Suction pads

Suction pads are used wherever objects (parts, packing materials etc.) need to be lifted, transported, turned over or handled in some other manner. They are the connecting element between the vacuum generator and the workpiece. Their technical and physical design is therefore of great importance.

A basic distinction is made between the following types of suction pads:
- Flat suction pads
- Bellows suction pads
- Grippers which operate on special principles

Each version has its own specific advantages, which can be improved or optimised by the use of suction pads made of various materials. Detailed explanations of the available suction-pad materials can be found after the section "Selection and Configuration".

Flat suction pads

Flat suction pads are particularly suitable for the handling of objects with flat or only slightly curved surfaces. Due to their flat shape, they can grip the workpiece in a very short time and can withstand the forces which result from fast movement of the object during handling.

Advantages of flat suction pads
- Wide range of suction-pads made from various materials and with differing sizes and shapes (round, oval, with steep or flat sealing lip)
- Low overall height and the resulting minimum internal volume ensures very short evacuation times
- Suitable for high lateral forces
- Good intrinsic stability when attached to the load

Typical applications
- Handling of smooth or slightly rough workpieces such as metal sheets, cardboard boxes, sheets of glass, plastic parts and sheets of wood

Bellows suction pads

Bellows suction pads are used when it is necessary to compensate for varying workpiece heights, to handle parts with uneven surfaces or to handle easily-damaged parts.

Advantages of bellows suction pads
- Good adaptation to uneven workpiece surfaces
- Lifting effect during evacuation
- Compensation for height differences
- Careful gripping of easily damaged workpieces

Typical applications
- Handling of curved or uneven workpieces such as car body work components, pipes, cardboard boxes etc.
- Handling of easily damaged workpieces such as electronic components, injection-moulded plastic parts etc.
- Handling of products packed in boxes or blister-packs

Both types of suction pads are available in a wide range of shapes and sizes. The table of contents for this section contains more basic data and information about the application areas for the various suction-pad types.

Grippers with special operating principles

This group contains all suction pads which do not belong to the two basic groups.

Floating suction pads

Floating suction pads are pneumatically powered suction pads including vacuum generation for low-contact handling of easily damaged objects.
They are used primarily for the handling of paper, plastic films, wood veneers, printed circuit boards, wafers and solar cells.

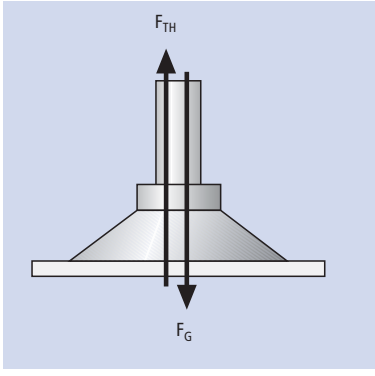
Magnetic grippers

Magnetic grippers are controlled by a vacuum and/or compressed-air. The magnetic field is generated by a permanent magnet. They are used primarily for the handling of steel sheets with drilled and cut holes which cannot be handled with normal suction pads.

Explanation of the technical data (does not apply to grippers with special functions)

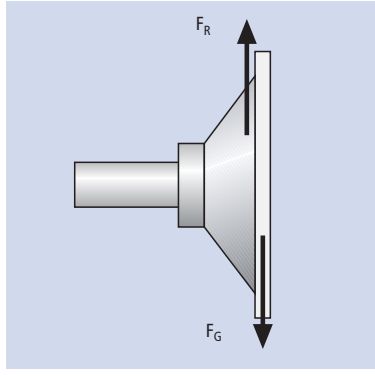
Various calculations must be made for the various components during the planning of a vacuum system. The following sections explain the most important technical data of the suction pads in order to simplify system design. These explanations do not apply to the floating suction pads SBS or magnetic gripper SGM.

Theoretical suction force



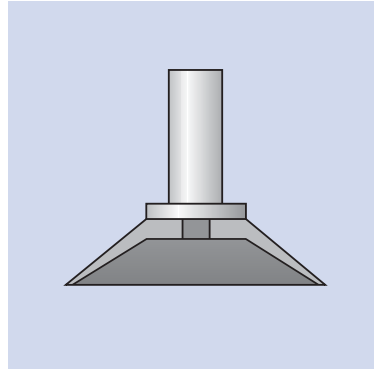
The theoretical value in N at a vacuum of -0.6 bar (at sea level). Depending on the operating conditions, this value may have to be reduced in order to take the necessary safety factor, the losses due to friction or a lower vacuum value (due, for example, to a porous workpiece).

Lateral force



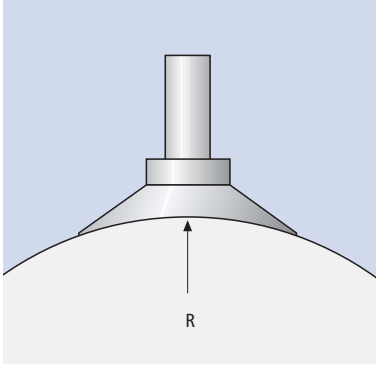
The measured value in N at a vacuum of -0.6 bar on a dry or oily, flat and smooth workpiece surface. These values do not include a safety factor.

Internal volume



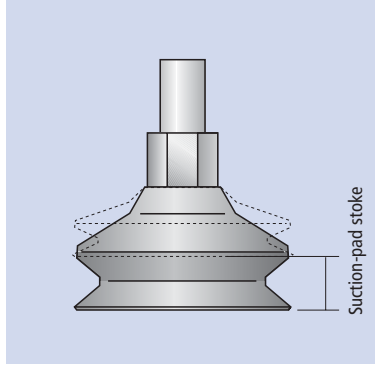
This is used to calculate the total volume of the gripper system and also affects the calculation of the evacuation time.

Minimum radius of curvature of the workpiece



This specifies the minimum radius at which the workpiece can be gripped securely by the suction pad.

Suction-pad stroke



This is the lifting effect which occurs during evacuation of the suction pad.

Suction pads

Selection

Suction-pad selection

The selection of the suction pad always depends on the actual application (the operating conditions and the material). For this reason, various physical values must be calculated and determined before the correct suction pad can be selected.

Coefficient of friction
It is not possible to specify generally valid values of the coefficient of friction "μ" between the suction pad and the workpiece. This means that this value must be determined beforehand by means of suitable tests (see also the table of typical values).

Table of typical values

Workpiece surface	approx. μ
Glass, stone, plastic (dry)	approx. 0.5
Sandpaper (dry)	1.1
Moist or oily surface	0.1 – 0.4

Calculation of the holding forces
The calculated holding forces can never be more than theoretical values. In practical applications, many factors, such as the size and shape of the suction pad, the surface finish and the rigidity of the workpiece (deformation) play a decisive role. For this reason, we recommend that you include a safety factor S of at least 2. The German accident-prevention regulations demand a minimum safety factor of 1.5.

If you intend to swivel or turn over the workpiece, you should use a safety factor of 2.5 or higher in order to cope with the resulting turning forces.

Suction-pad diameter
The diameter of the suction pad is important for the absolute holding force and also depends on the finish of the workpiece surface. The required diameter can be determined with the aid of the following formula.

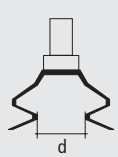
With the force applied horizontally:

$$d = 1.12 \cdot \sqrt{\frac{m \cdot S}{P_U \cdot n}}$$

With the force applied vertically:

$$d = 1.12 \cdot \sqrt{\frac{m \cdot S}{P_U \cdot n \cdot \mu}}$$

d = suction-pad diameter in cm,
(with double lip ≈ internal diameter,
for bellows suction pad = internal diameter of the sealing lip)



m = mass of the workpiece in kg
P_U = vacuum in bar
n = number of suction pads
S = safety factor
μ = coefficient of friction

An example:

Plastic sheet:	m = 50 kg
Vacuum:	P_U = – 0.4 bar
Number of suction pads:	n = 4
Measured coefficient of friction:	μ = 0.5
Safety factor:	S = 2

$$d = 1.12 \cdot \sqrt{\frac{50 \cdot 2}{0.4 \cdot 4 \cdot 0.5}}$$

d = 12.5 cm

A good solution in this case is the suction pad PFYN 150 with a nominal diameter of 150 mm.

Suction capacity [$\dot{V}$]
The desired vacuum value and the volume flow rate used to achieve this vacuum are decisive for calculation of the necessary suction capacity. The workpiece material is the decisive factor which determines the necessary suction capacity. The table shows typical values for the volume flow rate and the suction capacity for various suction-pad diameters.

Typical value (with smooth, air-tight surfaces)

Suction-pad Ø	Suction area A [cm²]	Volume flow $\dot{V}$ [m³/ h]	[l/min]
up to 60 mm	28	0,5	8.3
up to 120 mm	113	1,0	16.6
up to 215 mm	363	2,0	3.3
up to 450 mm	1540	4,0	66.6

Important:
For porous parts, you should always carry out suction tests!

Planning checklist for selection of suction pads

What are the dimensions and weight of the workpiece?	These are important for calculation of the suction force and the number of suction pads (see the technical information).
What is the surface finish of the workpiece (rough, structured, smooth)?	This determines the type of suction pad (material, shape, dimensions).
Could the workpiece be dirty? If so, what kind of dirt?	This is important for the dimensioning of the suction pad (see the technical information) and for the design of the dust filter.
What is the maximum temperature of the workpiece?	The temperature is important for selection of the suction-pad material. Special materials may be necessary for temperatures higher than 70 °C (see materials table).
Is precise positioning for picking up or placing of the workpiece required?	This determines the type, version and shape of the suction pad.
What cycle times are used?	This is important for the dimensioning and plays a part in the calculations (suction force of the pad etc.). See the technical information.
What is the maximum acceleration during handling?	This may affect the dimensioning and plays a part in the calculations (suction force, moment of inertia etc.). See the technical information.
What type of handling is needed (moving, slewing, turning over)?	This is important for the dimensioning and design of the suction force, together with the related calculations.
Which environmental effects exist?	These are important for selection of the suction-pad material (resistance to ozone and other chemicals, freedom from silicone etc.).

Suction pads

The material is decisive

Material overview

Chemical designation	Nitrile rubber		Silicone rubber		Natural rubber	High temp. material
Trade name	Perbunan (AS = antistatic)		Silicone (AS = antistatic)			
	Abbreviation	NBR	NBR-AS	SI	SI-AS	NK HT1
Wear resistance	●●	●●	●	●	●●	●●●
Resistance to permanent deformation	●●	●●	●●	●●	●●●	●●
General weathering resistance	●●	●●	●●●	●●●	●●	●●●
Resistance to ozone	●	●	●●●●	●●●●	●●	●●●●
Resistance to oil	●●●●	●●●●	●	●	●	●●●●
Resistance to fuels	●●	●●	●	●	●	●●
Resistance to alcohol, ethanol 96%	●●●●	●●	●●●●	●●	●●●●	●●●●
Resistance to solvents	●●	●●	●●	●●	●	●●
General resistance to acids	●	●	●	●	●●	●
Resistance to steam	●●	●●	●●	●●	●	●●●
Tensile strength	●●	●●	●	●	●●	●●
Abrasion value in mm3 to DIN 53516 (approx.)	100–120 at 55 Sh.	100–120 at 55 Sh.	180–200 ati 55 Sh.	180–200 at 55 Sh.	100–120 at 40 Sh.	100–120 at 60 Sh.
Specific resistance in [Ω· cm]	–	≤ 107	–	≤ 107	–	–
Short-term temperature resistance in °C	–30° to +120°	–30° to +120°	–60° to +250°	–60° to +250°	–50° to +120°	–30° to +170°
Longer-term temperature resistance in °C	–10° to +70°	–10° to +70°	–30° to +200°	–30° to +200°	–40° to +80°	–10° to +140°
Shore hardness to DIN 53505	40 to 90	55 ± 5	30 to 85*	55 ± 5	30 to 90	60 ± 5
Colour / coding	black, grey, blue, light blue	black	white, transparent	black	grey, light brown, black	blue

*After-bake of silicone 10 h/160 °C = + 5 . . . 10 Shore A

●●●● exellent ●●● very good ●● good ● poor to satisfactory

Selection aid for suction-pad materials

Applications	NBR	NBR-AS	SI	SI-AS	NK	HT1
Branch-specific applications	Universal application	Universal application	CD/DVD Packaging Plastics	CD/DVD Packaging Plastics	Wood	Plastics
Foodstuff quality			☑			
Oily workpieces	☑	☑				☑
No marking of workpieces						☑
Slight marking of workpieces	○		☑	☑	☑	
Higher temperatures			☑	☑		☑
Lower temperatures			☑	☑	☑	
Very heavy loads						
Very smooth surfaces (glass)	☑					
Rougher surfaces (wood, stone)					☑	

○ grey version with little marking

Suction pads

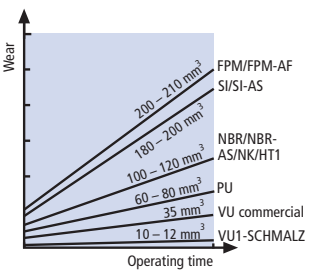
The material is decisive

Material overview

Polyurethane	Vulkollan	Fluorcaoutchuc Fluorkautschuk FPM (AF = no making		Epichlorocaoutchuc Herclor
PU	VU 1	FPM	FPM-AF	ECO
●●●	●●●●	●	●	●●
●	●●	●●●	●●●	●●●
●●●	●●●	●●●●	●●●●	●●●
●●●	●●●	●●●●	●●●●	●●●
●●●	●●●	●●●●	●●●●	●●●●
●●	●●	●●●●	●●●●	●●
●●●●	●●●●	●●	●●	●
●	●	●●●	●●●	●●●
●	●	●●●	●●●	●
●	●	●●	●	●●
●●●	●●●●	●●	●●	●●
60–80 at 55 Sh.	10–12 at 72 Sh.	200–210 at 65 Sh.	200–210 at 65 Sh.	
–	–	–	–	–
–40° to +130°	–40° to +100°	–10° to +250°	–10° to +250°	–25° to +160°
–30° to +100°	–40° to +80°	–10° to +200°	–10° to +200°	–25° to +130°
55	72	65 ± 5	65 ± 5	50
blue, green	dark green	black	black	black

The application and the ambient conditions are decisive for the selection of the appropriate suction-pad material. In many cases, for example, the application demands resistance to abrasion, resistance to oil or suitability for use with foodstuffs.

The overview summarises the properties of various suction-pad materials and shows typical applications for which the materials are particularly suitable.



Selection aid for suction-pad materials

PU	VU 1	FPM	FPM-AF	ECO
Packaging	Metal Wood Packaging	Typical application for high temperature	Typical application for high temperature	
☑	☑	☑	☑	☑
			☑	
☑	☑		☑	
		☑	☑	
☑	☑			
☑	☑	☑	☑	
☑	☑			

Suction pads accessories

Spring plungers (FSTE/FSTA/FSTI/FSTF)

Are used for spring-mounting of suction pads, particularly in fully automatic systems, to ensure that the pads can be placed carefully, even on easily damaged workpieces. Spring plungers also compensate for varying workpiece heights. Further information in Section 3.

Sensing valves (TV)

Can be screwed into many suction pads with screw nipples. They sense whether a workpiece is in contact with the pad and open the vacuum line only if this is so. Further information in Section 5.

Adapter nipples (ANW/AN)

Are used for rigid mounting of suction pads on, for example, a cross-beam or for mounting with a spring plunger. The vacuum connection is on the side. Further information in Section 3.

Flow resistors (SW)

Reduce the cross-sectional area of the vacuum and thus help to maintain the system vacuum if one or more suction pads are not in contact with the workpiece. The vacuum line is not fully closed. They are particularly suitable for the handling of porous workpieces. Further information in Section 5.

Ball joints and Flexolink (KGL/FLK)

Are screwed onto the suction pads to permit a certain amount of flexibility. They permit optimum adaptation of the pad to uneven workpieces. Further information in Section 3.

Check valves (SVK/SVKG/SVV/SVN)

Continuously measure the rate of flow of air through themselves. If one or more suction pads are not in contact with the workpiece, or if the workpiece is pulled away, they close in order to maintain the vacuum in the rest of the system. Type SVN is even suitable for use on porous workpieces. Further information in Section 5.

Sealing rings (DR)

Robust PA sealing rings with excellent sealing properties. Further information in Section 7.