Vacuum Cup Selection Guide

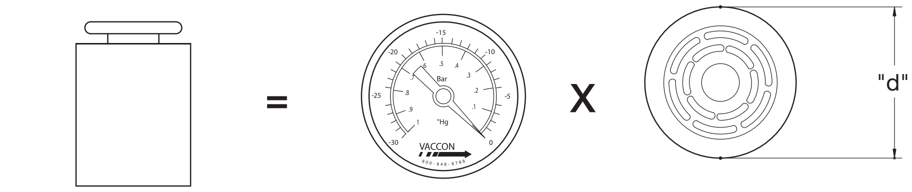
As is true in most vacuum applications, there is more than one correct answer. In order to successfully find the best cup(s) and pumps for a specific task, it is helpful to review the guidelines below.

Vacuum Cup Sizing

Choose the cup size, quantity, material and style based on the size of the object being handled, its weight, orientation, surface temperature, conditions and space available to mount the cups.

I. Determine the cup size by using the "Vacuum Cup Holding Force Calculation:"

FORCE | PRESSURE | AREA



OBJECT WEIGHT
SAFETY FACTOR * Lbs (Kg)

CONVERT "Hg TO PSI,
DIVIDE BY 2
(2Hg" = 1 PSI)
PSI (Kpa)

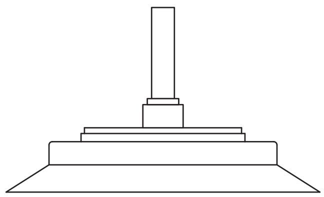
AREA = $\pi(d^2/4)$ or AREA = πr^2
π = 3.14
$in^2(cm^2)$

Force = Pressure x Area

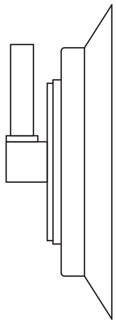
F = the weight of the objects in lbs(kg) multiplied by the safety factor, see below.
P = the expected vacuum level in PSI (Kpa) (2Hg" = 1 PSI)
A = the area of the Vacuum cup measured by in^2 [cm^2]

Safety Factors:

Always include safety factors when calculating lifting capabilities.



Safety Factor=2



Safety Factor=4

Horizontal Lift = 2

Safety factor of 2 is recommended when cup face is in horizontal position.

Vertical Lift = 4

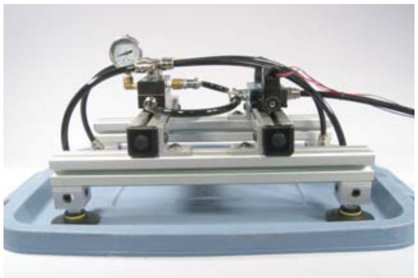
Safety factor of 4 is recommended when cup face is in a vertical position.

II. Determine Type of Material to be handled: Non-Porous, Porous, Flexible/Non-Porous

Materials being handled in pick & place applications can be grouped into three categories – non-porous, porous and flexible. It is important to determine what type of material you are working with in order to determine the cup type, and the fitting choices. Vaccon offers a variety of cup styles – including bellows, multi-bellows, round, oval, flat (with and without cleats), cups with removable fittings and cups with permanent fittings.

Non-Porous Materials: steel, glass, laminated chipboard, rigid plastic, semiconductors, etc.

VP20 pump with bellows cup picks up diamond tread plates – stacking application.

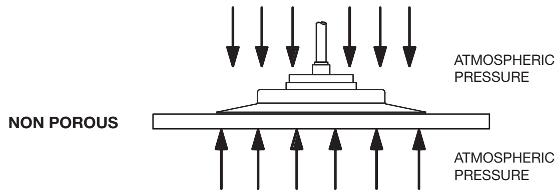


Vaccon EOAT with Multi-port pumps, manifold blocks and flat cleated cups – pick and place plastic lids for packaging application.

VP10 with bellows cups – pick and place deodorant packages for packing application.

Handling non-porous materials is the easiest application for choosing a Vacuum cup and vacuum pump because there is no vacuum flow (leakage). The cup seals to the surface of the object enabling the pump to reach its maximum vacuum level.

Typically, flat cleated cups are used for non-porous applications because the rigid, low profile design resists peeling away. In horizontal applications, where there is a large array of cups, bellows cups may be an option as they offer the pliability needed to ensure that all cups make contact with the object(s) being handled.



Example: Holding Force Calculation for Non-Porous Materials

Application: lift a 100 lb [45.36 kg] steel plate, 1/8" [3mm] thick, measuring 4' x 4' [121.9cm X 121.9cm] from a horizontal stack and place into a press

Vaccon recommends an "H" series pump when handling non-porous materials. All "H" series pumps generate 14 PSI [28"Hg, .965 bar].

$$F = P * A$$

Force = 200 lbs [90.72 kg](weight x safety factor/horizontal lift or 100 lbs [45.36 kg] x 2)
Pressure = 14 PSI [.965 bar] (convert 28"Hg to PSI by dividing by 2)

If **F** (200 lbs [90.72 kg]) = **P** (14 PSI [.965 bar]) * **A** (Solve for **A**)

A = 200/14 [90.72/.965] which is 14.3 in^2 [94.01 cm^2] – "**A**" represents the total area of the cup or all the cups combined to lift this load horizontally

Determine the Number of Cups Needed to Determine the Diameter of each Cup

Whereas the metal is only 1/8" [3mm] thick, it will tend to droop. Vaccon recommends using 2 rows of 3 cups each for a total of 6 cups.

Therefore, 14.3 in^2 [94.01 cm^2] divided by 6 cups = 2.38 in^2 [15.67 cm^2] is the area per cup

Solve for the diameter (**d**) using the equation: $A = \pi * d^2 / 4$ [$A = \pi * d^2 / 4$]
$d^2 = 4 \times 2.38 / \pi$ or $d^2 = 3.03\ in^2$ [$d^2 = 4 \times 15.67 / \pi$ or $d^2 = 19.96\ cm^2$]
d = sq. root of 3.03 or 1.74 in [**d** = sq. root of 19.96 or 44.7mm]

Solution: Choose a flat cup with cleats with a diameter of 1.75" [44.45mm] or greater. With plenty of space on the steel plate to position cups, choosing a larger cup will add to the holding force and take into account any acceleration or deceleration loads during transfer.

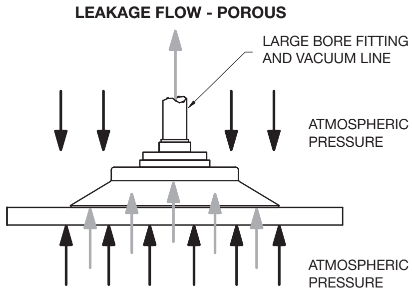
Porous Materials: corrugated, woven materials, or objects with extremely rough or uneven surfaces

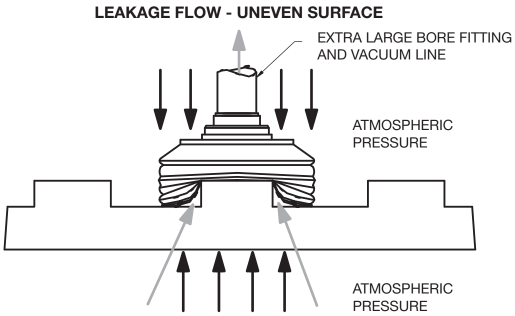
VDF pump w/flat cleated cup – picks up plywood with knots– palletizing application.

VP80 pump with manifold blocks and bellows cups picks up corrugated board for packaging application.

Two CDF pumps handle cheesecloth fabric bag – bag opening and closing application.

When handling porous materials, it is important that the flow path between the object and the vacuum pump is as large as necessary to allow the pump to draw away the air that leaks through the surface or from gaps between the cup and the surface. Pay close attention to the bore size of the fitting in the cup, as well as the size of the vacuum lines. To confirm vacuum lines are sized properly, see the Operating and Installation Instructions section for each pump.





When calculating the holding force for porous materials, the vacuum level that will be achieved is not normally known because the leak rate of the material is unknown. To move forward and determine the diameter of the Vacuum cups, assume that system will reach a vacuum level of 8 PSI [16"Hg, .542 bar].

Vaccon recommends the "M" series vacuum pumps to maximize flow and minimize compressed air usage when handling porous materials. To ensure that the vacuum level of 8 PSI [16"Hg, .542 bar] is achieved, contact Vaccon Tech Support for a pump recommendation.

Example: Holding Force Calculation for Porous Materials or Uneven Surfaces

Application: lift a 100 lb [45.36 kg]corrugated box with vacuum cups in the horizontal plane. Remember the safety factor and the equation **F = P * A**

200 lbs [90.72 kg] = 8 PSI [.542 bar] x **A** - Solve for **A** – the total vacuum cup(s) area.

A = 200 [90.72]/8 [.542 bar] = 25 in^2 [164.35 cm^2] of combined cup area. Assume the number of cups used will be 4.

Determine the Number of Cups Needed to Determine the Diameter of each Cup

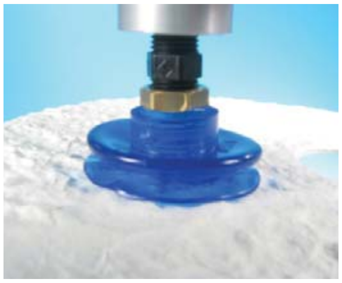
Divide the total area by the number of cups (25/4)[164.35/4] – area of each cup is 6.25 in^2 [41.09 cm^2]

Solve for the diameter (**d^2**) using the equation: **A** = π * $d^2/4$, 6.25 = 3.14 (d^2)/4 [**A** = π * $d^2/4$, 41.09 = 3.14 (d^2)/4]

d = square root of (6.25 * 4/3.14) = 2.82 [**d** = square root of (41.09 * 4/3.14) = 72.3 mm]

Solution: Choose a flat cup with cleats or bellows cups with a diameter of 3" [76.2mm] or greater. (Dimensions have been rounded up.)
In this situation, Vaccon recommends a VP80-250M vacuum pump.

Flexible Materials: plastic films, baked goods, IV bags, paper bags – things that wrinkle



Close up of a CDF 200 and VC 32C1-F cup picking up a donut textured surface

CDF 500H-75 and VC 129 oval bellows cup picking up 1000ml of saline solution in plastic bag

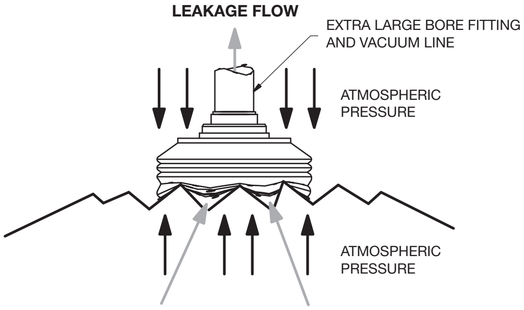
CDF 750 and VCUH cup picking up single layer cake

When handling flexible packaging materials, it is critical that the cup fitting and the vacuum line have a very large bore. Flexible materials wrinkle, causing large leak paths. The cup and the vacuum pump must be sized to accommodate that leak rate. The bore of the fitting must be close to a 1:2 ratio to the diameter of the cup.

Typically, handling flexible materials does not involve heavy weights. Calculating cup holding force is not required.

Choose a cup with a very thin flexible lip to ensure the cup conforms to the wrinkled material. Multi-bellows cups work well in these applications because of their flexibility. Vaccon's VCHF7 High Flex Vacuum cups easily conform to uneven, textured surfaces or wrap around odd shaped items creating a strong seal to securely hold products without distorting or damaging the surface.

The interaction between the Vacuum cup and the flexible material is critical. Because the leakage flow rates are so high, it is necessary to use our CDF Series of high flow (air amplifier) vacuum pumps. With so many variables affecting performance, Vaccon strongly suggests that a sample of the material be sent to our in-house test facility for a pump and cup recommendation.



Vacuum Cup Material Specifications:

Cups are available in various durometers, colors and materials. If you do not see what you are looking for, please consult factory. Below is a general description of the various materials available and their characteristics.

Material	Working Temperature	Wear Resistance	Oil resistance	Durometer	Application
*Vinyl	+32°F to +125°F [0°C to +52°C]	Excellent	Fair	A20-A75 Range	general purpose material for most applications
Oil Resistant Vinyl	+32°F to +125°F [0°C to +52°C]	Good	Excellent	A40-A60 Range	excellent for oil resistant applications
Polyurethane	+32°F to +150°F [0°C to +66°C]	Good	Good	A20-A70 Range	good for chemical resistance and glass handling
Chloroprene	-40°F to +230°F [-40°C to +110°C]	Excellent	Good	A50-A60 Range	general purpose material with good oil resistance and low temperature performance
Nitrile	+32°F to +194°F [0°C to +90°C]	Good	Good	A50-A60 Range	general purpose material with good oil and abrasion resistance
Silicone-Grey	-50°F to +392°F [-46°C to +200°C]	Good	Good	A30-A60 Range	good for applications involving high temperatures, food or non-marking situations
Silicone-Translucent	-92°F to +392°F [-69°C to +200°C]	Good	Good	A30-A60 Range	good for applications involving high temperatures, food or non-marking situations
(Dual Durometer) Polyurethane	50°F to 122° F [10°C to 50°C]	Excellent	Excellent	A30 / A60	good for chemical resistance and glass handling
Silicone-Red	-94°F to 536°F [-70°C to 280°C]	Good	Good	A30-A60 Range	good for applications involving high temperatures, food or non-marking situations
Silicone-Blue	-94°F to 536°F [-70°C to 280°C]	Good	Good	A30-A60 Range	good for applications involving high temperatures, food or non-marking situations
Natural Rubber	-40°F to 176°F [-40°C to 80°C]	Good	Poor	A40	good for non-marking situations and glass, solar panel and semiconductor/electronics handling

*Standard durometer for vinyl cups is A50 ±5 points — may vary with color. Other Materials Available - please consult factory: FDA Vinyl, Anti-Static Vinyl, FDA Silicone.

Vacuum Cup Terms and Definitions:

Bellows: The fold or collapsible area that allows the cup to compress like an accordion
Convolution: The folded area of a bellows cup that makes up 1 external "V"
Cleats: Bottom protrusions used for maintaining a larger vacuum area
Durometer: Method by which the hardness of a material is gauged
Insert/Fitting: Metal piece bonded or inserted into the material to allow fastening by threads or bolts
Vacuum cup: Cup that requires the use of an external vacuum source to adhere to a surface
Vacuum Level: The magnitude of suction created by a vacuum pump typically measured in inches of mercury "Hg or [mbar]
Vacuum Flow: The volume of free air induced by the vacuum pump per unit of time, typically measured in SCFM [L/min]
Porosity: Ability of air to pass through a material
Standard Atmospheric Pressure Measured at Sea Level: 1 ATM = 14.7 PSI = 29.92"Hg = 760 mmHg = 1 bar

Facts to Remember:

50 mmHg = 1 PSI
1mmHg = 1 torr (vacuum)
1"Hg = 25.4 mmHg
2"Hg = 1 PSI
29.92"Hg = 100 Kpa
14.7 PSI = 100 Kpa
14.7 PSI = 29.92"Hg
14.7 PSI = 760 mmHg

Conversion Chart – Vacuum vs. Pressure

% Vacuum	"Hg	mmHg	bar	PSI
10	3	76.92	-0.1	-1.47
20	6	153.85	-0.2	-2.94
30	9	230.77	-0.3	-4.41
40	12	307.69	-0.4	-5.88
50	15	384.62	-0.5	-7.35
60	18	461.54	-0.6	-8.82
70	21	538.46	-0.7	-10.29
80	24	615.38	-0.8	-11.76
90	27	692.31	-0.9	-13.23
100	30	769.23	-1.0	-14.70