







1

BASICS

	<i>Pressure and conversion tables</i>	1.2
	<i>Vacuum circuits</i>	1.3
	<i>Symbols and features</i>	1.4
	<i>Definitions</i>	1.5
	<i>Dimensioning of vacuum components</i>	1.6
	<i>Checklist on dimensioning of vacuum components</i>	1.15

Vacuum - An idea makes its way

The idea of vacuum has already been known for a long time. At least since 1654, when Otto von Guericke carried out his famous experiment with the "Hemispheres of Magdeburg". In the course of the rapid development of the automatization

processes, vacuum engineering, however, only found its way into the industry within the last 40 years. The applications mostly occur in the field of coarse vacuum.

Conversion Table Vacuum/ Pressure Units										
Meas.Unit	(Unit)	=	bar	mbar	kPa	at	Torr.	m WS	psi	inch Hg
1 bar	(10 ⁵ N/m ²)	=	1	1000	100	1,019	750,2	10,19	14,51	29,53
1 mbar	(10 ² N/m ²)	=	0,001	1	0,1	0,001019	0,7502	0,01019	0,01451	0,02953
1 kPa	(10 ³ N/m ²)	=	0,01	10	1	0,01019	7,502	0,1019	0,1451	0,2953
1 at	(10 ⁴ kp/m ²)	=	0,9807	980,7	98,07	1	735,7	10	14,23	28,96
1 Torr	(mm Hg)	=	0,001333	1,333	0,1333	0,001359	1	0,01359	0,01934	0,03936
1 m WS	(m H ₂ O)	=	0,09807	98,07	9,807	0,01	73,57	1	1,423	2,896
1 psi	(lb/in ²)	=	0,06893	68,93	6,893	0,07029	51,71	0,7029	1	2,035
1 inch Hg	(in Hg)	=	0,03387	33,87	3,387	0,03453	25,41	0,3453	0,4913	1

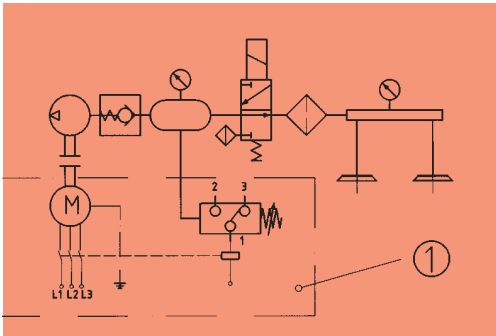
According to DIN 28400, vacuum is the state of a gas, whose pressure is smaller than the state of the atmosphere. In the field of coarse vacuum, the level of achieved vacuum is mostly indicated in percent. The pressure - conversion table on the right gives an overview over units often employed and their relationship to each other.

Pressure- Conversion Table								
Relative Vacuum (%)	Absolute Pressure p _{abs} (mbar)	Atmospherical Pressure Difference in Normal Atmosphere						
		P _e = P _{abs} - P _{amb} (P _{amb} = 1013.25 mbar according to DIN 5450)						
		(bar)	(kPa)	(at)	(Torr)	(m WS)	(psi)	(in Hg)
0	1013	0	0	0	0	0	0	0
10	911,9	-0,1013	-10,13	-0,1033	-75,99	-1,033	-1,470	-2,991
20	810,6	-0,2027	-20,27	-0,2027	-152,1	-2,027	-2,941	-5,986
30	709,3	-0,3040	-30,40	-0,3099	-228,1	-3,099	-4,410	-8,977
40	607,9	-0,4053	-40,53	-0,4133	-304,1	-4,133	-5,880	-11,97
50	506,6	-0,5066	-50,66	-0,5166	-380,1	-5,166	-7,350	-14,96
60	405,3	-0,6079	-60,79	-0,6199	-456,0	-6,199	-8,819	-17,95
70	304,0	-0,7093	-70,93	-0,7233	-532,1	-7,233	-10,29	-20,95
80	202,7	-0,8106	-81,06	-0,8266	-608,1	-8,266	-11,76	-23,94
90	101,3	-0,9119	-91,19	-0,9299	-684,1	-9,299	-13,23	-26,93

Vacuum and Altitude

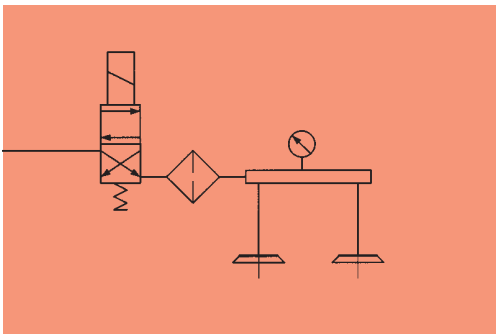
When calculating the required size of Vacuum Generators, one has to consider the altitude. The air pressure takes off approximately 12.5 mbar per 100 m of height. That means, if one takes a Vacuum Generator, which produces a pressure balance of 800 mbar at a height of 200 m, then the same Generator only reaches a pressure of 660 mbar at a level of 1500 m.

Air Pressure p in dependence of height h (Normal Atmosphere)	
Height h (m)	Air Pressure p (mbar)
0	1013,25
100	1001,3
200	989,5
300	977,7
400	966,1
500	954,6
600	943,2
700	931,9
800	920,8
900	909,7
1000	898,8
1200	877,2
1400	856,0
1600	835,3
1800	814,9
2000	795,0



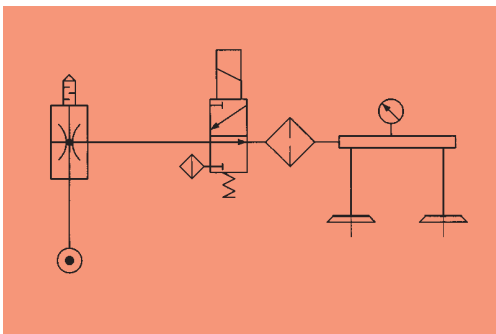
Vacuum circuit with vacuum pump

Used mainly with the handling of dense transport goods. The vacuum is created by an electric pump. This pump evacuates a tank. By means of an underpressure switch the vacuum in this tank is controlled. The vacuum-controlled motor switch (1) turns the pump on / off, when the actual values fall below / rise above the adjusted vacuum in the tank. This enlarges the lifespan of the pump and saves energy.



Vacuum circuit with blower

Blowers are mainly used with the handling of porous work pieces, such as MDF- or chipboards. The vacuum is created by a blower. A valve controls the "suck / release" - function. The use of a vacuum tank is not recommended, because of the high volume streams of blowers.



Vacuum circuit with ejector

By means of compressed air, ejectors create a vacuum. The suction cups/ plates can directly be connected to the ejector. Depending on the fact whether compressed air is available, the work piece will be sucked on or released. In more complicated systems further valves can be attached to the distribution conductor to control individual suction cups/ plates or suction circuits.

Vacuum engineering in practice:

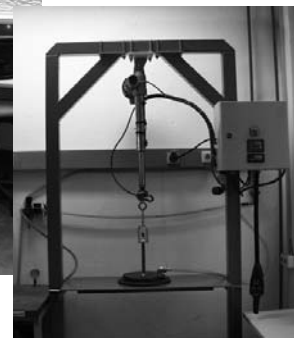
When choosing among vacuum systems, it should be considered that higher vacuums also mean higher costs in energy. Vacuum engineering usually works with low air pressures of 60 - 80 % with pumps and 20 - 30 % with blowers. That depends, of course, on the transported work pieces.




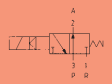

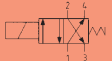









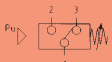












When transporting porous work pieces or work pieces without ideal density, the working vacuum can also be at 20 - 30 %. In special applications it is necessary to conduct various trials prior to choosing the final systems.



Carrying out tests to determine the best vacuum components.

Tests to determine the holding power of the various suction cups / suction plates.



	Vacuum pump		3/2-way impulse valve
	Vacuum blower		Vacuum-controlled 3/2-way valve
	Ejector		Solenoid Valve 4/2-way valve
	Flat suction cups		Flow valve
	Bellow type cups		Non-return valve
	Suction plates with flat sealing		Stylus valve
	Suction plate with roof type lip sealing		Vacuum regulating valve
	Suction plate with froth rubber sealing		Mechanical underpressure switch
	Special suction plates		Electronic underpressure switch
	2/2-way ball valve		Digital underpressure switch
	3/2-way ball valve		Filter
	3/2-way hand slide valve		Water separator
	3/2-way foot interruptor		Tanks
	3/2-way solenoid valve		Gauge (control gauge)

Sealing profile of suction cups/ plates

When choosing among suction cups and suction plates, many things have to be taken into consideration, before the optimal suction cup can be determined. The sealing between the suction cup and the work piece is of great importance.

The better the sealing, the more energy can be saved during the working process. Available are various sealing profiles, which all have special functions.

Flat suction cup

- suitable for:
- metal parts
 - cartonage
 - electronic parts
 - food products

with extra sealing

- suitable for:
- scaly metal sheets
 - bended parts

with roof type lip

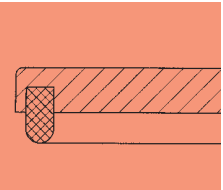
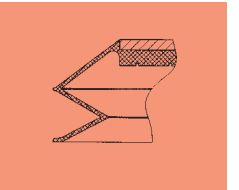
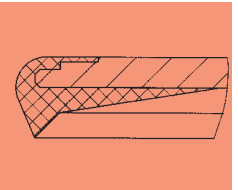
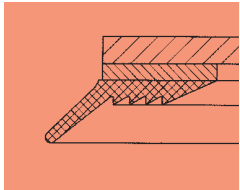
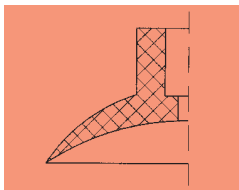
- suitable for:
- chequered / beaded sheets
 - structured glass
 - stones
 - saw-rough wood

Bellows type cup

- suitable for:
- bended parts
 - warped parts
 - uneven parts
 - separate parts from a pile

Sponge-/ froth

- suitable for:
- saw-rough wood
 - split strips/ coils
 - chequered/ beaded sheets
 - paper rolls



The table on the right shows common surface structures and the possible suction cups / plates.

You will find more information about the choice of the right material and the right dimensioning on the following pages.

Please read chapters 2 and 3 to find information about available sizes.

Dimensioning help for suction cups and different surfaces

Surface Type:	smooth	rough	structured	damp oily	bent	wavy	round material	long goods
FS-G	✓✓✓	✓		✓	✓	✓		
FS-GR	✓✓✓	✓		✓✓	✓	✓		
FBS-GF	✓✓✓	✓		✓	✓✓✓	✓✓✓	✓	✓
FBS-GFD	✓✓✓	✓		✓	✓✓✓	✓✓✓	✓✓	✓✓
DP-FSRL	✓✓✓	✓		✓✓	✓	✓		
DP-FSL	✓✓	✓✓	✓	✓	✓✓✓	✓✓		
DP-FSD	✓	✓✓✓	✓✓✓	✓	✓✓	✓		
DP-FSM	✓✓	✓✓✓	✓✓	✓				
SP-KPHL	✓✓✓	✓✓		✓	✓✓✓	✓✓		
SP-(K)PHM	✓✓	✓✓✓	✓✓✓					
SP-PHZ	✓✓	✓✓	✓✓✓					
DP-FS	✓✓✓	✓		✓	✓		✓	✓✓
DP-FBS	✓✓✓	✓		✓	✓✓✓	✓✓✓	✓✓✓	✓

- without not suitable
- ✓ partly suitable
- ✓✓ well suitable
- ✓✓✓ very well suitable

- Abbreviations/ Features suction plates:**
- FS-G Flat suction cup
 - FS-GR Flat suction cup w/ gr. rubber lining
 - FBS-GF Bellows type cup with 1.5 creases
 - FBS-GFD Bellows type cup with 2.5 creases
 - DP-FSRL Suction plate with grooves
 - DP-FSL Suction plate without grooves
 - DP-FSD Suction plate with roof type sealing
 - DP-FSM Suction plate w/ sponge rubber sealing
 - DP-FBS Suction plate bellows type

DIMENSIONING OF VACUUM COMPONENTS

Which holding forces and dimensions are necessary?

Quantity of suction cups/plates:

To determine the quantity of suction cups/ plates only the inherent stability of the material is relevant. For instance, a 30 mm thick steel plate can be transported with less suction plates than a 1 mm thick plate.

To exactly dimension the quantity one has to consider the maximum possible overhang in connection with the **minimum** material thickness. This put into relation to the max. length and width one can fairly easily determine the required quantity.

max. overhang allowed "Ü" on various materials (mm):

Materialdicke	Stahl	Alu	Holz
< 0,5 mm	300	300	300
< 1,0 mm	400	400	400
< 2,0 mm	600	600	600
< 4,0 mm	800	800	800
< 8,0 mm	1.200	1.300	1.000
> 12,0 mm	1.800	2.000	1.500

The required quantity is determined by:

Long direction : $n_L = \frac{L}{2 \times \ddot{U}}$

Cross direction: $n_B = \frac{B}{2 \times \ddot{U}}$

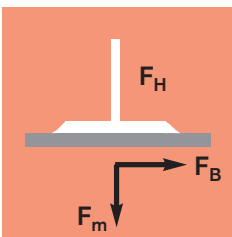
Total quantity: $n_G = n_L \times n_B$

n_L Quantity of suction plates in long direction
 n_B Quantity of suction plates in cross direction
 n_B Total quantity of suction plates required
 \ddot{U} max. possible overhang (see table)

Determination of suction cup/plates:

Once the required quantity of suction plates is determined one must decide on the dimensions and holding forces. The catalogue states the holding force of any suction cup/plate at 60% vacuum w/o safety factor. The correct holding force depends on the following factors:

- Kind of handling (horizontal or vertical)
- Occuring cross acceleration forces, especially in automatic processes or in robot operations
- Friction factor between workpiece and suction plate
- Safety factors



Horizontal handling with cross acceleration:

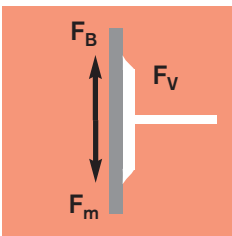
$$F_H = (F_m + F_B) \times S = \left(m \times g + \frac{m}{\mu} \times a \right) \times S ;$$

On horizontal transport with little cross acceleration (e.g. manual handling devices), the holding force is calculated as follows:

$$F_H = m \times \left(g + \frac{a}{\mu} \right) \times S$$

$$F_H = m \times g \times S$$

F_H total holding force on horizontal handling
 F_V total holding force on vertical handling
 F_m mass force of the work piece
 F_B occuring maximum acceleration forces
 m weight of work piece(kg)
 $g = 9,81 \text{ m/s}^2$
 a cross acceleration in m/s^2
 μ friction factor on work piece (see.table)
 S safety factor
 $S=2$, as per DIN EN 13155



Vertikales Handling mit Querbewegung:

$$F_V = (F_m + F_B) \times S = \left(\frac{m}{\mu} \times g + \frac{m}{\mu} \times a \right) \times S ; F_V = \frac{m}{\mu} \times (g + a) \times S$$

Bei vertikalem Transport bei denen keine wesentlichen Vertikalbeschleunigungen herrschen (z.B. manuelle Handhabungsgeräte), errechnet sich die Haltekraft wie folgt:

$$F_V = \frac{m}{\mu} \times g \times S$$

Reibwerte einiger Werkstoffe

Oberfläche	Reibwert
rauh bis strukturiert	0,6 - 0,7
glatt und trocken	0,5
nass bis feucht	0,3 - 0,4
ölig	0,1 - 0,2

Resulted holding force H per suction cup/plate:

$$H_E = \frac{F_H \text{ (bzw. } F_V)}{n_G}$$

F_H total holding force on horizontal handling
 F_H total holding force on vertical handling
 n_G total quantity of suction cups/plates
 H_E single holding force per suction cup/plate

The right material makes the difference

Important for the lifespan of the suction cup/ suction plate and the working security of the vacuum system is not only the right dimensioning, but also the right material of the suction cup.

High temperatures, usage in the food industry or usage in connection with oils, acids or lyes demand special materials. Depending on demand and usage, you can easily find the right material in the table shown below.

Overview over Features of the different Materials										
Bezeichnung	Perbunane	Silicone	Neoprene	Buna Rubber	Norserexe	Polyurethane	Vitone	Natural Rubber	Sponge Rubber	Froth Rubber
Abbreviation	NBR	SI	CR	BK	NRS	PU	VI	NK	M	Z
Wear resistance	✓✓	✓	✓	✓✓	✓✓	✓✓✓	✓✓	✓	✓	✓
Weather resistance	✓✓	✓✓✓	✓✓✓	✓	✓	✓✓✓	✓✓✓	✓✓	✓✓	✓✓
Ozone resistance	✓	✓✓✓	✓✓	✓	✓✓	✓✓	✓✓✓	✓	✓	✓
Oil resistance	✓✓✓	✓	✓✓			✓✓✓	✓✓✓	✓	✓	✓
Solvent resistance	✓✓	✓✓	✓✓			✓	✓✓✓	✓	✓	✓
Acid resistance	✓	✓	✓	✓✓✓		✓	✓✓	✓	✓	✓
Repositioning capability	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓	✓✓✓	✓✓	✓✓✓
Food suitability		✓✓✓								
Small imprint		✓✓✓	✓✓✓		✓	✓	✓✓		✓✓✓	✓✓
Abrasion resistance	✓	✓✓	✓✓	✓	✓	✓✓✓	✓✓	✓✓	✓✓	✓✓
Tensile strength at 20°C (N/mm²)	ca. 25	ca. 10	ca. 25	ca. 25	ca. 8	ca. 35	ca. 17	ca. 28	ca. 20	ca. 20
Tensile extension in (%)	ca. 500	ca. 500	ca. 450	ca. 450	ca. 550	ca. 600	ca. 300	ca. 600	---	---
Temp. resistance long term (°C)	-10 + 80	-20 + 200	-10 + 100	-30 + 100	-10 + 70°	-30 + 100	-10 + 200°	-20 + 80	-10 + 80	-10 + 80
Temp. resistance short term (°C)	-20° + 120°	-50° + 230°	-20 + 130°	-30 + 110°	-10 + 75°	-40 + 120°	-10 + 200°	-30 + 100°	-10 + 90°	-10 + 90
spec. resistance (antistat. type.)	800 - 1000 Ω / cm	5 - 15 Ω / cm								
Colour/ Feature	black/ grey	transparent/ red/ black	white/ black	black	black	blue/ grey	grey	light brown	black/ grey	red
Shore strength(A)	25 + 80	30 + 80	50	35 + 90	20 + 65	40 + 60	50	30 + 60	30	30

- without not suitable
- ✓ partly suitable
- ✓✓ well suitable
- ✓✓✓ very well suitable

How do suction cups/ plates have to be built in?

Mounting of suction cups/plates

An unqualified mounting of suction cups and suction plates often is the cause for defective functionality. The fixing of suction cups and suction plates is a very important feature of their mounting. On the one hand the weight has to be taken on in a secure manner, on the other hand, it has to be distributed evenly over the entire surface.

FEZER not only offers you a fully developed programme for vacuum suction cups, but also the right fixing elements for every type. The various elements can be combined discretionarily, so you will find the optimal fixing for each case!

Overview over the various fixing possibilities

rigid



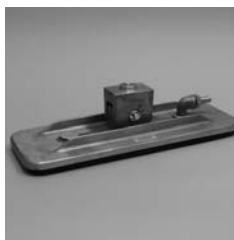
Basic fixing for suction cups and rigid suction plates. Simple and inexpensive solution, especially suitable for stable goods and for a number of up to 4 suction plates (no equalization of weight necessary).

articulated



The articulated fixing is mainly used for bended or slightly uneven parts. An excellent adaption to the unevenness of the surface is achieved with this fixing.

hinged



This fixing is mainly used for the transportation of rather long and slim parts. An excellent adaption to the bowing of the parts is achieved with this fixing.

non-spring loaded



This fixing is mainly used for stable goods or with a small number of suction cups or suction plates. It is a very inexpensive and in many cases sufficient fixing.

spring loaded



Due to the use of springs, all materials will be treated very gently and an even weight distribution is guaranteed. Especially recommended for bended materials and wavy parts.

Overview over fixing of suction cups and suction plates

Requirements:	rigid	articulated	hinged	non-spring loaded	spring loaded
Small parts	x			x	
Stable goods	x			x	
Formed parts		x		x	
Bent parts		x	x		x
Wavy parts		x	x		x
Sensitive surfaces		x	x		x
High acceleration		x			x
Height adjustment					x

x recommended

Please note:

This table only shows a small overview. Please read the advice and safety information in chapter 5 "Fixing Elements". Please contact our Sales Specialists if further questions should appear!

Determination of the right spring:

To determine the right spring the following data is required:

- ✓ **bolt diameter used D:**
results from the used suction cups/plates and the given connection dimensions.
- ✓ **Quantity of suction cups/plates n:**
they determine the proportional force for one spring
- ✓ **Maximum weight of the work piece: F_W**
pertinent for dimensioning the upper spring and thus an even load distribution amongst all suction cups/plates
- ✓ **desired force and own weight on lifting device: F_{AE}**
they determine the proportional force of the lower spring

$$F_{DF-top} = \frac{F_W}{n}$$

$$F_{DF-bottom} = \frac{F_{AE}}{n}$$

F_{DF-top} force of upper spring (N)
 F_W max. weight of work piece (N)
 F_{AE} pressing force and own weight of lifting device(N)
 n quantity of mounted suction cups/ plates

$F_{DF-bottom}$ force of lower spring (N)
 F_W max. weight of work piece (N)
 F_{AE} pressing force and own weight of lifting device(N)
 n quantity of mounted suction cups/ plates

Spring diameter:

The inner diameter of the spring results from the construction of the suction cup/plate. Depending on tappet diameter and type the following inner diameters of the springs result:

Required spring per bolt type				
Diameter	12 mm	16 mm/6-KT-14	20 mm	30 mm
bolt type				
STN-	DF-13-L60	DF-17-L70	DF-21-L80	---
STG-	DF-13-L60	DF-17-L70	DF-21-L80	DF-33-L90
ST-6KT-	---	DF-17-L70	---	---
ST-KPL-	---	---	DF-21-L80	---
ST-KPS-	---	---	DF-21-L80	---
ST-KPT-	---	---	---	DF-33-L90

Please contact our sales specialists for the dimensioning when using the bolt types KPT-30/ 40!

Example for determining the right pressure spring!

Example

For this example we assume a vacuum lifter with the following features:

Carrying capacity: 240 kg $F_W = 2400\text{ N}$
Own weight: 60 kg $F_{AE} = 600\text{ N}$
Suction plates: KGHRL 160
Bolt: STN-16-M12-285
Number of plates: $n = 4$

Determination upper spring

$$F_{DF-top} = \frac{2\,400\text{ N}}{4} = 600\text{ N}$$

Determination lower spring

$$F_{DF-bottom} = \frac{600\text{ N}}{4} = 150\text{ N}$$

When using suspension bolt type STN-16-M12-285 the inner diameter of the spring, according to the table, is $DI = 17$. Corresponding with the „Technical Data“ this results in the following spring sizes:

Upper spring: DF-L70-DI17-DS3,5
Spring force 690 N
max. elasticity 31 mm

Lower spring: DF-L70-DI17-DS2
Spring force 150 N
max. elasticity 49 mm

Please note:

When choosing among the springs it is recommended to always select the spring with the next higher spring force (see example).



Basic Information

The creation of a vacuum is the basic element of every vacuum system. Many vacuum generators are available and each of them has its own characteristics and advantages. Available are

- ✓ Vacuum Pumps
- ✓ Vacuum Blowers
- ✓ Ejectors

Vacuum pumps are again divided into oil-lubricated and oilless pumps.

When the dimensioning of a system has to be considered, it is decisive whether a vacuum tank or a vacuum generator without any further tanks is used.

Advantages of the use of vacuum tanks are:

- increase of safety standards, especially when power failures occur.
- shorter suction times
- smaller vacuum generator necessary, especially with a small switching frequency, which means a reduction of energy and other costs.
- protection of the pump when using in connection with vacuum-controlled motor switching units

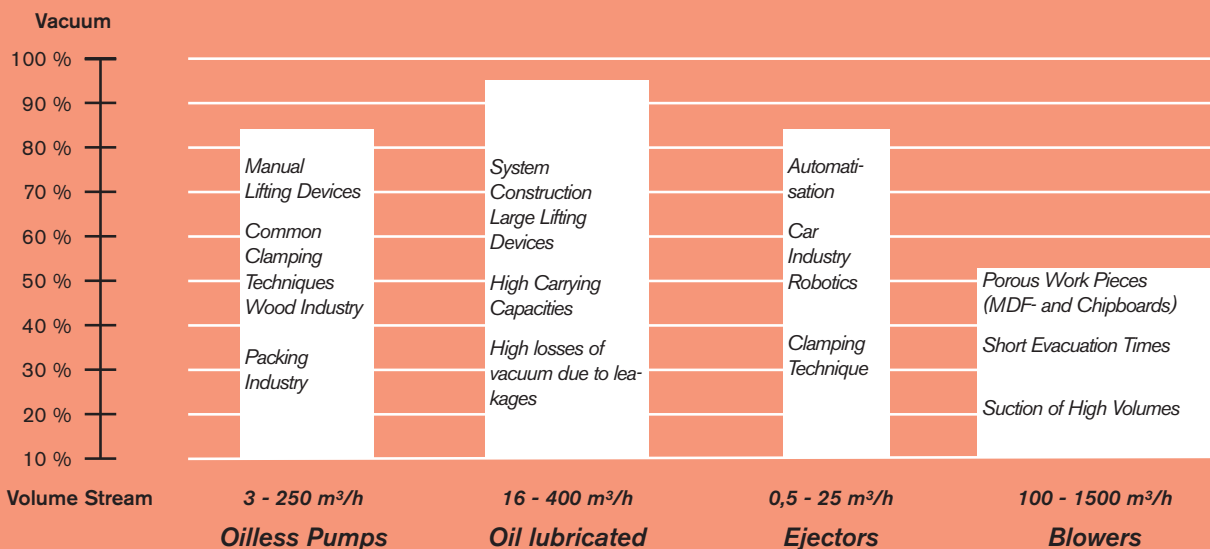
The chart on the right shows a comparison of the various vacuum generators and it enables you to make a quick choice:

Comparing Vacuum Generators

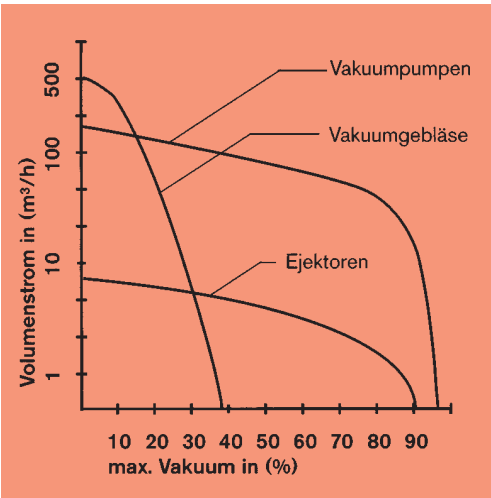
Requirements	Oilless Pumps	Oil Lubricated Pumps	Ejectors	Blower
max. Vacuum	✓✓	✓✓✓	✓✓	✓
max. Volume stream	✓✓	✓✓	✓	✓✓✓
Mounting Position	discretionary	horizontal	discretionary	discretionary
Own Weight	✓✓	✓✓✓	✓	✓✓✓
Evacuation Times	✓✓	✓✓	✓	✓✓✓
Low Noise	✓✓	✓✓✓	✓✓	✓
Maintenance Frequency	✓✓	✓✓✓	✓✓✓	✓✓
Efficiency	✓✓	✓	✓✓	✓

- ✓ partly suitable
- ✓✓ well suitable
- ✓✓✓ very well suitable

Overview of Vacuum Generators and their Field of Usage



What has to be achieved?



It depends on several factors, which vacuum generator is the right one:

- ✓ Which basic way of creating a vacuum is preferred: electronic or pneumatic?
- ✓ How dense is the sealing of the suction cups?
- ✓ Is the work piece dense or porous?
- ✓ Which suction times have to be achieved?
- ✓ Do any requirements (ex-proof regulations, noise regulations, etc.) have to be met?
- ✓ Which measurements or other factors have to be considered for mounting the unit?

Use of a vacuum tank

When using a vacuum tank, it should be dimensioned in such a way, that the overall vacuum (primary and secondary vacuum) does not fall below 60 % during sucking. This guarantees a satisfying operational vacuum after the suction process.

The dimensioning of the pump-size depends on the needed cycle. Within this cycle the vacuum pump has to increase the vacuum from 60 % to 80 %. This leads to the following pump-size:

$$V_S = 3 \times S \times V_R$$

$$\dot{V} = 3,25 \times S \times \frac{V_S}{t}$$

V_S	(l)	Volume of the vacuum tank
V_R	(l)	Volume to be evacuated
S		Safety factor, advised 2.0
t	(s)	Time between 2 cycles ($t = 60 \text{ s} / \text{number of cycles}$)
\dot{V}	(m³/h)	Volume stream of the pump

Please note:

When choosing among different vacuum generators, always take the next higher production series in comparison to the calculated figure into consideration, in order to compensate leakage losses which were not considered.

Dimensioning of control valves

To control the vacuum mainly 2/2- and 3/2-way valves are used. It is important to choose the right type and, moreover, the right size.

Use of 2/2-way valves:
 individual suction plates can be switched on and off when various transport goods have to be transported.

Use of 3/2-way valves:
 mainly to control "suction" and "release". The suction plate is ventilated by outside air when "release" is chosen.

The ventilation process is often underestimated. The nominal diameter of the valves should be at least as big as the exit of the used vacuum pump, in order to get short ventilation times.

First of all, the size of the valves depends on the suction resp. ventilation times which is required. With the vacuum system's rest volume and the suction and ventilation times known, the necessary flow for the valve can be calculated by using the table shown below. All valves come along with their flow-value, so a suitable valve can be chosen..

The formula and the chart shown below support the determination of suitable valves!

$$\dot{V} = 3,6 \times \frac{V_R}{n \times t}$$

- V_R (l) Volume of the vacuum circuit (l)
- n Number of valves
- t (s) Evacuation time
- \dot{V} (m³/h) Flow of the valve (l/min)

Chart for vacuum valves:

After determining the rest volume (sum of distribution line, suction cup, suction plate volume and other elements), the necessary flow of the valve can be determined over the evacuation, resp. ventilation time.

Example:

The rest volume of the vacuum circuit was calculated and equals 4.8 l. The necessary suction time cannot be more than 0.5 s.

Using the chart on the right, the following can be calculated:

rest volume 5 l
 time 0.5 s
 a flow of 36 m³/h

You can choose among the different valves in chapter 7 "Control Valves and Measuring Units".

Necessary flow (m³/h) of the valves with certain rest volume (l) and ventilation times (s)

Restvol. (l)	0,1 s	0,25 s	0,5 s	1,0 s	1,5 s	2,0 s
1	36	14	7	4	2	1
2	72	29	14	7	5	4
3	108	43	22	11	7	5
4	144	58	29	14	10	7
5	180	72	36	18	12	9
6	216	86	43	22	14	11
7	252	101	50	25	17	13
8	288	115	58	29	19	14
9	324	130	65	32	22	16
10	360	144	72	36	24	18
15	540	216	108	54	36	27
20	720	288	144	72	48	36

Please note:

Since the effect of post-suction (especially for suction plates with a large volume and long sealing rings) can occur during ventilation, it is advised to choose bigger valves than determined.

How is the vacuum supervised?

Choice of vacuum measuring units

In order to make sure that the operational vacuum is always sufficient enough, vacuum switches and vacuum gauges (control gauges) are installed in every vacuum system. While vacuum gauges only serve for optical checks, vacuum switches can be used for checks as well as a control instrument.

There are cases in which the vacuum generator can be shut off for some time, for example when working with dense pieces, or when not using often enough. This feature takes care of the vacuum pump and at the same time reduces costs. Vacuum switches are divided into mechanical and electronic features.

MECHANICAL VACUUM SWITCHES

are mainly used in the field of vacuum transport and handling-engineering. Features as safety, durability and robustness are especially important. Mechanical vacuum switches exist in two different versions: with installed hysteresis and with a freely adjustable switch (preadjusted to 60 % resp. 80 %- vacuum).

ELECTRONIC VACUUM SWITCHES

are mainly used in situations, where it depends on precise switching, shortest switch circuits and on high and precise repetition. Further advantages of electronic vacuum switches are their small size, as well as the stepless and very precise adjustment possibilities of switch and hysteresis.

Brief overview over vacuum switches

Requirements	mechanical	elektrical
Measuring precision	✓✓	✓✓✓
Repetition precision	✓	✓✓✓
Size and weight	✓	✓✓✓
Lifespan	✓✓✓	✓✓
Robustness	✓✓✓	✓✓
Measuring area vacuum	5 - 100 %	5 - 100 %
Temperature range	0 bis + 50° C	0 bis + 50°C
Class	IP 55	IP 65

- ✓ medium
- ✓✓ good
- ✓✓✓ very good

Advice:

You will find further information about the various vacuum switches in chapter 7 "Control Valves and Measuring Units"!

Filters and Connection Elements

The right dimensioning and especially the steady maintenance of filters and connection elements is an important feature for the optimal functioning and operability.

This is why you should definitely consider choosing elements, which are not too small. We recommend to choose the diameter of filters and connection elements at least as big as the exits of the vacuum generator, resp. the valves.

Hose Connections

In order to prevent unnecessary leakage losses and to give the highest possible safety, hose connections have to be secured with nuts or with hose clips. When dimensioning vacuum hoses in narrow rooms, it also has to be considered that you do not fall below the minimal bending radius. Otherwise the hose might be bent and destroyed.

Flow Resistance in Vacuum Circuits

When setting up distributor lines, you should consider that the flow resistance within the distributor system is not too big.

That means:

- ✓ *Big dimensioning of cross sections*
- ✓ *Keep distributor lines short, don't produce unnecessary lengths*
- ✓ *Choose straight ways, do not use any unnecessary angles, exits or other distributor pieces*

Installation of Filters and Maintenance

- ✓ *Check, clean and change filters regularly!*
- ✓ *When cleaning the filters with air pressure, they should always be blown against the way of the stream!*
- ✓ *When installing vacuum filters, the clean air nozzle should always be on top!*
- ✓ *When changing the filter cartridges, make sure that no dirt particles get inside the tube!*

Please note:

FEZER offers you a variety of functional and safe standard vacuum distribution elements. Please pay attention to the various products!

VACUUM-COMPONENT DIMENSIONING CHECKLIST

The easy way to a fast solution!

Company:.....
 Contact:
 Street:
 Zip Code/ Place:
 Phone:..... Fax:
 e-mail:

Many influential factors have to be considered when dimensioning a vacuum system. The following checklist offers you a list of basic information about the dimensioning of a vacuum system:
 Feel free to contact our Sales Specialists for difficult questions! They will be there for you!

Phone no.: (07 11) 3 60 09 - 0
Fax-No: (07 11) 3 60 09 - 34

- ✓ **What material do you use?**
- ✓ **Dimensions**
- ✓ **Surface**
- ✓ **Suction capability**
- ✓ **Extras**

Metal Wood Glass Plastic Carton/Paper
 Others:

	<i>min:</i>	<i>max:</i>	<i>min:</i>	<i>max:</i>
Length (mm):	Width (mm):
Thickness (mm):	Weight (kgs):

smooth rough structured dry wet/damp/oily
 dense slightly porous very porous suction try-out necessary
 Temperature:..... (°C) Others:

- ✓ **Transportation of work piece**

horizontally vertically swivel 90° turn 180°
 automatically cycle time:.....(s) max. acc. forces: (m/s²)

- ✓ **Vacuum generator**

oilless oil-lubricated blower pneumatically (Ejektor)
 230/400V, 50Hz 230V, 50 Hz 24V= V,Hz

- ✓ **Vacuum control**

manual electric 24V= 230V, 50Hz
 Others:

- ✓ **Supervision of vacuum**

optical (vacuum gauge) mechanical (VSM) electronical (VSE) digital (VSD)

- ✓ **Additional Information**

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