Suction cups

Introduction

A suction cup allows you to lift and move objects that differ in shape, size and weight by means of a vacuum. The Venturi phenomenon allows a vacuum to be created inside the cup lowering the internal atmospheric pressure by 30 to 98%, thus creating a near vacuum.

The theoretical holding force (N) of a suction cup is calculated by multiplying the surface area of the suction cup by the decrease in pressure (%):

Suction force (N) = suction cup surface area (cm^2) x vacuum level (%) x 0.099366

To guarantee operational safety and to allow for movement and acceleration, safety coefficients should be applied, these are a Factor of 3 for horizontally applied suction cups and 5 for those vertically applied to allow for any sliding.
You will find the typical forces (N) of the suction cups at different vacuum rates (%) in the table below.

Example: for a 50mm diameter suction cup and a 90% vacuum, the theoretical suction force = 175.5N = 17.5kg = 5.83kg (when FoS of 3 applied).

Suction cup diameter (mm)	Surface area cm^2	Theoretical force (N) of the suction cup at vacuum level (%)								
		10%	20%	30%	40%	50%	60%	70%	80%	90%
5	0,196	0,195	0,390	0,585	0,780	0,975	1,170	1,365	1,560	1,755
6	0,282	0,280	0,561	0,842	1,123	1,404	1,685	1,966	2,247	2,528
8	0,502	0,499	0,998	1,498	1,997	2,497	2,996	3,496	3,995	4,495
10	0,785	0,780	1,560	2,341	3,121	3,902	4,682	5,462	6,243	7,023
15	1,767	1,755	3,511	5,267	7,023	8,779	10,53	12,29	14,04	15,80
20	3,141	3,121	6,243	9,365	12,48	15,60	18,73	21,85	24,97	28,09
25	4,908	4,877	9,755	14,63	19,51	24,38	29,26	34,14	39,02	43,89
30	7,068	7,023	14,04	21,07	28,09	35,11	42,14	49,16	56,19	63,21
35	9,621	9,560	19,12	28,68	38,24	47,80	57,36	66,92	76,84	86,04
40	12,56	12,48	24,97	37,46	49,94	62,43	74,92	87,40	99,89	112,3
50	19,63	19,51	39,02	58,53	78,04	97,55	117,0	136,5	156,0	175,5
60	28,27	28,09	56,19	84,28	112,3	140,4	168,5	196,6	224,7	252,8

Materials	Working temperature C°	Shore hardness	Colour	Information
NBR = Nitrile	-25 to +110	55 ±5	black	most common
SI = Silicone	-30 to +220	55 ±5	translucent	resistant to high and low temperatures, suitable for food prep.
NR = Natural rubber	-25 to +90	50 ±5	grey	good friction resistance and very supple

Materials	tearing	cracking	elasticity	wear	friction	age	ozone	petrol	oil and grease	acid	alkali	hot water
NBR = Nitrile	4	5	4	4	4	4	4	5	6	2	4	4
SI = Silicone	5	4	5	4	5	4	6	4	6	3	3	3
NR = Natural rubber	4	3	4	2	2	2	3	3	3	1	2	2