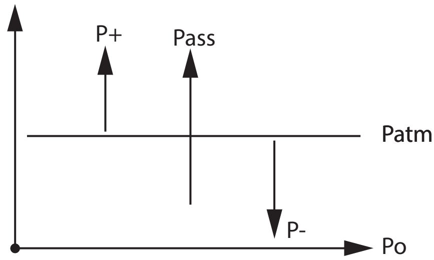
12 Vacuum components

Introduction to the vacuum

The term "vacuum" refers to the physical situation that occurs in an environment where the gaseous pressure is llower than atmospheric pressure.

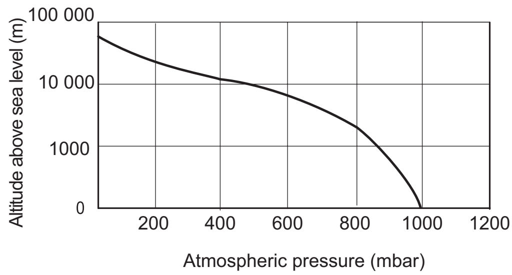
Positive pressures are defined as all pressures with values higher than atmospheric pressure; all those with lower values are negative.

P_{ATM} = Atmospheric pressure
P_O = Zero pressure, absolute vacuum
P_+ = Positive relative pressure
P_{ASS} = Absolute pressure
P_- = Negative relative pressure



Pressure dimensionally represents a force per unit of surface, its unit of measurement is the Pascal (Pa symbol) which represents the pressure obtained when a force of 1 N (Newton) is exerted on the unit surface of 1 m^2.
Therefore, the result is:
Pascal = Newton/metro² ==> Pa = N/m²

It is common for some applications to use alternative units of measurement such as the millibar (mbar) equal to 100 Pa and the Torr or mmHg, which is equal to 133.322 Pa; the latter is mainly used for measurements in the medical field (blood pressure) although it is not used as a unit of measurement in the International System (IS).
Atmospheric pressure, measured in mbar, decreases as altitude varies (measured in m), as better specified in the diagram below.



Comparison between atmospheric pressure values measured at sea level with the same values measured at different altitudes.

mmHg	mbar	Altitude m	-60 kPa	-75 kPa	-85 kPa	-90 kPa	-99 kPa
760	1013.25	0	60.0	75.0	85.0	90.0	99.0
750	999.9	111	58.7	73.7	83.7	88.7	97.7
740	986.6	200	57.3	72.3	82.3	87.3	96.3
730	973.3	275	56.0	71.0	81.0	86.0	95.0
720	959.9	467	54.7	69.7	79.7	84.7	93.7
710	946.6	545	53.3	68.3	78.3	83.3	92.3
700	933.3	655	52.0	67.0	77.0	82.0	91.0
690	919.9	778	50.7	65.7	75.7	80.7	89.7
571	894.6	1000	48.7	63.1	73.1	78.1	87.1
593	790.6	2000	37.7	52.7	62.7	67.7	76.7

Lifting force

One of the reference parameters for selecting vacuum cups and reported in the tables is the lifting force (expressed in kg), unique for each type of vacuum cup and calculated with the following formula:

$$F = \frac{SxP}{\eta}$$

Where:
F = Lifting force expressed in Kg;
S = Gripping surface of the vacuum cup, expressed in cm^2;
P = Force exerted by atmospheric pressure, depending on the degree of vacuum, expressed in Kg/cm^2;
η = Safety coefficient.

Safety coefficient

The internal geometric volume of the vacuum cup and represents the volume to be added to the entire distribution circuit for the calculation of the evacuation time, especially if multiple vacuum cups are used.

The values shown have been obtained taking into consideration:
P = 0.75 Kg/cm^2: value developed by a vacuum level of approximately 250 mbar abs. (-75 KPa).
η = 3: safety coefficient, valid when the gripping surface of the vacuum cups is horizontal, the surface is smooth and waterproof and the acceleration or deceleration of the moving load is less than 10 m/s^2.

Volume

The internal geometric volume of the vacuum cup and represents the volume to be added to the entire distribution circuit for the calculation of the evacuation time, especially if multiple vacuum cups are used.
In practice this is the quantity of air to be "emptied" and which must be added to the volume of the entire vacuum distribution circuit to calculate the evacuation time; a parameter used to determine the suction flow capacity of the vacuum generator.
This parameter takes on particular relevance when the sizing of the generator is related to the handling of products that generate a perfect seal with the lower surface of the vacuum cups, for example metal sheets or glass sheets.
In all situations in which the material to be handled is potentially "breathable", it is recommended to carry out grip tests with the single vacuum cup, in order to determine the correct suction flow rate.

Parameters for the choice of vacuum cups

To select the type of compound most suitable for each application and type of product, the following parameters should be considered:
- the weight and dimensions of the load;
- the intensity of the work cycles and their severity;
- the roughness of the surface of the load to be lifted and its temperature;
- the presence of oils, solvents, chemical substances, or other corrosive elements on the gripping surface;
- environmental conditions: presence of particular atmospheric agents and temperatures for use;
- if the load surface must not have marks and fingerprints on the gripping surface;
- if the surface of the load must grip, it is necessary to dissipate electrostatic charges.

General features of the rubber compounds

Material	International acronym	Elesa name	Features	Colour	Operating temperature	Hardness	Chemical resistance	Applications
Nitrile or oil-proof rubber	NBR	A	Highly resistant to oils, heat, and ageing. Low permanent deformation. Good impermeability to air and gases. If left untreated, low resistance to ozone. Poor dielectric properties. Low resilience	Black	From -40 to +130°C	60 ÷ 70° Shore A	Resistance to mineral and vegetable oils, hydrocarbons, gas, water, and steam.	Excellent mechanical characteristics allow these vacuum cups to handle heavy loads and resist tears, crushing, and blows. They are suitable for gripping metal sheets, glass, and loads with smooth surfaces.
Natural rubber	NR	N	Excellent elasticity and resistance to wear, cuts, and tears.	Black	From -70 to +80°C	45 ÷ 50° Shore A	Moderate resistance to sea water and medium concentration acids	The flexibility of the compound allows grip on rough and irregular surfaces. They are suitable for wood, cardboard, marble, brick, glass, and plastic.
Silicone	VMQ	S	Excellent performance at high and low temperatures. Conductive compound.	Neutral white	From -50 to +300°C	40 ÷ 45° Shore A	Excellent resistance to chlorinated substances, solvents, ozone, oxygen, and UV rays.	They are widely used in the food packaging industry, in the electronic and pharmaceutical (medical) sectors where in general the surface temperature of the product is a fundamental parameter (very high temperatures or below 0°C).
Yellow natural rubber	NR	NG	Excellent elasticity and resistance to wear, cuts, and tears.	Natural yellow Red	From -50 to +70°C	40 ÷ 45° Shore A	Moderate resistance to sea water and medium concentration acids.	The greater flexibility of the compound allows grip on rough and irregular surfaces. They are recommended for gripping paper, cardboard, plastic, plastic films for packaging, etc.
Hydrogenated nitrile rubber	HNBR	B	Excellent resistance to wear, ageing, oils containing chlorine, greases, and petrol. Low permanent deformation. It does not leave streaks on the gripping surfaces of the vacuum cups.	Red	From -40 to +170°C	60 ÷ 75° Shore A	Resistance to mineral and vegetable oils, chlorine, hydrocarbons, gas, water, and steam.	The high resistance to deformation allows these vacuum cups to handle heavy loads and resist strong stress such as tears, crushing, and blows.