TECHNOLOGY FOR VACUUM APPLICATIONS

Components for pneumatic automation

PNEUMAX GREEN LINE: TECHNOLOGY & INNOVATION

PNEUMAX®

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SUCTION CUPS

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LEVEL COMPENSATORS

2

VACUUM GENERATORS

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VALVES AND SOLENOID VALVES

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ACCESSORIES

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Overall dimensions and technical information are provided solely for informative purposes and may be modified without notice.

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Introduction:

"*The vacuum is an experimentally attainable state", as it is defined in physics.*, By vacuum, we mean a space completely void of matter, "called absolute vacuum".In practice, this state is unattainable, so when we say vacuum, we mean that the air pressure inside an environment is lower than atmospheric pressure, or when the density of the particles in the air is lower. With the expressions "Vacuum", "suction", "negative pressure", etc., we are referring to a pressure below atmospheric pressure, due to the weight of the overlying air. At sea level, this pressure is equal to 1013 mBar.

Degree of Vacuum

Depending on whether the pressure is higher or lower than atmospheric pressure, the phenomena that occur can vary considerably, and thus the means of achieving and measuring such pressure also varies. Usually we distinguish between different degrees of vacuum that are referred to by specific names as a function of the various intervals of sub-atmospheric pressure, as indicated below:

1) Low vacuum
2) Medium vacuum
3) High vacuum
4) Ultra high vacuum
5) Extreme high vacuum

In the industrial field, the vacuum is subdivided into three areas of application, which depend on the degree of vacuum required:

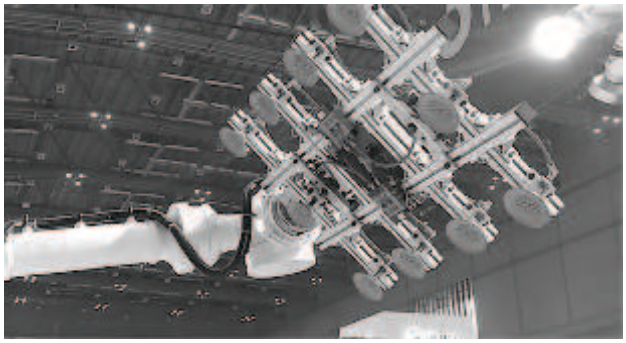
- **Low vacuum:** This term means a degree of vacuum between 0 and -20 KPa inclusive, most often used in applications where high air flow suction is required. In this industrial segment, electromechanical impeller pumps, side channel blowers, vacuum generators etc.
- **Industrial Vacuum**: this term refers to a degree of vacuum between -20 and -99 KPa inclusive. This range includes many of the applications where the vacuum is produced mainly by vacuum generators based on the Venturi principle, powered by compressed air and by vacuum pumps of the rotary vane, liquid ring, piston and hook-and-claw types, all driven by electric motors.
- **Process Vacuum:** This is a degree of vacuum higher than -99 KPa, where the main generators of this degree of vacuum are the two-stage rotary vane pumps, turbo molecular pumps, diffusion pumps, cryogenic pumps, etc., all driven by electric motor.

The highest value of vacuum reached on Earth is still far from the value of an absolute vacuum, which remains a purely theoretical matter. Even in space, so therefore in the absence of an atmosphere, there is a small presence of molecules per cubic metre. The impetus to improve vacuum technologies comes from industry and research. There is a great number of practical applications and highly disparate sectors: vacuum is used in the metallurgical, aerospace and food industries, in particle accelerators, in microelectronics, in the glass and ceramics industry, in industrial robotics, in moving and handling with suction cups, etc.

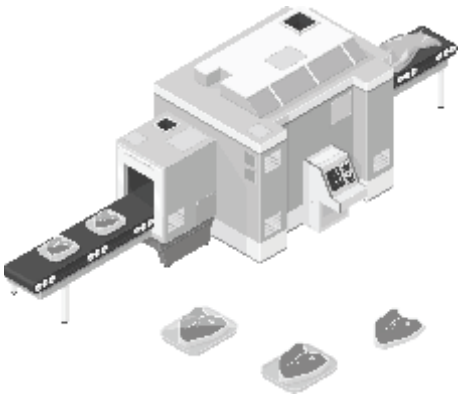
Some examples of application

Moving fragile products
- Handling eggs
- Handling glass
- Handling ceramic parts
- Handling electronic components

Robotics
- Handling auto parts for the automotive sector
- Palletisation in packaging sector
- Handling sheets of glass
- Handling slabs of marble
- Handling wood panels

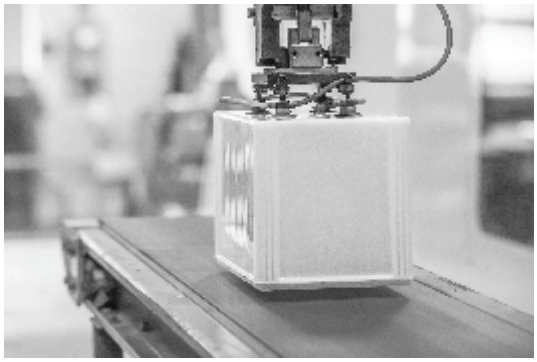


Other examples of application



Vacuum packaging of food in modified atmosphere

Pick and Place
- Plastic sector
- Automotive sector
- Electronic sector
- Printing sector
- Packaging sector



Cardboard box forming
With the help of suction cups and vacuum generators, the cardboard boxes can be formed easily and quickly.

Transportation of powders and granules
With vacuum, it is possible to transport powders and granules while avoiding harm to the product and maintaining high standards of hygiene and safety.

Vacuum clamping
With the help of vacuum and proper suction cups, it is possible to clamp products such as wood, marble, glass, fibre composites, etc. onto workstations.

Evaporation and degassing
Vacuum can be used to lower the boiling point of any liquid, which considerably reduces the time needed to reach that point. In degassing applications, vacuum is used to reduce the gases present in a substance.
These gases may cause bubbles which have an adverse effection the product.

Vacuum infusion
Infusion of composite materials is a production process that is becoming increasingly more popular to improve the aesthetic quality of the end product and reduce total manpower costs. The general principle of infusion is to "absorb" the resin into there and in the fabrics to be reinforced by using vacuum technology. The vacuum reduces the pressure at one end of the layers of fabric, allowing the atmosphere to push the resin through all the layers of fabric. The speed and distance at which a stack of fabric can be filled depends on the viscosity of the resin system, permeability of the layers of fabric and pressure gradient that acts on the infused resin.

Thermoforming
Vacuum can be used in the process of thermoforming plastic materials.The preheated sheet of plastic material is placed on the die via suction (vacuum), so as to conform to the relief features of the die.

Medical
Vacuum is used in a number of procedures in the medical sector, such as: dentistry and oral prosthetics, compression therapy and other hospital procedures.

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Conversion table for positive pressure

	Pa (N/m^2)	bar	Kg/cm^2	Torr	psi (ibf/in^2)	kPa	inHg
1 Pa	1	0,00001	$10.1792x10^{-6}$	$7.50062x10^{-3}$	$0.145038x10^{-3}$	0.001	$0.3x10^{-3}$
1 kPa	1000	0.01	$10.1792x10^{-3}$	7.50062	0.145038	1	0.3
1 bar	100000	1	1.01972	750.062	14.5038	100	30
1 kg/cm^2	98066.5	0.980665	1	735.559	14.2233	98.0665	29.42
1 torr	133.322	$1.33322x10^{-3}$	$1.35951x10^{-3}$	1	$19.3368x10^{-3}$	0.133322	0.04
1 Psi	6894.76	$68.9476x10^{-3}$	$70.3096x10^{-3}$	51.7149	1	6.89476	2.07

Conversion table for negative pressure

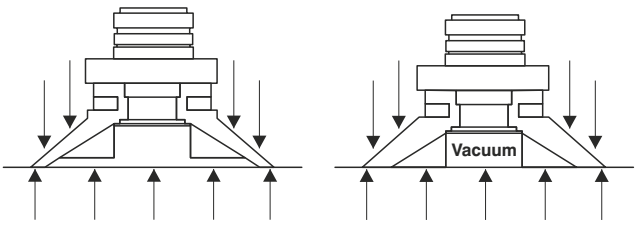
	mbar	kPa	-kPa	%Vacuum	Torr	-mmHg	-inHg
Atm	1013	101.3	0	0	760	0	0
	913	91.3	10	9.9	685	75	3
	813	81.3	20	19.7	610	150	6
	713	71.3	30	29.6	535	225	9
	613	61.3	40	39.5	460	300	12
	513	51.3	50	49.3	385	375	15
	413	41.3	60	59.2	310	450	18
	313	31.3	70	69.1	235	525	21
	213	21.3	80	79	160	600	24
	113	11.3	90	89	85	675	27
Absolute vacuum	0	0	101.3	100	0	760	30

Conversion table of Flow rate per unit of time

	m^3/s	m^3/h	l/min	l/s	ft^3/min (scfm)
1 m^3/s	1	3600	60000	1000	2118.9
1 m^3/h	$0.28x10^{-3}$	1	16.6667	0.2778	0.5885
1 l/min	$16.67x10^{-4}$	0.06	1	0.0167	0.035
1 l/s	$1x10^{-3}$	3.6	60	1	2.1189
1 ft^3/min (scfm)	$0.472x10^{-3}$	1.6992	28.32	0.4720	1

Suction cups

Suction cups are vacuum accessories that are indispensable whenever there is a problem with lifting, clamping or handling manufactured products, sheets or other objects that are "difficult to grip" with traditional gripping means, because they lack handholds, are fragile or are easily deformable.
Correct application of suction cups ensures simple, economical and safe gripping operations, which are critical requirements for the proper execution of any automatic action.
The suction cup adheres to the surface of an object whenever the pressure surrounding it outside (atmospheric pressure) is higher than the pressure existing between the suction cup and the surface of the object.
In order to generate low pressure inside the suction cup, the latter may be connected to a vacuum pump.
The lifting force of the suction cup will depend on the degree of vacuum attained by the pump and its capacity to compensate for losses.
The suction cup is an effective, simple and economical system for handling all kinds of shapes and surfaces.
The suction cup itself can have a number of different shapes:
flat, oval, conical bellows with the possibility of adding various accessories, such as filters, shut-off valves, level compensators.
Any given suction cup is designed for a specific vacuum movement application.



Applications:
Gripping, handling, lifting, forming, palletising, pick & place, transferring, positioning. The materials that can be managed with suction cups are highly varied, but we can roughly categorise them as follows:
1) METALS: heavy loads, large sizes, middle frequencies, dirty surfaces.
2) PLASTIC: light loads, medium to small sizes with irregular shapes, no surface deposits.
3) WOOD: rough surface, slightly deformed, middle-weight loads, no surface deposits.

Criteria for selecting a suction cup:

Suction cups are gripping elements (or devices) that can handle many different kinds of objects; obviously their shape, weight, material, size and type of movement have a direct effect on the choice of suction cup, both in terms of shape and the material of which it is composed. Generally speaking, suction cups can have two or three types of shapes: flat, profiled and bellows (single or multiple).Flat and profiled suction cups are suitable for gripping and moving smooth, flat or slightly curved surfaces, especially in a direction perpendicular to the gripping surface, with good shear strength. For deformable, very heavy and/or superficially dirty surfaces, suction cups that have a high grip coefficient are available, obtained by using specially-shaped anchors in the gripping area. The bellows suction cups are suitable for gripping and moving irregular, cylindrical, curved surfaces. The suction cup's capacity to conform to the surface depends on the number of changes the bellows will have to make. Obviously the shear strength will be considerably less than for smooth suction cups, but the capacity for "articulated" action is highly flexible for angular grips.

The force of the suction cup is proportional to the degree of vacuum generated inside it and to the surface covered by this same suction cup.
The main reference data are:
Theoretical force (Ft): Ft = surface of the suction cup x percentage of vacuum
Effective force (Fe): Fe = Ft – 50%
K Factor (Safety coefficient): This factor is used to correctly and safely size the suction cup as a function of the various applications; the K factor will differ depending on the application.

K=2 : horizontal linear movement
K=4 : vertical linear movement and movement along more than one axis
axis K=6 : vertical movement along more than one axis (rotation)

Level of vacuum to be generated during gripping:

In practical applications no surface to be moved using vacuum is actually entirely impermeable.In cases of porous materials and surfaces that are non-regular (wood, cardboard, etc.) and smooth, some of the air will leak out in the direction of the vacuum; in this case, it is necessary to keep the vacuum flow rate high to compensate for the aforementioned leakage and maintain the grip; this is brought about with a low level of vacuum and broader diameters of the suction cups; on the other hand, if the materials are rigid and nonporous (metal, thick plastic, glass, etc.), the flow rate of the vacuum stays weak or non-existant, and so you need to raise the level of vacuum using more compact suction cups. In summary:

1) Porous materials: degree of vacuum between 35 – 60%
2) Nonporous materials: degree of vacuum between 55 – 80%

Determination of the suction cup diameter

After having chosen the type of suction cup and the material, you can go on to calculate the diameter of that suction cup; to do this, you need to use predefined formulas that take into account the following:

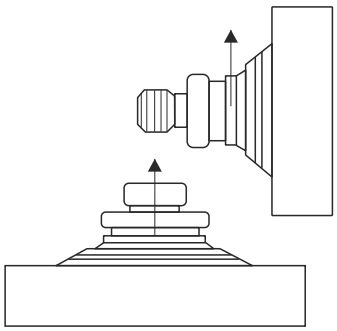
D *= diameter of the suction cup in mm* / ***K*** *= safety factor* / ***V*** *= degree of vacuum (- Kpa)*
n *= number of suction cups in the application* / ***m*** *= mass to be handled (in Kg)*

The formula will vary as a function of the type of suction cup (flat - profiled - bellows single or multiple).
The formulas are the following:

Flat suction cup $D = 140 * \sqrt{\frac{m*K}{V*n}}$

Profiled suction cup $D = 123 * \sqrt{\frac{m*K}{V*n}}$

Bellows suction cup $D = 152 * \sqrt{\frac{m*K}{V*n}}$ **(two bellows 223 / three bellows 558)**



We can subdivide the applications with suction cups into:
Horizontal, where the object is lifted and moved parallel to the plane
Vertical, where the object is lifted and moved perpendicular to the plane

Due to a number of factors intrinsic to the handling system, such as friction, gravity and acceleration, the safety factor has to be implemented to prevent the object from slipping and detaching while it is being moved.

Safety factor table

K (Safety factor)	Type of handling
2	Horizontal movement
4	Vertical movement
4	Horizontal movement with Robots
6	Vertical movement with Robots

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Choice of suction cup:

Pneumax suction cups are available in different shapes, each one of which can meet a number of existing application requirements; the choice of cup must be made based on the characteristics listed below:

Suction cup Flat series TP:
Suction cup to be used for moving sheets and in those applications where the lifting force is parallel to the gripping plane. Internal reinforcements improve stability and make this cup suitable for handling heavy objects.

Suction cup Bellows series TS:
Suction cup best used in particular for moving light items in those applications where the lifting force is parallel to the gripping plane.
The range of the bellows makes it possible to compensate for the irregularity of the surface and height of the object. The long bellows suction cup is best used in applications where it is necessary to pick off and move light products such as: leaves of paper or pieces of cardboard, thin sheets, wood panels, etc.
Due to their greater flexibility, these can be used to compensate for errors of flatness or to grip inclined surfaces, but are not suitable for applications with vertical loads or with a high degree of vacuum.

Suction cup (Plain) Cup series TN:
Among the most common types of suction cup, used in sectors of industry where special performance is not required: Handling of objects made of plastic, wood panels, thin sheets of glass and metal, etc.
Recommended for vertical movement of heavy objects.

High Grip suction cup:
Suction cup with high coefficient of friction, developed for the handling of oily surfaces, such as sheet metal in moulding processes, and also recommended for handling wet marbles and glasses, slabs and loads in general, subject to high accelerations and decelerations during movement.
Recommended for the "automotive" sector, available in various sizes and shapes: round and oval flat and round and oval bellows.
Suitable for horizontal and vertical movement.

Foam rubber suction cups:
This suction cup allows for the moving and gripping of loads with coarse, very rough or uneven surfaces, such as: textured, non-slip or ribbed/corrugated sheets, and sawn, bush-hammered or flamed marble. Items made of rough concrete, garden walkway tiles and brick in general. Recommended for use with oiled surfaces and to move vertical loads.

Choice of Mix. The choice of mix to be used is made by consulting the technical tables as a function of the individual application, and after having carefully evaluated the following factors :

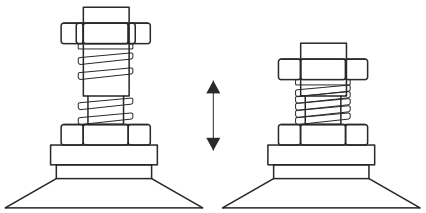
- ☛Surface roughness of the load to be moved and its temperature
- ☛Weight and dimensions of the load.
- ☛The presence of chemical substances, oils, solvents etc. on the gripping surface.
- ☛How labour-intensive and complex the work processes are.
- ☛How important it is to ensure that no specks exist on the gripping surface.

Suction Cup Characteristics and Materials

Material	Temperature °C	Abrasion resistance	Oil resistance	Resistance to weather/atmospheric agents
N-NBR	-20 ÷ +110	Excellent	Excellent	Very good
S-Silicone	-40 ÷ +200	Good	Low	Excellent
PU-Polyurethane	10 ÷ 50	Excellent	Excellent	Excellent
F-Fluorinated rubber	-10 ÷ +230	Excellent	Very good	Very good

Level Compensator:
This accessory makes it possible to overcome differences in height that may be found in various applications, for example in lifting systems where the suction cups are fixed to a rigid structure or when a suction cup is used on the arm of an anthropomorphic robot or in a similar system where the items must be accurately positioned at the required height; in addition, the device makes it possible, within certain limits, to absorb pushback.

The Pneumax range is subdivided into three types:
- ●Compensator with external spring
- ●Compensator with internal spring
- ●Anti-rotation compensator with internal spring



Pneumatic pumps

Vacuum pumps of the pneumatic type or pneumatic vacuum generators, which operate on the Venturi principle: one or more nozzles are fed by compressed air, generating a jet of air that drags (in contact with the environment) the surrounding air and then evacuates. This "dragging" creates a depression which results in the generation of a vacuum. The big advantage of pneumatic pumps is that they can only operate when the suction cups or the application connected to them require vacuum.

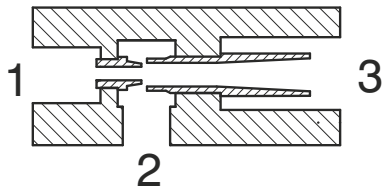
Advantages:

Consumption of air (and therefore power) limited to the moment of use.
Installation directly proximate to the suction cups (simplification of layout / savings).
Short response times and high capacity.
Flow rates for any requirement.
No limit to applications.
Compactness / lightness / reliability / little or no wear.

Types:

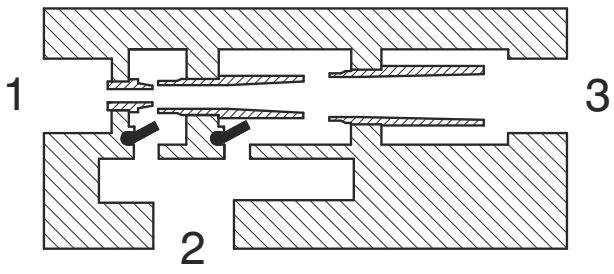
In terms of dimensions, functions and operation, we can categorise generators as one of two major types:

1) Single stage, compact and/or miniaturised, with pneumatic or electropneumatic control, for direct-contact installation with suction cup holders and suction cups.



Multistage generator

2) Multistadio con o senza funzioni integrate, a comando pneumatico / elettropneumatico per montaggio de-localizzato e per gestione di gruppi di Suction cups.



Multistage generator

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Range:

The **PNEUMAX** range consists of single-stage and multistage equipment of various sizes and types; the single-stage generators use the Venturi effect in a single medium/high throughput nozzle and promptly generate vacuum, flow rate and suction values that are suitable for medium/light applications.
Multistage generators having more than one nozzle (ejectors) in a line, using the kinetic energy that this layout generates to ensure, based on the flow rate, limited consumption of energy and attainment of a vacuum level equal to 90%, with various suction capabilities.
Single-stage generators, very fast in switching pressure/vacuum, can also be equipped with a quick-release system for highly cyclical applications.
On the other hand, **multistage generators** can often be accessorised with integrated management and control functions, such as for example electropneumatic control for power supply and power shut-off, quick-release blowing, a regulator to measure this release and a vacuum switch, to control the degree of vacuum generated.
These latter generators can be installed as modules as well, creating actual stand-alone generation modules and decentralised vacuum management for controlling more than one gripping element

Adjustable vacuum generators conveyor
Based on the Venturi principle, these differ from the ones described further above in that they have an ejector with a much larger diameter, and are adjustable.
This feature makes it possible to change the device's flow rate and degree of vacuum without affecting the supply pressure.
Their special shape and their operating principle make them suitable for suction and the transfer of powders, granules, sawdust, metal chips, liquid or dry food products, etc.;to control suction cups in the presence of large quantities of powders or liquids; these can also be used to suction smoke, coolant fog, water vapour, etc.

Suction filters
Preventing contaminants from reaching the pneumatic vacuum generator is very important for ensuring long-term and good operation.
This is why Pneumax vacuum filters are installed at the suction inlet of the pneumatic vacuum generators and/or on the pipework of the equipment.
The Pneumax product line includes vertical suction filters with flow rates ranging from 150 to 2520 l/m and threads running from G3/8" to G1".
In-line filters with flow rates ranging from 20 to 50 l/m and instant connectivity for pipes with diameters ø4, ø6 and ø8mm