Introducing Piab

“The Piab mission is to increase productivity for industrial customers and provide energy saving solutions by promoting our superior technology universally.”

Giving you the best solution possible

We share our knowledge and experience with our customers and offer the vacuum solution most suited to their particular situation, contributing to reduced energy consumption, increased productivity and. improved working environment.

Through vacuum expertise and industry competence

Piab’s ground breaking work within vacuum technology is based on investments in R&D and experience working with a broad variety of manufacturing industries globally. Combining expertise with an understanding of many different industry settings enables us to provide customers with the best vacuum solutions on the market.

Past & Present

The history of Piab starts in 1951 when the inventive company was established. The first product, an innovative pair of compasses, gave Piab (π+ AB) its name. In 1960, the first Piab vacuum product, the “Pneucette”, was developed for the electronic industry. The foundation for today’s compressed-air driven vacuum system was laid in 1972 when the first multi-stage ejector was patented. Since then, Piab has continued to lead the way in the development of vacuum technology.

A powerful business partner

Piab’s objective is to improve our customers’ profitability and competitiveness. We strive to increase productivity, reinforcing their edge in the market. We also aim to contribute to our customers’ reduced energy consumption and improve the work environment, aiding in their ability to attract and keep qualified personnel. Partnering with Piab means more than having a reliable vacuum solution supplier.

Technical leadership

We take pride in being the innovators in vacuum technology. Technical leadership means finding and developing solutions that have not yet been found. Our customers should feel confident in knowing that their relationship with us will keep them on the cutting edge.

Local presence and global competence

Being the global leader means designing, building and installing vacuum solutions in every corner of the world. Therefore, Piab has a worldwide organization with subsidiaries and distributors in more than 50 countries.

Contributing to a sustainable world

We believe strongly in taking responsibility for our shared environment. Therefore, we have developed an ambitious Environmental Policy and implemented an ISO 14001 certified Eco Management System. In addition, we always look for the most environmentally-friendly means of transportation for our products, and encourage our suppliers to research and develop materials that allow for sound manufacture, function and recycling. For our customers, our vacuum solutions are in themselves a mean to reduce energy and hence contribute to a better environment. Piab focuses on developing systems that consume minimal energy and have minimal environmental impact, reducing the user’s carbon footprint. Performance is never sacrificed, so productivity is consistently maximized. Contact Piab for information about our Energy Saving Innovations that will increase your productivity.

COAX® technology

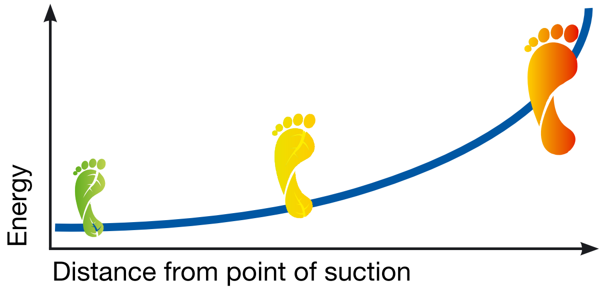
COAX® is an advanced solution for creating vacuum with compressed air. Based on Piab's multi-stage technology, COAX® cartridges are smaller, more efficient and more reliable than conventional ejectors, which allows for the design of a flexible, modular and efficient vacuum system.

A vacuum system based on COAX® technology can provide you with three times more vacuum flow than conventional systems, allowing you to increase speed with high reliability, while reducing energy consumption.

Environmental index

At the basis of the highest performing, energy-efficient production process is an optimised handling solution. By never using more energy than absolutely necessary, companies can reduce their carbon footprint as well as their costs. From the vacuum pump itself down to each and every control accessory, Piab can work with you to achieve the lowest possible energy consumption.

Your pump will require less compressed air when it is placed close to the point of suction, thus reducing CO_2-emissions and energy consumption. The graph below demonstrates the relationship between environmental impact and the distance of the pump from the point of suction.

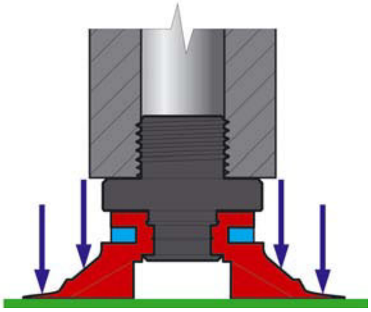


Vacuum theory

What is vacuum?

When using the terms ”vacuum”, ”negative pressure”, ”suction”, etc., we mean a pressure that is lower than the atmospheric pressure, which is the pressure of the weight of the air above us. At sea level it is usually 1,013 mbar = 101.3 kPa. 1 Pa equals 1 N/m^2 which means that a column of air with a cross-sectional area of 1 m^2 presses on the surface of the earth with a force of around 100,000 N. By reducing the pressure in a closed space the atmospheric pressure becomes a potential energy source.

A vacuum cleaner does not suck. Air and dust are pressed into the vacuum cleaner by the surrounding higher atmospheric pressure.

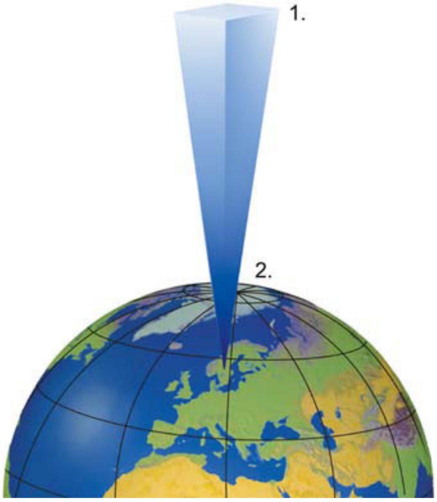


A suction cup adheres to a surface by the surrounding higher pressure.

Altitude above sea level

As the atmospheric pressure is the working force, the force will consequently change with the atmospheric pressure. This means that the present barometric pressure and the altitude above sea level must be taken into consideration. Up to 2,000 m, the pressure is reduced by around 1% per 100 m. An application which is dimensioned to hold 100 kg at sea level, can manage only 89 kg at an altitude of 1,000 m.

The chapter “Tables” shows the effect of the atmospheric pressure on the vacuum level.



1. Atmospheric pressure = 0 at an altitude of 1,000 km

2. 1 bar (101.3 kPa) at sea level

At the summit of Mount Everest (8,848 m) the atmospheric pressure is approximately 330 mbar (33 kPa).

A definition for vacuum is:

”A room without matter”. In everyday language; ”Air-free or almost air-free space”.

Source: Nationalencyklopedin, Bra Böcker, Höganäs, Sweden.

Expressions and units

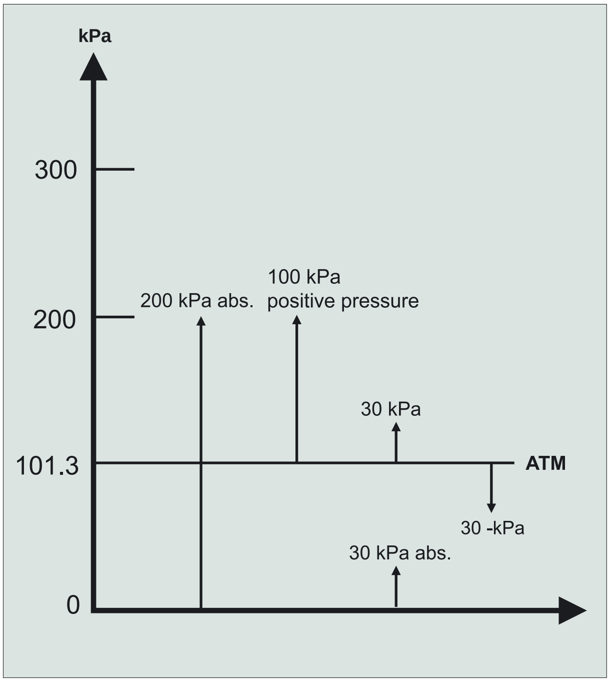
In everyday speech there are many different expressions and units for pressure below the atmospheric pressure. It is therefore important to relate to the same vocabulary in discussions. The adjoining table shows some common expressions and units used in connection with vacuum. For conversion tables between the different units, see tables No. 1, 2 and 3 in the “Tables” chapter.

Expressions
Under pressure
Absolute pressure
% vacuum (% of vacuum)
Negative pressure

Units	
-kPa	bar
inHg	mm H_2O
mmHg	torr
hPa	mbar

Different terms for pressure in relation to "absolute vacuum"

Physically there is only one kind of ”pressure” and that is the one that starts from ”0” or absolute vacuum. All above ”0” is pressure and correctly named absolute pressure. Normal atmospheric pressure (101.3 kPa is used as a reference, which is why the terms “positive pressure” or “negative pressure” are used. Earlier the term “% vacuum” was used, where 0% was atmospheric pressure and 100% absolute vacuum. Consequently, in industry -kPa is the unit used most often since it nearly corresponds to “% vacuum”. In the chemical branch of industry, and in deep vacuum, mbar is generally used. Thus, it is very important to be clear about which unit and reference point is meant. In this catalogue, -kPa is generally used (as in industry), and for laboratory pumps, mbar absolute is specifically used.



This diagram shows the relation between absolute, negative and positive pressures. It also illustrates the problem that may occur if the pressure is not clearly specified. 30 kPa can ”carelessly spoken” imply three different values.

Applied vacuum can normally be divided into three main categories

Blowers or low vacuum	0–20 -kPa	For ventilation, cooling, vacuum cleaning, ...
Industrial vacuum	20–99 -kPa	For picking, holding, automation, ...
Process vacuum	99 -kPa –	Deep vacuum for laboratories, manufacturing of microchips, plating, ...

Energy needs for different vacuum levels

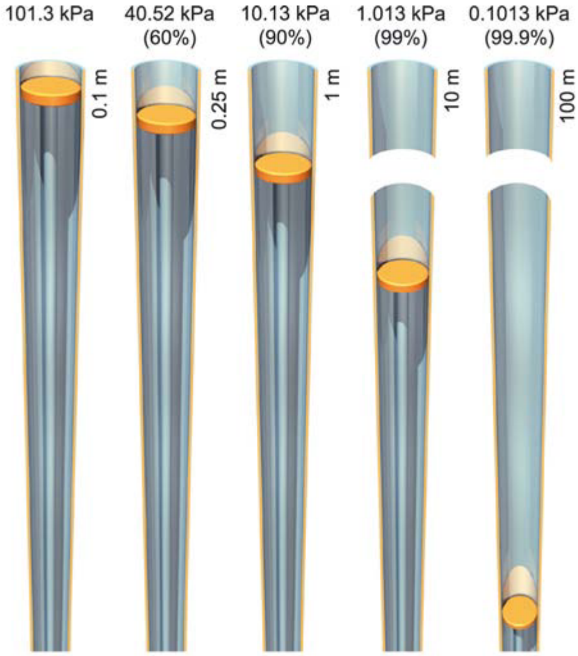
The energy required to create vacuum increases asymptotically towards infinity with increased vacuum. To obtain optimum energy exchange it is very important to choose the least possible vacuum. To illustrate the energy needs, a cylinder with a piston (piston pump) is suitable.

According to Boyle's Law the pressure (p) in a gas is inversely proportional to its volume (V) at constant temperature:

$$P_1 \times V_1 = P_2 \times V_2$$

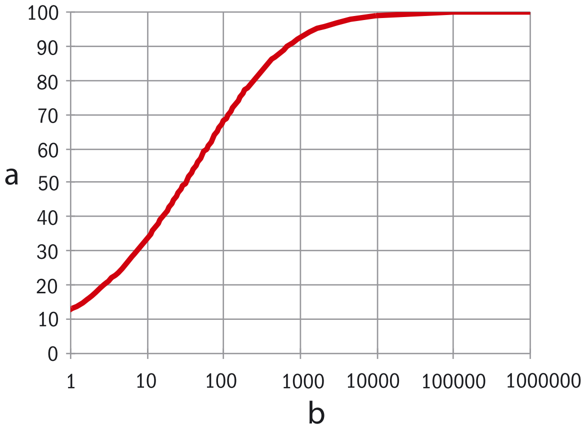
This means that increased volume gives a lower pressure.

By pulling the piston slowly, the distance extended will show the increased energy needs. The temperature is not constant in practice. However, at a slow operation the temperature effect is negligible.



Energy requirement at increased vacuum

The diagram illustrates the energy requirement at increased vacuum. As can be seen, the energy requirement increases drastically above 90 -kPa, which is why a vacuum level below this is always advisable.



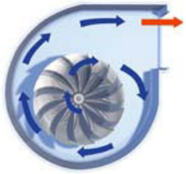
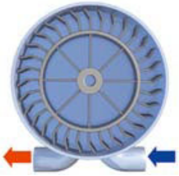
a) Pressure below atmospheric -kPa

b) Energy factor

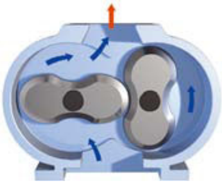
Vacuum pumps

Mechanical pumps

The main principle for all mechanical pumps is that they convey, in one way or another, a certain volume of air from the suction side (the vacuum side) to the exhaust side. In that way they create a vacuum. Mechanical pumps usually have an electric motor as power source, but it can also be an internal combustion engine, a hydraulic or a compressed air-driven pump.

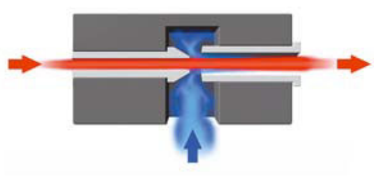
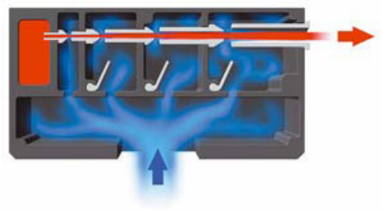
Fans		**Advantages**	**Disadvantages**
	Centrifugal blower	Few moving parts Large suction volumes Strong	Low maximum vacuum Slow start-up and long stop time High noise level
	Regenerative blower	Few moving parts Large suction volumes Low energy consumption	Low maximum vacuum Slow start-up and long stop time High noise level

Displacement pumps

Displacement pumps		**Advantages**	**Disadvantages**
	Piston pump	Relatively low price	High heat emission Low maximum vacuum
	Membrane pump	Few moving parts Compact Low price	Small suction volumes
	Vane pump	High vacuum and flow Relatively low noise level	Sensitive to contamination Relatively high price High service requirements High heat emission
	Roots pump	High flow Low service requirements	High price High heat emission High noise level

Compressed air-driven ejector pumps

All ejector pumps are driven with pressurised gas, usually compressed air. The compressed air flows into the ejector pump, where it expands in one or more ejector nozzles. When expanding, the stored energy (pressure and heat) is converted into motive energy. The speed of the compressed air jet increases rapidly, while the pressure and the temperature go down, attracting more air and thereby creating a vacuum on the suction side. Some ejector pumps may also be used to blow air.

Compressed air-driven ejector pumps		**Advantages**	**Disadvantages**
	Single-stage ejector	Low price No heat emission Compact	High noise level Gives either high flow or high vacuum Poor efficiency
	Multi-stage ejector	High efficiency Low energy consumption High reliability Low noise level No heat emission	
	COAX® technology	High efficiency Low energy consumption High reliability Low noise level No heat emission Operates even at low feed pressure Integrated features Modularly built Easy to supplement and upgrade later on Easy to clean	

Vacuum flow, how is it measured?

In order to obtain pressure lower than atmospheric pressure in a container, some of the air mass must be removed by a vacuum pump. For example, half the air mass must be removed to obtain a vacuum level of 50 -kPa. The air evacuated by the pump per unit of time is called the vacuum flow and is a measure of how quickly the pump can perform this function.

Many manufacturers of mechanical vacuum pumps state vacuum flow in terms of the pump's displacement volume. This flow is called "displacement flow" or "volume flow". Displacement flow equals the chamber volume times the number of revolutions per unit time. In mechanical pumps, this value is constant and can lead the observer to think, incorrectly, that the vacuum flow is constant during the entire evacuation process.

In the evacuation process the air actually becomes thinner and thinner for every stroke of the cylinder until the pump reaches the maximum vacuum level which is that point where the vacuum flow would then be zero. The pump is still pumping the same volume flow but the air mass is so thin that compared to air at normal atmospheric pressure it is as if there was no air.

To account for the change in air mass during the evacuation process Piab provides flow data in terms of normal litre per second (Nl/s). Also called free air flow, this method normalizes the flow to standard atmospheric conditions. As the vacuum becomes deeper and the air is thinner, a higher actual volume must be displaced to evacuate each normal litre. The table below lists one pump's performance in terms of displacement flow (l/s) and free air flow (Nl/s). At zero vacuum, the flows are equal. This is because the actual conditions are in fact standard conditions. But as the vacuum level increases, the values diverge. At 50 kPa (50%) vacuum, the displacement flow figure is twice the free air flow figure. At deeper vacuum levels, the difference is even greater.

Displacement flow vs free air flow

Units		**Vacuum level -kPa**									
		0	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**
Displacement flow	l/s	10	10	10	10	10	10	10	10	10	10
	m^3/h	36	36	36	36	36	36	36	36	36	36
Free air	Nl/s	10	9	8	7	6	5	4	3	2	1
	Nm^3/h	36	32.4	28.8	25.2	21.6	18	14.4	10.8	7.2	3.6

Vacuum systems

When making a vacuum system/lifting device there are several different methods to increase safety and reliability. To give efficient operation and good economy it is important that the designed system is made for a specific application. In addition to the choice of suction cups with attachments, the type and size of vacuum pumps, accessories, safety level and type of system must also be decided upon.

Sealed systems

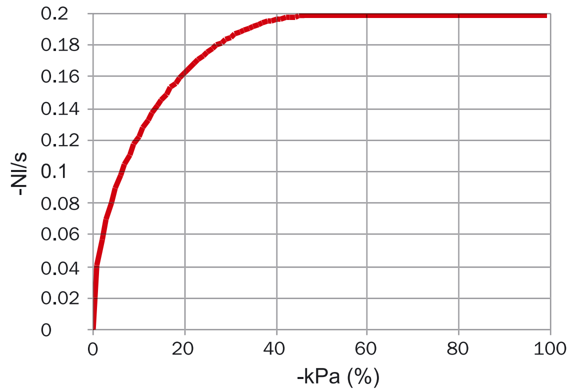
For sealed systems the capacity of the pump is determined by how fast the system can be evacuated to a certain vacuum level. This capacity is called the evacuation time of the pump and is normally specified in s/l. This value is multiplied by the volume of the system in order to obtain the evacuation time to the desired vacuum level.

Non-sealed systems

With non-sealed systems (lifting of porous materials) the case is different. To maintain the desired vacuum level the pump must have the capacity to pump away the air leaking in. Leakage can be due to, for example, porous material or that one is forced to lift over holes. By establishing the leaking flow, it is possible, by reading the pump data, to find the right pump for the application in question.

If the leakage occurs via a known aperture, the flow can be established according to the adjoining diagram. The diagram gives values for leakage flow when the leakage area is known. The leakage flow is valid when there is an opening of 1 mm^2 (normal atmospheric pressure at sea level). To obtain the total flow, the value is multiplied by the total leakage area.

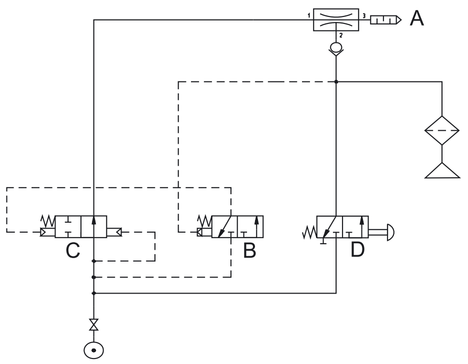
When the leakage occurs through a porous material or in an unknown way, the flow can be established by a test with a vacuum pump. The pump is connected to the system and the obtained vacuum level is read. (It should be at least 20 -kPa.) The flow that is pumped away at this vacuum level can be seen on the page of the particular pump. This flow roughly corresponds to the leaking flow.



At 47 -kPa the air reaches sonic velocity, and consequently the flow is constant.

Energy-saving systems

Electrically driven, mechanical vacuum pumps normally work during the whole operating cycle and the vacuum requirements are controlled by a valve on the vacuum side. In systems with compressed air-driven vacuum pumps it is often possible to save a lot of energy. As these pumps have a faster reaction time (fast start-up and stop time) the pump can be shut off when the vacuum is no longer needed. The principles of a simple energy-saving system are shown to the right. Many pumps can be delivered with an energy-saving system as standard.



A = Vacuum pump with non-return valve.
B = Vacuum control unit.
C = Feed valve for compressed air.
D = Release valve.

Vacuum system calculations

General input

Vacuum systems for material handling can be decentralized or centralized. A decentralized vacuum system is designed so that each suction cup has a dedicated, independent vacuum source. A centralized vacuum system is designed to have one vacuum source for multiple suction cups. Handling sheet metal is an example of a sealed system and handling cardboard is an example of a leaking system.

The examples are calculated using the following general assumptions:

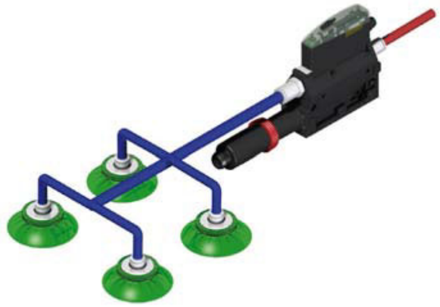
Initial flow required are for the sealed system examples is 0.7 Nl/s per suction cup FC75P, and the corresponding value is 1.2 Nl/s for the leaking system examples using the suction cup BX75P. CO_2-emission, world index: 0.019 kg CO_2 per produced m^3 of compressed air and 0.19 kg CO_2 per kWh. Machine operating hours per year: 3.000 h.

Sealed systems/handling non-porous material

System description:

Decentralized vacuum system using: Vacuum Gripper System VGS™3010 with suction cup FC75P and COAX® cartridge Xi10 2-stage vacuum pump with non-return valve, AQR Atmospheric Quick Release, Vacustat and 3/2 on/off-valve.

Annual cost of ownership: 188 €
Annual CO_2 emission: 13 kg
Annual energy usage: 17 kWh



System description:

Centralized vacuum system using: P5010 with AVM™ – Automatic Vacuum Management control, COAX® cartridge Xi40 3-stage vacuum pump with non-return valve and suction cup FC75P.

Annual cost of ownership: 301 €
Annual CO_2 emission: 171 kg
Annual energy usage: 900 kWh

System description:

Centralized vacuum system using: 550 W electromechanical vacuum pump with suction cup FC75P and vacuum on/off-valve.

Annual cost of ownership: 722 €
Annual CO_2 emission: 443 kg
Annual energy usage: 1656 kWh

- Electric vane vacuum pumps are running constantly.
- Energy cost: 1.5 Euro-cent per produced 1 m^3 compressed air and 12 Euro-cent per kWh.
- Annual cost of ownership include: energy costs, purchase price, annual cost, service and CO$_2$ emission tax 0.025 Euro per kg. Suction cups excluded.
- Capital interest rate: 5%
- Pump life time: 5 years

Red tubing = Compressed air
Blue tubing = Vacuum

Calculating carbon footprint:

Based on the world average of power generation, 1 Nl of compressed air will result in a 19 mg CO$_2$ emission footprint. To calculate your specific footprint, just multiply your air consumption (Nl/s) by 19. The result is your CO$_2$ emission footprint per second.

Leaking systems/handling porous material

System description:

Decentralized vacuum system using: Vacuum Gripper System VGS™3010 with suction cup BX75P and COAX® cartridge Si08 3-stage vacuum pump and 3/2 on/off-valve.

Annual cost of ownership: 249 €
Annual CO$_2$ emission: 145 kg
Annual energy usage: 762 kW/h

System description:

Centralized vacuum system using: P5010 with COAX® cartridge Si32 3-stage vacuum pump, suction cup BX75P and 3/2 on/off valve.

Annual cost of ownership: 227 €
Annual CO$_2$ emission: 203 kg
Annual energy usage: 1067 kW/h

System description:

Centralized vacuum system using: 750 W electromechanical vacuum pump with suction cup BX75P and vacuum on/off-valve.

Annual cost of ownership: 808 €
Annual CO$_2$ emission: 429 kg
Annual energy usage: 2258 kW/h

Optimising controls

Aside from placing the pump close to the point of suction, it is important to complete and optimise your vacuum system with control accessories that will limit the use of compressed air to the amount that the system requires. This way, you will have an efficient vacuum system with minimum usage of compressed air. Piab has a range of optimising controls and this selection guide will help you to choose the one(s) optimal for your system.

Regulators

Energy saving can be achieved in many ways, but the most simple way is by using a pressure regulator to control your pump's optimum feed pressure.

piSAVE release

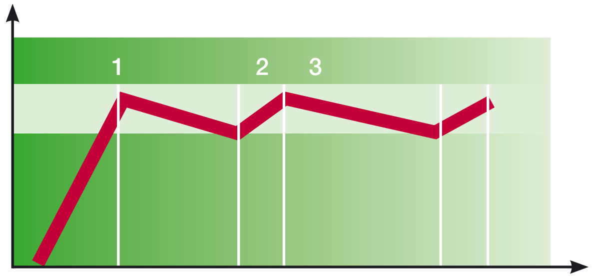
Instead of using compressed air to release objects you can use piSAVE release to provide a fast release. The piSAVE release is a valve that breaks vacuum seal in e.g. suction cups by equalizing pressure with atmospheric air and at the same time do not consume additional compressed air.

piSAVE optimize

The piSAVE optimize automatically regulates the feed pressure towards an optimal programmed vacuum level. Fluctuations in vacuum pressure caused by product variations or changes in cycle time allow the pump to only consume the amount of air that the optimised vacuum level requires.

piSAVE onoff

When handling sealed objects many times the vacuum pump can be turned off when not needed. The piSAVE onoff's are vacuum-controlled valves that shut off the flow of compressed air to the pump when the pre-set vacuum level is reached (1). From micro leakage in the system, the vacuum level drops, and after a while the start-up level of the valve is reached (2). At this point, the pump will start and work until the shut-off level is reached again (3) etc.



AVM™ – Automatic Vacuum Management

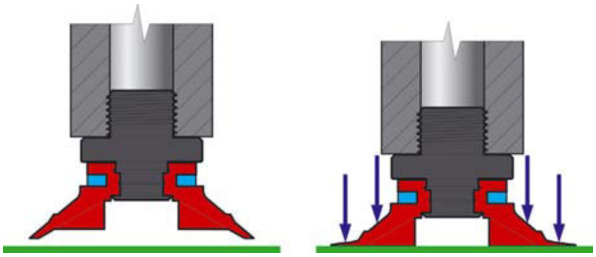
Like the piSAVE onoff the AVM™ instantly shuts off the flow of compressed air when the pre-programmed vacuum level is reached and turns on again when the start-up level of the valve is reached. The AVM™ not only saves energy it also features a complete monitoring system with on/off valves and vacuum switches.

Contact Piab for information about our products that will increase your productivity and provide for energy savings.

Suction cups

How does a suction cup work?

A suction cup adheres to a surface as the surrounding pressure (atmospheric pressure) is higher than the pressure between the suction cup and the surface. To create the low pressure in the suction cup it is connected to a vacuum pump. The lower the pressure (higher vacuum), the greater the force on the suction cup.



$$\Delta p = P_{AT} - P_1$$

Advantages and limitations of the suction cup

Material handling with suction cups is a simple, inexpensive and reliable technique. It is therefore a solution worth considering before going over to more complicated methods. Suction cups can lift, move and hold objects that weigh just a few grams up to several hundred kilograms.

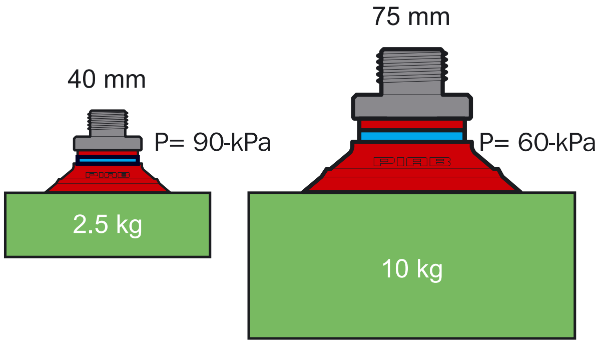
Advantages	Limitations
Easy installation Low service requirements Low price Does not damage the material handled Quick attachment and detachment	Limited force (atmospheric pressure) Positioning accuracy

Sizing suction cups

Suction cups have quite different capacities depending on the design. Please see the values in the tables for respective suction cup.

Energy requirements at different vacuum levels

A deep vacuum means that the suction cup has to work harder and thus wears out quicker; also the energy requirements increase at higher vacuum levels. If the vacuum level increases from 60 to 90 -kPa, the lifting force increases by 1.5 times but with ten times the energy requirement. It is better to maintain a lower vacuum level and instead increase the suction cup area. In many applications, a good target for the vacuum level could be 60 -kPa; at this level you get a high lifting force with relatively low energy requirements.



Consider the height above sea level

Atmospheric pressure decreases with increased height. This means that the available force decreases at the same rate. An application designed for lifting 100 kg at sea level, can only manage to hold 89 kg at 1,000 metres. A vacuum gauge is normally calibrated with atmospheric pressure as a reference. This means that the gauge shows available vacuum levels at different heights.

Lifting force in different directions

A suction cup can be used irrespective of whether the force is perpendicular or parallel to the surface. If the force is parallel, it is transferred through friction between the suction cup and the surface. A suction cup with cleats is most suitable in this case because it is rigid and provides high friction.

Thread systems

ISO thread:

- Cylindrical metric thread: designated with the letter M. Example M5.
- Cylindrical Inch thread (also called Unified thread): designated with the letter UNF. Example 10-32UNF.

Dry seal thread (American system of pipe threads):

The dry seal system consists of cylindrical and conical pipe-threads. The threads have a 60° profile angle and are sealed without packing or seal rings (please note that when these are used in other combination of thread systems, that "sealing" is not applicable). The dimensions are given in inches and Piab’s catalogue uses the letters NPT and NPSF:

- Conical thread is designated NPT. Example: 1/8" NPT.
- Cylindrical thread is designated NPSF: Example: 1/8" NPSF.

BSP thread (British system of pipe threads):

- The threads have a 55° profile angle and are dimensioned in inches.
- Cylindrical thread is designated with the letter G. Example: G1/8".

Compatibility of different thread systems

Please note that some thread size in different thread systems not always fit. See below table.

	M5 male	**M5 fem.**	**G1/8" male**	**G1/8" fem.**	**G1/4" male**	**G1/4" fem.**	**G3/8" male**	**G3/8" fem.**	**G1/2" male**	**G1/2" fem.**	**G3/4" male**	**G3/4" fem.**	**G1" male**	**G1" fem.**	**G2" male**	**G2” fem.**
10-32UNF female or male	+	+++														
NPSF1/8" female			+++													
NPT1/8" female or male			–	+												
NPSF1/4" female					+											
NPT1/4" female or male					–	–										
NPSF3/8" female							–									
NPT3/8" female or male							–	–								
NPSF1/2" female									+							
NPT1/2" female or male									–	+++						
NPSF3/4" female											+					
NPT3/4" female or male											–	+++				
NPT1" female or male													–	–		
NPT2" female or male															–	–

+++ Fits
+ Fits with short thread
– Does not fit

Tables

In everyday speech, many different expressions and units are used for both pressure and flow. It is important to agree on what is meant by them.

Pressure

P=F/A (Force/Area).
SI unit (Système International d'Unités): Pascal (Pa). 1 Pa = 1 N/m^2.
Common multiple units: MPa and kPa.

Pa (N/m^2)	**bar**	**kp/cm^2**	**torr**	**psi (lb/in^2)**
1	0.00001	10.1972x10^{-6}	7.50062x10^{-3}	0.145038x10^{-3}
100 000	1	1.01972	750.062	14.5038
98 066.5	0.980665	1	735.559	14.2233
133.322	1.33322x10^{-3}	1.35951x10^{-3}	1	19.3368x10^{-3}
6 894.76	68.9476x10^{-3}	0.145038x10^{-3}	51.7149	1

Table No. 1
1 torr = 1 mm HG à 0 °C
1 mm column of water = 9.81 Pa

Pressure above atmospheric

kPa	**bar**	**psi**	**kp/cm^2**
1,013	10.13	146.9	10.3
1,000	10	145	10.2
900	9	130.5	9.2
800	8	116	8.2
700	7	101.5	7.1
600	6	87	6.1
500	5	72.5	5.1
400	4	58	4.1
300	3	43.5	3.1
200	2	29	2
100	1	14.5	1
0	0	0	0

Table No. 2

Pressure below atmospheric

	kPa	**mbar**	**torr**	**-kpa**	**-mmHg**	**-inHg**	**% vacuum**
Sea level	101.3	1,013	760	0	0	0	0
	90	900	675	10	75	3	10
	80	800	600	20	150	6	20
	70	700	525	30	225	9	30
	60	600	450	40	300	12	40
	50	500	375	50	375	15	50
	40	400	300	60	450	18	60
	30	300	225	70	525	21	70
	20	200	150	80	600	24	80
	10	100	75	90	675	27	90
Absolute vacuum	0	0	0	101.3	760	30	100

Table No. 3

Change in atmospheric pressure in relation to altitude (height above sea level)

A vacuum gauge is normally calibrated with normal atmospheric pressure at sea level as a reference, 1013.25 mbar, and is influenced by the surrounding atmospheric pressure in accordance with the table below. The vacuum gauge shows the differential pressure between atmospheric pressure and absolute pressure. This means that the gauge shows what vacuum level is available at different heights.

Atmospheric pressure

Barometric pressure			The reading on the vacuum gauge at 1,013.25 mbar				
mmHg	**mbar**	**Equivalent m above sea level ***	**60 -kPa**	**75 -kPa**	**85 -kPa**	**90 -kPa**	**99 -kPa**
593	790.6	2,000	37.7	52.7	62.7	67.7	76.7
671	894.6	1,000	48.1	63.1	73.1	78.1	87.1
690	919.9	778	50.7	65.7	75.7	80.7	89.7
700	933.3	655	52.0	67.0	77.0	82.0	91.0
710	946.6	545	53.3	68.3	78.3	83.3	92.3
720	959.9	467	54.7	69.7	79.7	84.7	93.7
730	973.3	275	56.0	71.0	81.0	86.0	95.0
740	986.6	200	57.3	72.3	82.3	87.3	96.3
750	999.9	111	58.7	73.7	83.7	88.7	97.7
760	1,013.25	0	60.0	75.0	85.0	90.0	99.0

Table No. 4

**) At normal barometric pressure.*

Flows

Flows, volume per unit of time. Quantity designations: Q, q, = V/t (volume/time).
SI Unit: cubic metres per second (m^3/s).
Common multiple units: l/min, l/s, m^3/h.

m^3/s	**m^3/h**	**l/min**	**l/s**	**ft^3/min (cfm) ***
1	3,600	60,000	1,000	2,118.9
$0.28x10^{-3}$	1	16.6667	0.2778	0.5885
$16.67x10^{-6}$	0.06	1	0.0167	0.035
$1x10^{-3}$	3.6	60	1	2.1189
$0.472x10^{-3}$	1.6992	28.32	0.4720	1

Table No. 5

**) 1 ft » 0.305 m*

Leakage flows

The table below shows the leakage flow at different levels and through an opening of 1 mm^2.

Vacuum level -kPa	**Leakage flow l/s and mm^2**
10	0.11
20	0.17
30	0.18
40	0.2 *

Table No. 6

**) From about 47 to 100 -kPa the flow is constant.*

Pressure drop in compressed air hoses

When installing compressed air hoses it is important that the dimension (diameter) and length do not lead to excessive pressure drops. Piab vacuum pumps are supplied with recommended hose dimensions that will not cause excessive pressure drops at lengths below 2 m. In cases when the pressure drop has to be calculated, the formula below can be used.

$$\Delta P = \frac{1{,}6x10^{12}xqv^{1{,}85}xL}{d^{5}xP1}$$

$$\Delta d = \left(\frac{1{,}6x10^{12}xqv^{1{,}85}xL}{\Delta PxP1}\right)^{0{,}2}$$

Δ P = Pressure drop in kPa
qv = Flow in m^3/s
d = Inner diameter in mm
L = Length of compressed air hoses in m
P1 = The absolute starting pressure in kPa

Applications and solutions

Injection moulding

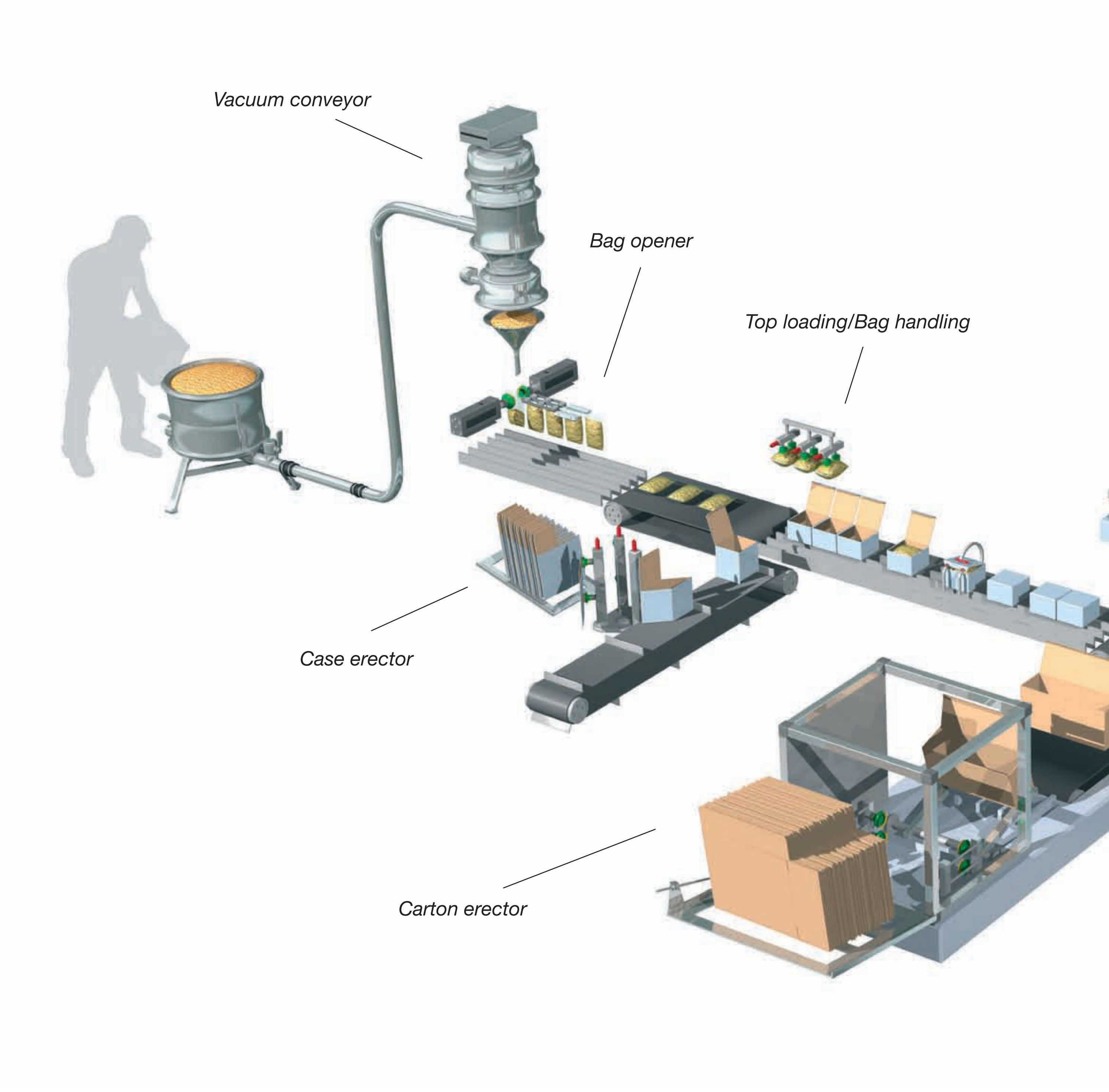
Pick-and-place

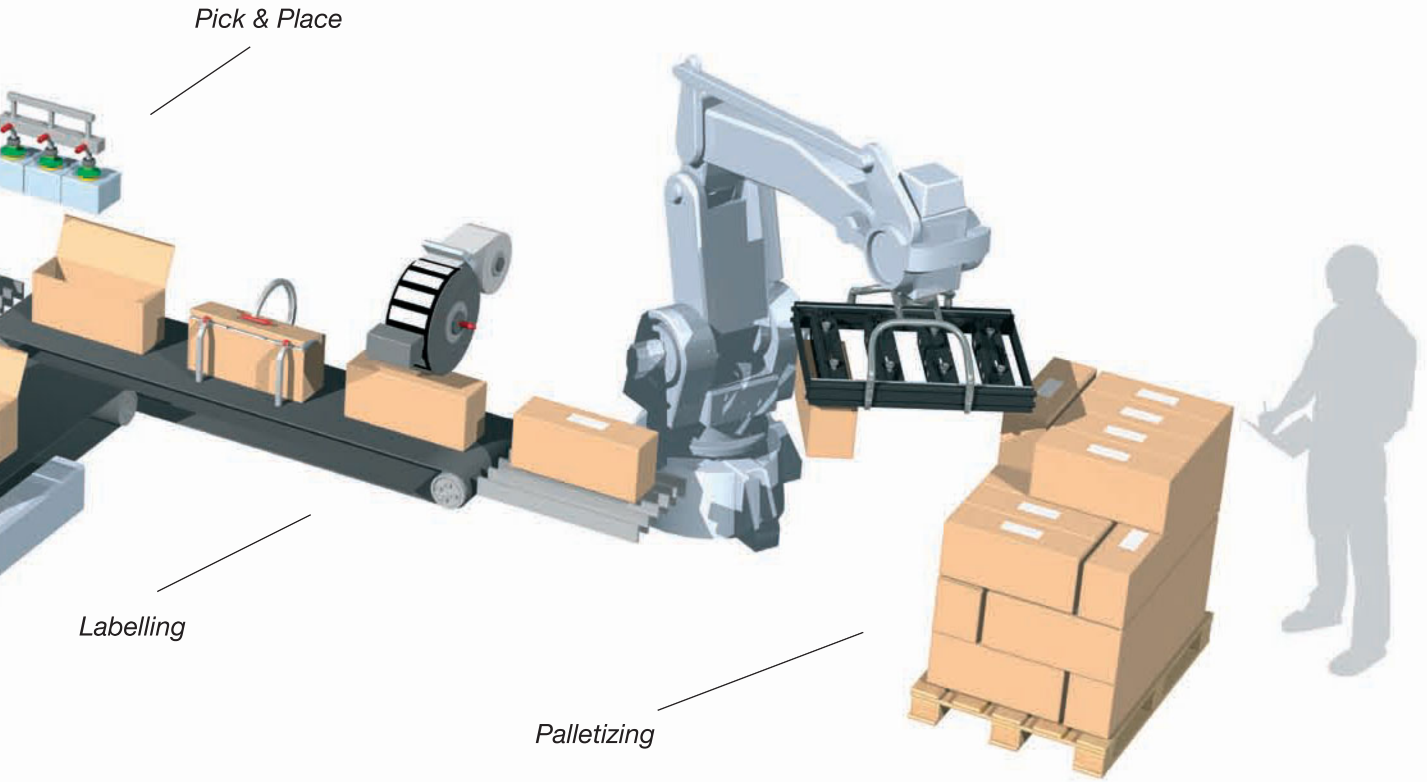
Vacuum moulding tires

Sheet brake

Press to press transfer

Applications and solutions




Pick & Place
Labelling
Palletizing