Vacuum Components/selection

Must read before use

Vacuum Element Selection and Configuration

1. Selection and Configuration of Suction Cups

The questions that need to be determined in the selection	explain
What is the weight and size of the workpiece?	An important basis for calculating suction and number of suction cups (see suction cup diameter and weight for details)
How to move (translate, rotate, flip)?	An important basis for calculating suction and system design
How smooth is the surface of the workpiece (rough, grid, smooth)?	Select the type of suction cup (material, shape, size)
How clean is the surface of the workpiece? Is there any pollutant (dust, particulate dust, etc.)?	Determine the size and design of the suction cup is an important basis for pollutant filter
How much precision positioning is required for the pick-up or placement of the workpiece?	Determine the structure, type and shape of the suction cup, and select appropriate hardware

There are many factors to be considered in vacuum adsorption. Please describe the selection in detail when selecting the model. The selected product calculated by experience cannot guarantee 100% usability. Therefore, it is best to do physical adsorption test if conditions permit. If you need physical adsorption test, please contact us.

Calculate the weight of the workpiece

Calculating the weight of the captured workpiece is the basis of all calculations.
We can calculate it using the following formula:

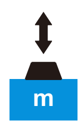
$$m = L \times B \times H \times \rho$$

m: Weight (kg)
L: Length (m)
B: Width (m)
H: height (m)
ρ: density (kg/m³)

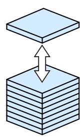
Determine the theoretical suction required for the suction cup

To calculate suction force, the calculated weight of the workpiece must be used. Additionally, the vacuum cup must withstand forces generated by acceleration. For flat, airtight workpieces, the minimum safety factor is 1.5. For uneven, permeable, or rough-surfaced workpieces, the safety factor must be ≥2.0. If acceleration and friction coefficients are unknown or cannot be accurately determined, the safety factor for horizontal lifting must be ≥4.0. For workpieces requiring rotation or flipping, it is recommended to select a safety factor of 8 or higher to accommodate the forces needed during flipping processes.

Load condition 1-The vacuum cup is lifted horizontally under vertical load force



Leveling jacks

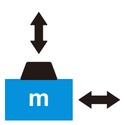


Vertical lifting of workpiece
(No lateral movement)

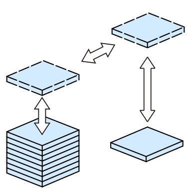
$$F_m = m \times (g + a) \times t$$

F_m: Theoretical suction (N)
m: Weight (kg)
g: Weight acceleration (9.81 m/s^2)
a: System acceleration (m/s ^{2})
t: Safety factor ≥ 1.5
≥ 2.0 (workpiece with uneven or breathable material and rough surface)

Load condition 2-A vacuum cup is lifted horizontally, subject to both horizontal and vertical load forces



Leveling jacks



The workpiece is vertically lifted and horizontally moved

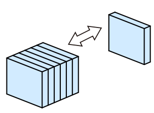
$$F_m = m \times (g + a/\mu) \times t$$

F_m: Theoretical suction (N)
m: Weight (kg)
g: Weight acceleration (9.81 m/s ^{2})
a: System acceleration (m/s ^{2})
t: Safety factor ≥ 1.5
≥ 2.0 (for workpieces with non-uniform or permeable material and rough surface)
μ: Friction coefficient = 0.1 Oily surfaces
= 0.2~0.3 moist surface
= 0.5 Wood, metal, glass, stone surfaces
= 0.6 Rough surfaces

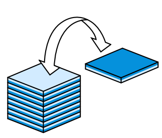
The above friction coefficient is only the theoretical value, the actual friction coefficient of the workpiece needs to be determined by experiment.

Load condition 3-Vertical lift with vacuum suction, subjected to vertical load force

Vertical hangers



Workpiece horizontal movement



Workpiece flipping

$$F_m = (m/\mu) \times (g + a) \times t$$

F_m: Theoretical suction (N)
m: Weight (kg)
g: Weight acceleration (9.81 m/s^2)
a: System acceleration (m/s ^{2})
t: Safety factor ≥ 2.0
≥ 4.0 (for workpieces with non-uniform or permeable materials and rough surfaces) μ: Friction coefficient = 0.1 Oily surface
= 0.2 ~0. 3 moist surface
= 0. 5 Wood, metal, glass, stone surfaces
= 0. 6 Rough surfaces

The above friction coefficient is only the theoretical value, the actual friction coefficient of the workpiece needs to be determined by experiment.

Vacuum Components/selection

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Vacuum suction selection

The calculated theoretical suction force is equivalent to the suction required for safe handling of the workpiece.

$$F_s = F_m / n$$

F_s: suction force (N)
F_m: Theoretical suction (N)
n: Number of suction cups (pcs)

Calculation of suction force and diameter of a single suction cup

The theoretical suction force (P) is calculated as P = (Vacuum Degree) × S (Effective Suction Area) × 0.1. However, practical applications require consideration of multiple factors including the suction cup's size and shape, as well as the workpiece's surface finish, hardness, and deformation characteristics. Therefore, when acceleration or friction coefficients are unknown or cannot be precisely determined, we recommend maintaining a safety factor (t) ≥4. In systems utilizing vacuum generators, the vacuum pressure typically ranges around-60 kPa. For workpieces with permeable surfaces or roughness that facilitates air infiltration, atmospheric intake may cause vacuum pressure drops. Such cases require validation through suction tests to ensure compliance.

horizontal lifting

Vertical hangers

$$F_s = P \times S \times 0.1 \times \frac{1}{t}$$

F_s: suction force (N)
P: vacuum (kPa)
S: Effective adsorption area of suction cup (cm²)
n: Number of suctioncups
t: Safety coefficient
horizontal lifting ≥ 4
vertical lifting ≥ 8

The above safety factor is under the condition that the acceleration and friction coefficient are unknown or cannot be accurately determined.

2 Vacuum Generator Selection and Configuration

The questions that need to be determined in selection	explain
How is the surface finish of the workpiece (breathability workpiece, airtight workpiece)?	The important basis for choosing the type of vacuum generator can be calculated by formula or test method to obtain the leakage.
How much vacuum is required?	An important basis for calculating suction and system design
How long is the work cycle?	It is an important basis for calculating the response time of adsorption workpiece
What is the required emission?	See the performance of the vacuum generator (l/min)
What is the cycle time of the entire system?	An important basis for determining the size of the suction cup

For standard adsorption workpieces without leakage, the standard reference of nozzle diameter for one suction cup is shown in the table below.

Pipette diameter	Vacuum generator nozzle diameter
ø80 or less	ø0.5
ø below 150	ø1.0
ø below 200	ø1.5
ø340 and below	ø2.0

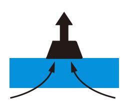
When selecting a vacuum generator nozzle diameter for standard adsorption workpieces with leakage, increase the diameter by one size grade compared to the standard. If feasible, determine the required nozzle diameter using experimental methods to measure leakage volume. When employing multiple suction cups, also increase the nozzle diameter by one size grade beyond the standard specification.

a Leakage Rate During Workpiece Adsorption

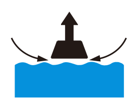
Official calculation method: When the suction cup adsorbs a workpiece with air permeability or rough surface, it will suck in the atmosphere, so that the vacuum degree inside the suction cup can not reach the necessary vacuum degree for the workpiece. When adsorbing such a workpiece, the leakage amount of the workpiece should be calculated to select the size of the vacuum generator or vacuum switching valve.

$$Q_L = 11.1 \times S_L$$

Q_L: Leakage rate (l/min)
S_L: the gap between the workpiece and the suction cup or the effective cross-sectional area of the opening of the workpiece (mm²)



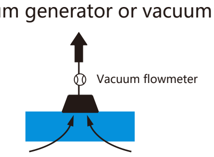
Breathable workpiece



Surface rough workpiece

Experimental method: The test circuit is shown in the figure on the right. It is composed of a vacuum generator or vacuum pump, a suction cup, a workpiece and a vacuum flowmeter.The value of the vacuum flowmeter is the leakage amount Q_L.

Vacuum generator or vacuum pump



Breathable workpiece

Vacuum Components/selection

Must read before use

b Adsorption workpiece response time

In the case of transporting workpieces by suction cup, the time from the action of the supply valve (or vacuum switching valve) to the time when the vacuum in the suction cup reaches the vacuum degree necessary for adsorption is called the adsorption response time. The adsorption response time can be calculated by the following formula.

Adsorption response time $T_1 = \dfrac{3.14 \times D^2 \times L \times 60}{4000 \times (Q + Q_L)}$

Adsorption response time $T_2 = 3 \times T_1$

Pv: Final vacuum (kPa)
T_1: Arrival time of 63% of the final vacuum Pv (s)
T_2: Arrival time of 95% of the final vacuum Pv (s)
Q: Average inhalation flow rate (l/min)
Q_L: Leakage (no leakage = 0) (l/min)
D: Inner diameter of pipe (mm)
L: piping from vacuum generator or switching valve to suction cup length (m)

Find the average inhalation flow rate Q:
a. Vacuum generator applications
Q = (1/2 ~ 1/3) x maximum suction flow rate of vacuum generator (l/min)
b. Vacuum pump applications
Q = (1/2 ~ 1/3) x 11.1 x effective cross-sectional area of the switching valve (mm^2)

c The size of the vacuum generator and the vacuum switching valve is determined according to the maximum vacuum suction flow

The maximum vacuum suction flow rate of the vacuum generator is Q_{max} = (2~3)xQ+Q_L

* Select a vacuum generator with maximum vacuum suction flow rate>Q_{max} .

Effective cross-sectional area of vacuum switching valve $S = \dfrac{Q_{max}}{11.1}$

* Select a vacuum switching valve with an effective cross-sectional area greater than S.

Q_{max}: maximum vacuum suction flow rate (l/min)
Q: Average inhalation flow rate (l/min)
Q_L: Leakage (no leakage = 0) (l/min)
S: effective cross-sectional area of the switching valve (mm^2)

3 Selection of Supply Valve

The solenoid valve with an effective cross-sectional area that can fully meet the air consumption of the vacuum generator should be selected. The standard for selection is that the effective cross-sectional area of the supply valve is more than three times the nozzle diameter of the vacuum generator. The standard is shown in the following table.

Vacuum generator nozzle diameter	Effective cross-sectional area of the gas supply valve (mm^2)
ø0.5 ~ ø1.0	More than 3 times
ø1.3 ~ ø1.5	More than 7 times
ø1.8 ~ ø2.0	More than 12 times
ø2.5	More than 18 times
ø3.0	25 times more

4 Air Compressor Selection and Configuration

A compressor with a capacity that can steadily supply the air consumption of the vacuum generator should be selected.

$$W = 0.153 \times t \times Q$$

W: Equivalent power of air compressor (W)
t: Total working time of vacuum generator per minute (s)
Q: Air consumption of vacuum generator (l/min)

Example calculation:

Use two vacuum generators CV-10-R, use pressure 0.5MPa, vacuum generator working time 10 seconds, stop time 15 seconds.

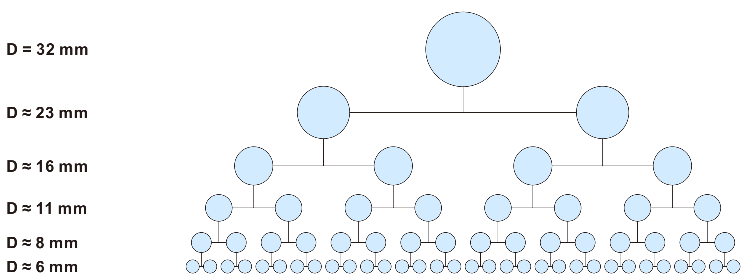
The vacuum generator runs for t = 30s per minute

Vacuum generator performance table check air consumption: 44 (l/min) Q= 44 x 2=88 (l/min)

The equivalent power of the air compressor is W =0.153 x 30 x 88 =403.92(W)

5 Selection of Diverter Hose Diameter

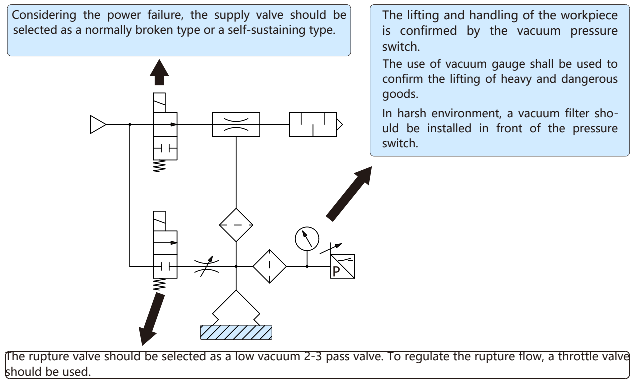
A hose with an inner diameter of 32mm has the same internal flow as 32 hoses with an inner diameter of 6mm or two hoses with an inner diameter of 23mm.

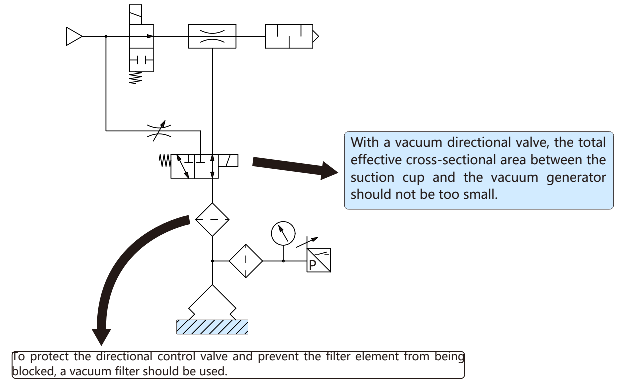


Vacuum Suction Cup Usage Precautions

Must read before use

Attention in the Selection of Vacuum Components

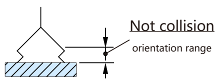




Vacuum Suction Usage Notes

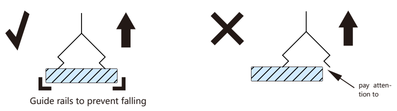
- **The shock of the suction pump**

When the suction cup contacts the workpiece, avoid excessive force or impact to prevent deformation, cracking, and wear that could shorten its lifespan. The ribs should gently contact the workpiece within the deformation range of the suction cup's side edge. This is especially important for small suction cups where precise positioning must be ensured.

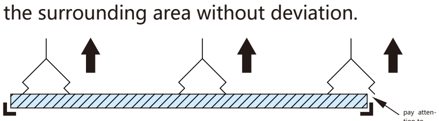


- **Keep the suction cup and the workpiece in balance**

The suction area of the suction cup should not be larger than the surface of the workpiece to avoid leakage and unstable suction.



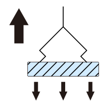
In the case of large areas of plate objects transported by multiple suction cups, a good balance should be ensured when the suction cups are arranged. Special attention should be paid to the positioning of the suction cups in the surrounding area without deviation.



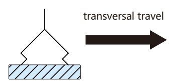
When necessary, auxiliary parts can be set to prevent the workpiece from falling off. For example, guide rails can be set to prevent falling.

- **Keep the suction cup and the workpiece in balance**

In addition to the weight of the workpiece, the inertial force and wind resistance caused by the acceleration of motion should be considered when the workpiece rises.

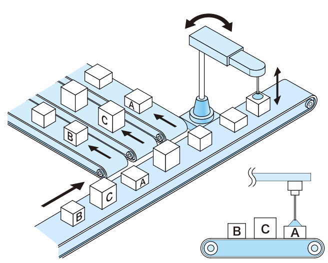


In the case of horizontal lifting, when moving horizontally, the workpiece will be offset due to the difference in the magnitude of acceleration and the friction coefficient between the suction cup and the workpiece. The acceleration of horizontal movement should be reduced as far as possible.



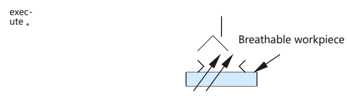
- **Where the height of the workpiece is inconsistent**

Suction cups and workpieces that cannot be positioned in cases where the workpiece is highly inconsistent should be used with spring buffers. Buffer brackets that are not reversible can be used in cases where orientation is required.



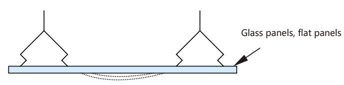
- **For ventilated workpieces and perforated workpieces**

When working with porous materials or breathable materials like paper that get inflated during suction, it's essential to use a sufficiently small suction cup. Additionally, in scenarios with significant air leakage, lower suction force requires increasing the vacuum generator's or vacuum pump's suction capacity, while also expanding the effective cross-sectional area of the piping system.



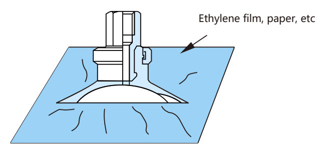
- **Tablet workpiece applications**

In the case of glass plates and plates with large suction area, a larger wind resistance is added. Due to the impact, waves will appear, so the size and reasonable configuration of the suction cup should be considered.



- **Suction of soft workpieces**

When soft workpieces such as ethylene film and paper sheet are lifted by suction, the vacuum pressure will cause deformation or creasing of the workpiece. Small suction cup and ribbed suction cup should be used and the vacuum degree should not be too high.



Vacuum Suction Cup Replacement Period and Other Problems

Vacuum cups are consumables and should be replaced regularly.

As vacuum cups are used, their contact surfaces gradually wear down and the cup's dimensions progressively shrink. While the reduced diameter decreases suction force, the device remains functional. Determining the optimal replacement cycle proves challenging due to multiple factors including surface roughness, environmental conditions (temperature, humidity, ozone exposure, chemical solvents), and operational parameters (vacuum pressure levels, workpiece weight, clamping force applied, presence of cushioning mechanisms). Therefore, the replacement period should be determined by customers based on initial usage patterns and their own assessment of wear progression.

If the nut is used to install, the buffer action is not smooth and no sliding phenomenon occurs.

Cause: when installing the buffer rod, the nut is tightened with too much torque; there are dust attached or scratches on the sliding part; the buffer rod has transverse load and excessive friction.

Solutions: Use the recommended clamping torque for assembly; in addition, according to the use conditions and environment, the screws are loose. Regular maintenance should be carried out.