Vacuum Technology

Introduction

Basic terminology

What is Vacuum?

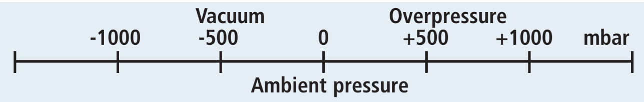
Vacuum is the term for air pressures which lie below normal atmospheric pressure. The vacuum values used depend on the specific application. For vacuum handling, relatively low vacuum values are sufficient.

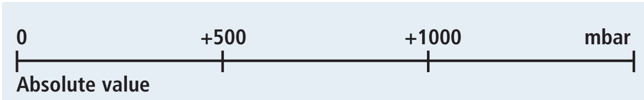
These values lie in the range between 1 mbar and atmospheric pressure (1013 mbar).

How are vacuum values specified?

Specification as a relative value
In the sector of vacuum handling, the vacuum is specified in the form of a relative value, i.e. referred to the ambient pressure. Such vacuum values always have a negative sign, because the ambient pressure is used as the reference point, which is defined as 0 mbar.

Specification as an absolute value
Scientists specify a vacuum in the form of an absolute value, using the absolute vacuum which exists, for example, in space as the reference point. These vacuum values are therefore always positive. The following table shows the relationship between relative and absolute values for various vacuum values.





The following table shows some comparisons between absolute and relative pressure values.

Vacuum/pressure conversion table								
Absolute pressure [mbar]	**Relative vacuum**	**bar**	**N/cm²**	**kPa**	**atm, kp/cm²**	**mm H_2O**	**Torr; mm Hg**	**in Hg**
900	10%	-0.101	-1.01	-10.1	-0.103	-1030	-76	-3
800	20%	-0.203	-2.03	-20.3	-0.207	-2070	-152	-6
700	30%	-0.304	-3.04	-30,4	-0.31	-3100	-228	-9
600	40%	-0.405	-4.05	-40.5	-0.413	-4130	-304	-12
500	50%	-0.507	-5.07	-50.7	-0.517	-5170	-380	-15
400	60%	-0.608	-6.08	-60.8	-0.62	-6200	-456	-18
300	70%	-0.709	-7.09	-70.9	-0.723	-7230	-532	-21
200	80%	-0.811	-8.11	-81.1	-0.827	-8270	-608	-24
100	90%	-0.912	-9.12	-91.2	-0.93	-9300	-684	-27

Which units of measurement are used?

Of the many units of measurement which exist for pressure, vacuum technology generally uses the units Pascal [Pa], Kilopascal [kPa], Bar [bar] and Millibar [mbar]. Conversion between Pascal and Bar is easy.

0.001 bar = 0.1 kPa = 1 mbar = 100 Pa

All values in the Schmalz Vacuum Technology catalogue are specified in bar, mbar or %. The specification as a percentage is typically used to show the relative performance of a vacuum generator, since it is unaffected by changes in the actual ambient pressure. Internationally, various other units of measurement are used, and some of these are shown in the following table.

Vacuum/pressure conversion table							
	bar	**N/cm²**	**kPa**	**atm, kp/cm²**	**mm H_2O**	**Torr; mm Hg**	**in Hg**
bar	1	10	100	1.0197	10197	750.06	29.54
N/cm²	0.1	1	10	0.1019	1019.7	75.006	2.954
kPa	0.01	0.1	1	0.0102	101.97	7.5006	0.2954
atm, kp/cm²	0.9807	9.807	98.07	1	10332	735.56	28.97
mm H_2O	0.0001	0.001	0.01	0.0001	1	0.074	0.003
Torr; mm Hg	0.00133	0.01333	0.1333	0.00136	13.6	1	0.0394
in Hg	0.0338	0.3385	3.885	0.03446	345.4	25.25	1

Energy required for vacuum generation

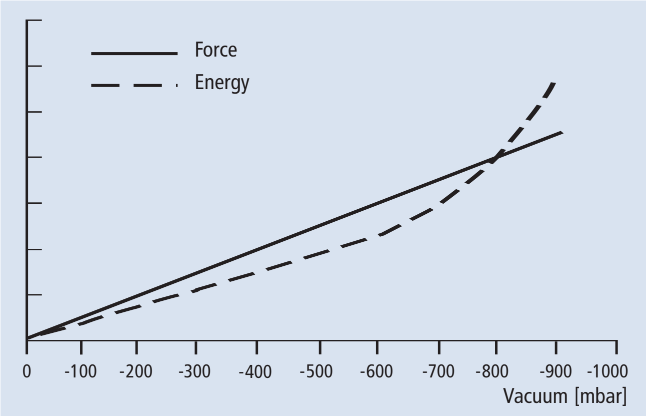
The energy required for generation of a vacuum increases far more quickly than the vacuum value which is achieved. Increasing the vacuum from -600 mbar to -900 mbar, for example, increases the holding force by a factor of 1.5, but the evacuation time and the energy needed to achieve this vacuum value increases by a factor of 3!
It is thus clear that the maximum achievable vacuum value is not the optimum value for vacuum handling tasks.

Commonly used value:

- **for air-tight surfaces**
  (such as metal, plastics, etc.)
  60 % to 80 % vacuum (-600 to -800 mbar)

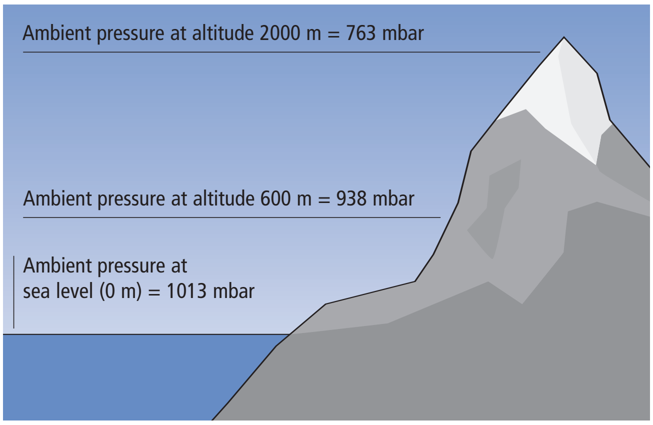
- **for porous materials**
  (such as cardboard, chipboard and MDF sheets, etc.)
  20 % to 40 % vacuum (-200 to -400 mbar); in this vacuum range, the necessary holding force is generated by increasing the suction capacity of the vacuum generator and by increasing the effective area of the vacuum grippers.

Important:
In the catalogue, the holding forces of the vacuum grippers are always specified for the most economical vacuum level of -600 mbar!



The atmosphere and its effects on vacuum technology

The (ambient) air pressure depends on the altitude of the place where it is measured. As can be seen from the following illustration, the air pressure at sea level is 1013 mbar. At an altitude of 600 m (at the factory of J. Schmalz GmbH in Glatten), the air pressure is only 938 mbar. At an altitude of 2000 m it drops to only 763 mbar.



This pressure drop naturally affects the use of vacuum. As the air pressure drops with increasing altitude, the maximum pressure difference which can be achieved also drops, which means that the maximum possible holding force of a vacuum gripper is also lower. For each 100 m height increase, the air pressure drops by about 12.5 mbar. A vacuum generator which achieves a vacuum of 80 % (-800 mbar) at sea level can thus generate a vacuum of only -610 mbar (80 % of the ambient air pressure of 763 mbar) at an altitude of 2000 m. The maximum possible holding force of a vacuum gripper decreases proportionally. Operation at sea level is thus the ideal case.

Important:
All specifications in the Schmalz Vacuum Technology catalogue are based on an ambient pressure of 1000 mbar and an ambient temperature of 20 °C.

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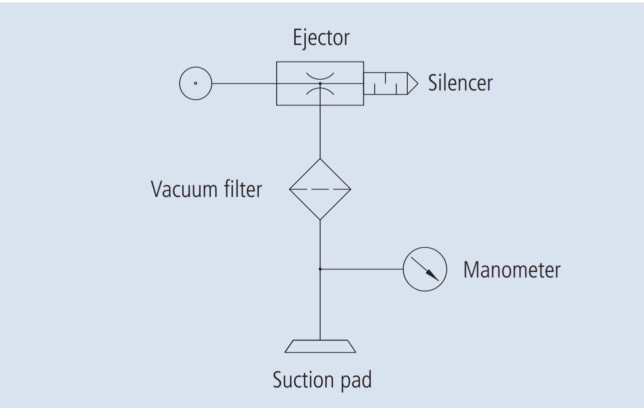
Basic terminology

Technical symbols

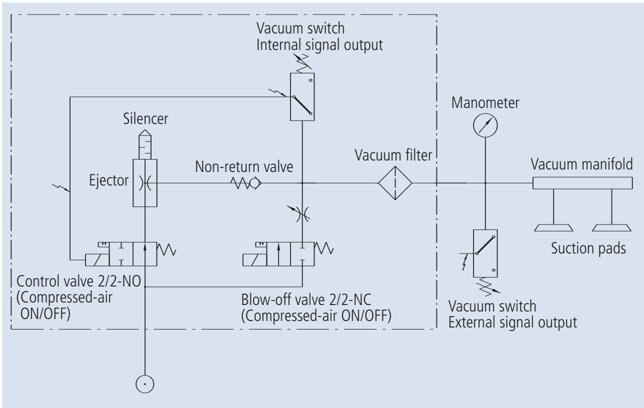
Vacuum technology also makes use of circuit diagrams and function diagrams, in which symbols for components and assemblies are used. The following overview shows the most important and commonly used symbols for the vacuum components produced by Schmalz.

Valve (general)	Vacuum/pressure switch	Special suction pad	Ejector, single-stage
Ball cock, two-way	Check valve	Flat suction pad with single lip	Ejector, multi-stage
Ball cock, three-way		Flat suction pad with double lip	
Manual slide valve, three-way	Pressure-limiter valve	Flat suction pad with sealing profile	Silencer
Solenoid valve, 3/2-way	Non-return valve	Bellows suction pad	Vacuum blower
Solenoid valve, 3/2-way, pneumatic pilot operation		Spring plunger	Vacuum pump
	Sensing valve	Flexolink, ball joint	Vacuum regulator
Filter	Flow resistor	Sealing cord	Hose
Manometer		Adapter nipple	Reservoir

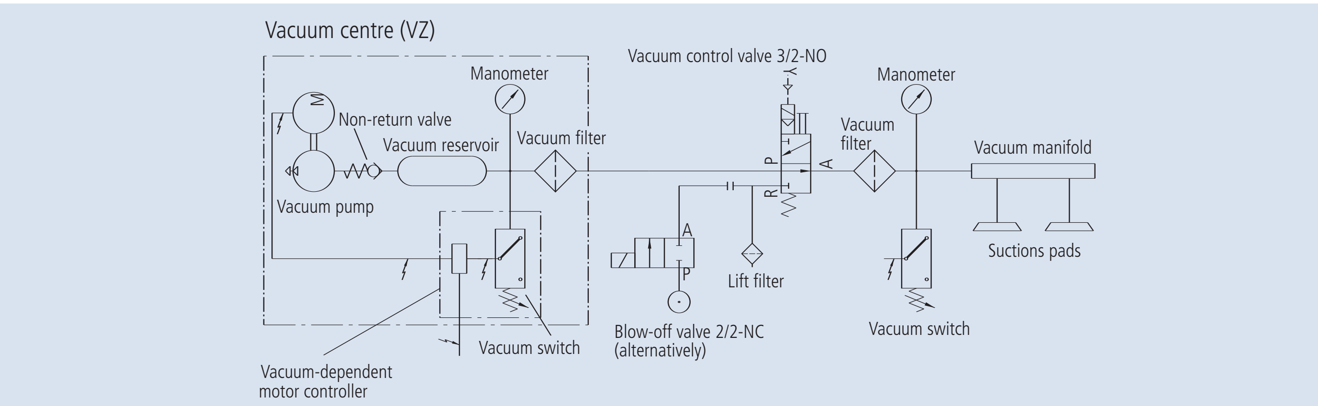
Circuit diagrams for all relevant vacuum components can be found in the operating instructions in the area "Service" at www.schmalz.com.
Typical vacuum circuit diagrams for various handling solutions:



Example: Vacuum circuit with a basic ejector



Example: Vacuum circuit with a regulated compact ejector



Example: Vacuum circuit with vacuum center