600	800	1000
flow rate in m3/h	0	1,3	2,4	2,75	2,85	2,9	2,95	3



Vacuum pumps and blowers Vs Ejector

All the vacuum generators moved by compressed air used Nl or Nm3

All the vacuum generators moved by electricity used l or m3

But even if we are using different units we can easily convert from one to the other.

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Vacuum pumps and blowers Vs Ejector

Conversion chart from l to Nl

Nl = l x absolute pressure

ie : a pump that give 40l @ 300 mbars absolute means in Nl :

40 x 0,3 => 12 Nl

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Vacuum pumps and blowers Vs Ejector

Conversion chart from Nl to l

l = Nl /absolute pressure

ie : an ejector that give 12 Nl @ 70% vacuum means in l :

12/0,3 => 40 l

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Vacuum pumps and blowers Vs Ejector

Is it Clear for everybody ???

Yes ?!

EXERCISE

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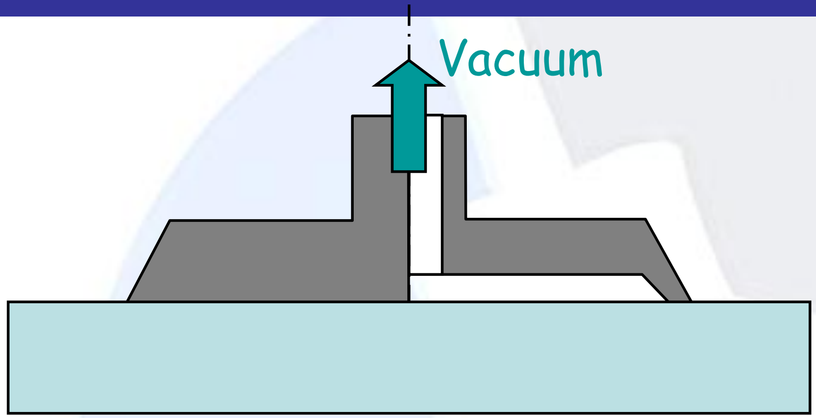
Suction cups

- ✓ Introduction
- ✓ Selecting a suction cup

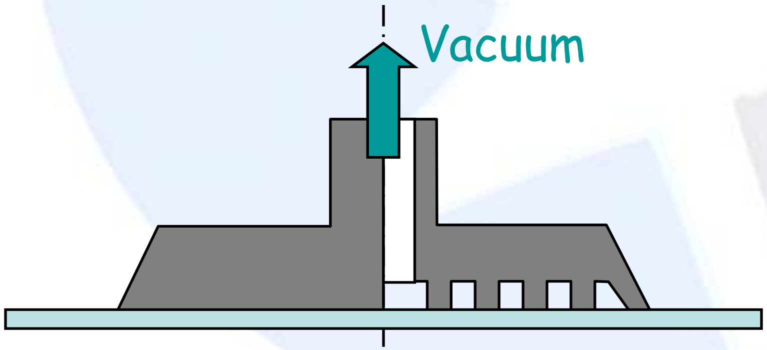
Shapes

Flat suction cups



Without stops

Flat or slightly curved, rigid and smooth objects



With stops

Fine, flexible, deformable... objects

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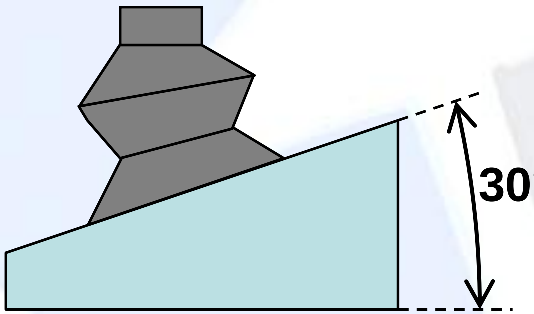
Shapes

Bellows type suction cups

The more bellows there are, the greater their technical characteristics

Gripping of spherical, cylindrical or ovoid objects



Gripping at different levels, ball joint effect, lifting motion and angular gripping

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Diameters

The choice of the diameter is linked to:

-The available gripping aera on the object

-The force required to handle the object

COVAL range:

from 2 mm to 580 mm

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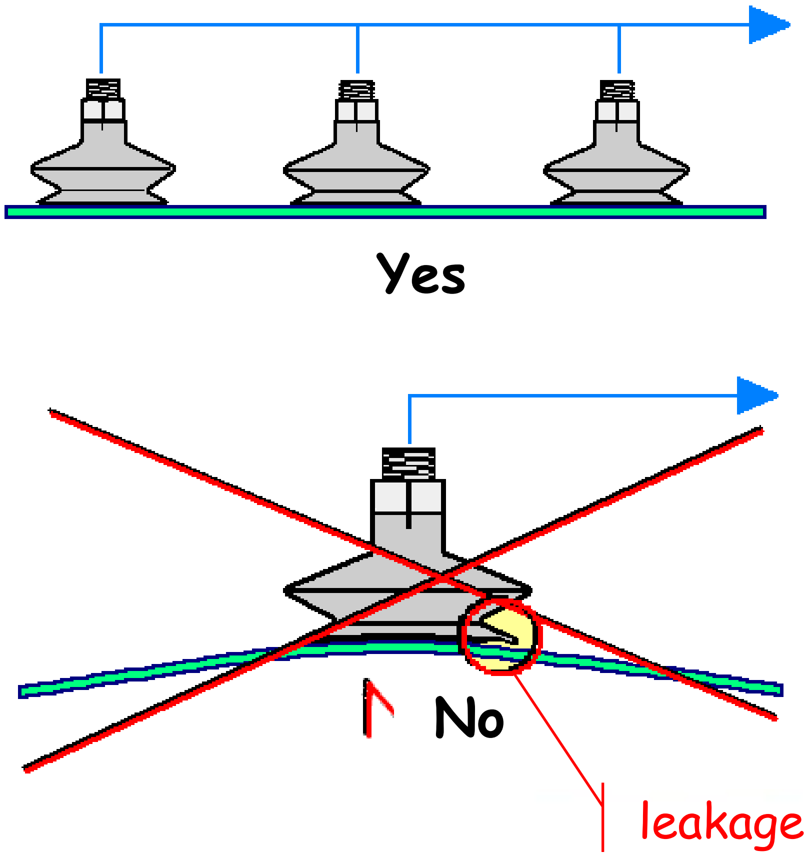
Number of suction cups

The number of suction cups is linked to:

-the required handling force

-an homogenous distribution of this force



Force

The force of a suction cup is proportional to its area under vacuum.

It also depends on its general shape, its flexibility, its material and, above all, the level of vacuum reached.

The **theorical force** of the suction cup (F_{th}), given in Newton (N), is calculated as above: (***d*** = diameter of the suction cup, ***%*** = perecentage of vacuum)

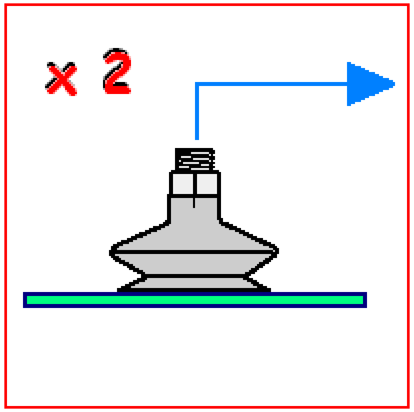
$$F_{th} = \frac{d^2 \cdot \pi}{4} \cdot \% \cdot 0{,}1013$$

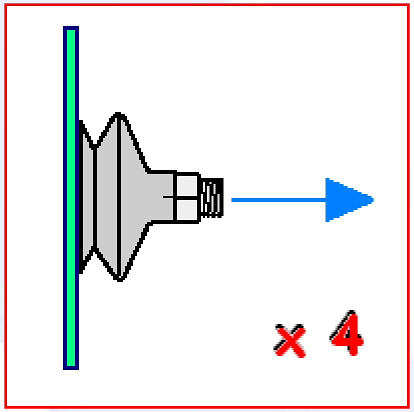
The **actual force** is the effective force of the suction cup in use.
Experiments have shown that this force is generally 50% less than the calculated theorical force. This difference is explained by the deformation of the suction cup during handling, which reduces gripping area, and by the surface finish of the handled part.

Force

The safety factor

The forces indicated in catalogues are actual practical forces. They are generally calculated at 90% vacuum with a safety factor of:





- ✓ ≥ 2 for horizontal gripping
- ✓ ≥ 4 for vertical gripping

In case of applications involving high acceleration rates, the safety coefficient is calculated accordingly.

Parameters

The main parameters to be taken into account when choosing a suction cup are:

- ✓ Shape of load: flat, curved, cylindrical, ovoid, spherical…
- ✓ Load material: porous, sealed, deformable, rigid, fragile...
- ✓ Load surface finish: smooth, grainy, silicone-coated, abrasive…
- ✓ State of load: damp, oily, dusty, viscous, dry…
- ✓ Weight of load: heavy, light…
- ✓ Temperature of load: from –40°C to 250 °C according to materials selected…
- ✓ Direction of grabbing: horizontal, vertical, angular, different levels…
- ✓ Type of grip: handling, lifting, holding, unstacking… of objects
- ✓ Duration of cycles: accelerations.
- ✓ Available gripping areas

Vacuum cups

For a metal sheet handling :

⇒ Specific range of cup (CBC, CFC, CBOC, CFOC ranges)

⇒ Doing calculation Vs weight/speed/acceleration/Right number of cups/load surface finish

Vacuum network

The vacuum network must breath and be homogenous:

- Never undersized the vacuum network (using the right diameter tube Vs length and size of the ejector),
- Reducing the length between the vacuum source and the cups,
- Use of screwed fittings instead of pushing fittings to avoid leaks,
- Y and straight fittings instead of elbowed and T versions,
- Parallel piping instead of serial,

Vacuum network

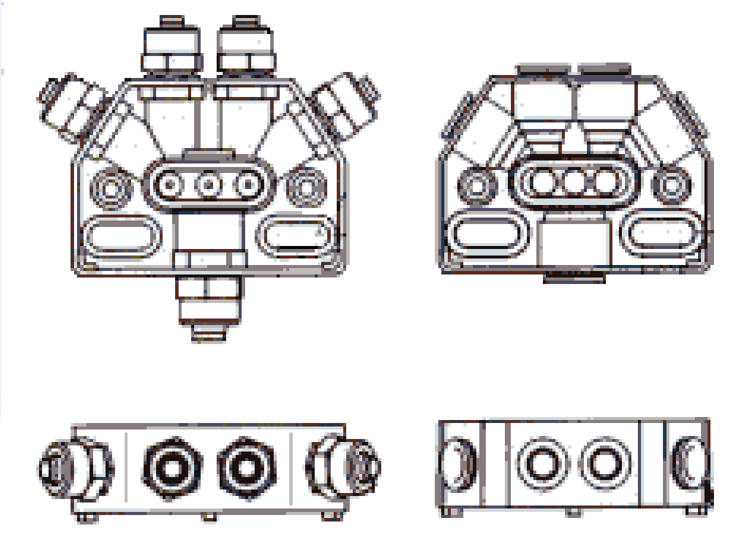
Tube diam.	area in mm²	volume for 1m in l	volume for 10 m in l
6x4	12,56	0,01256	0,1256
8x6	28,26	0,02826	0,2826
10x8	50,24	0,05024	0,5024
12x10	78,5	0,0785	0,785

Formula = $3{,}14 \times R^2$

Vacuum manifold

In vacuum networks, leakage and bad mounting are the worst things that can happen.

One of the main reason is the mountig between the ejector and the cups.
Tubes with restrictions (elbowed or too small diameter) or elbowed fitting or T that reduce highly generators characteristics (decrease of lifting force, increase in evacuation time).



To allow a better repartition of the suction flow, it is adviced to use such manifolds developped to reduce as much as possible this problem.

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