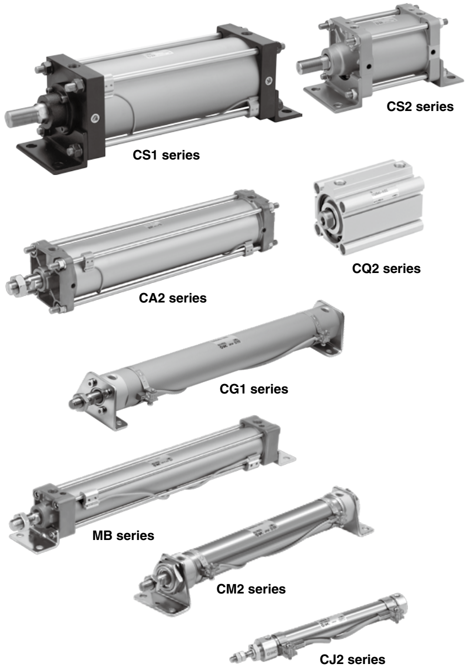
Air Cylinders Model Selection



Technical data for air cylinders

For detailed technical data other than the air cylinder model selection, refer to pages 1569 to 1576.

Data 1: Bore Size Selection (page 1570)
Data 2: Air Consumption and Required Air Volume (page 1574)
Data 3: Theoretical Output Table (page 1575)
Data 4: Condensation (page 1576)

Step

1 Obtain the bore of the cylinder tube. → Refer to Graph (1) and (2).

① **Determine the load factor in accordance with the purpose.**

Purpose of operation		Load factor η
Static operation (Clamping, Low-speed vise crimping, etc.)		0.7 or less (70% or less)
Dynamic operation	Horizontal movement of load on guide	1 or less (100% or less)
	Vertical and horizontal movement of the load	0.5 or less Note) (50% or less)

Note) If it is particularly necessary to operate at high speeds, the load rate must be reduced further. (In the graph, it is possible to select a load rate of 0.4, 0.3, 0.2, or less.)

② **Determine the operating pressure.**
Generally, set the regulator to 85% of the source air pressure. (In the graph, a selection between 0.2 MPa and 0.8 MPa is possible.)

③ **Determine the direction in which the cylinder force will be used.**
Extending side → Refer to Graph (1).
Retracting side → Refer to Graph (2).
Note) If the same load is applied both for pushing and pulling in a horizontal operation, set the direction to the retracting side.

Step

2 Take the impact at the stroke end into consideration.

① **When an external stopper (shock absorber, etc.) is provided to absorb the impact, select a stopper with sufficient absorption capacity.**

② **Stopping the piston with the cylinder without a stopper:**
Verify in Graphs (3) to (10) the absorption capacity of the cushion that is enclosed in the cylinder.
1) Rubber bumper ······ Urethane rubber is used for preventing metal-to-metal contact between the piston and the cover.
2) Air cushion············ The air in the exhaust side is compressed slightly before the stroke end, and its reaction force absorbs the kinetic energy of the load, thus enabling the piston to stop quietly.

Step

3 The aspects indicated below may need to be taken into consideration, depending on how the cylinder is operated.

① **If a lateral load is applied to the piston rod:**
Verify in Graphs (11) to (19) whether the lateral load is within an allowable range.

② **When using a cylinder with a relatively long stroke, if a buckling force acts on the piston rod or the cylinder tube, verify in the table whether the stroke or the operating pressure is within a safe range.**

Step

4 Obtain the cylinder's air consumption and its required air volume.

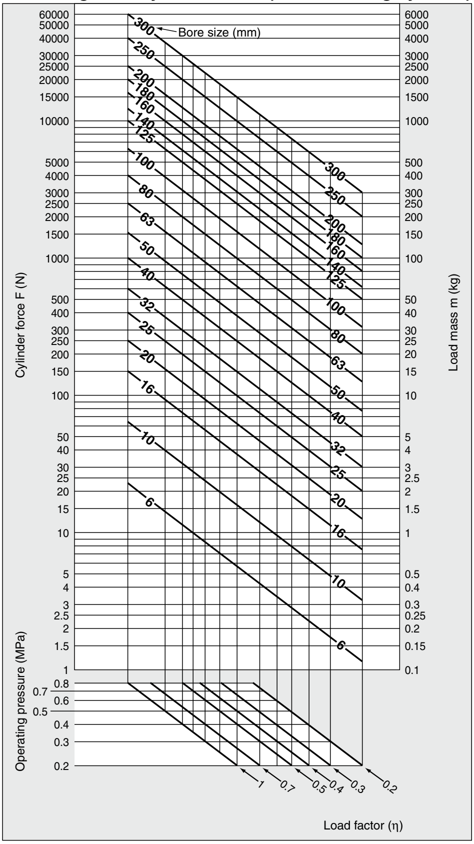
Obtain the air consumption selecting a compressor and for calculating the running cost and the required (Graphs (21), (22)) that is necessary for selecting a compressor and for calculating the running cost and the required air volume (Graph (23)) that is necessary for selecting equipment such as an air filter or a regulator, or the size of the piping upstream.

Air Cylinders Model Selection

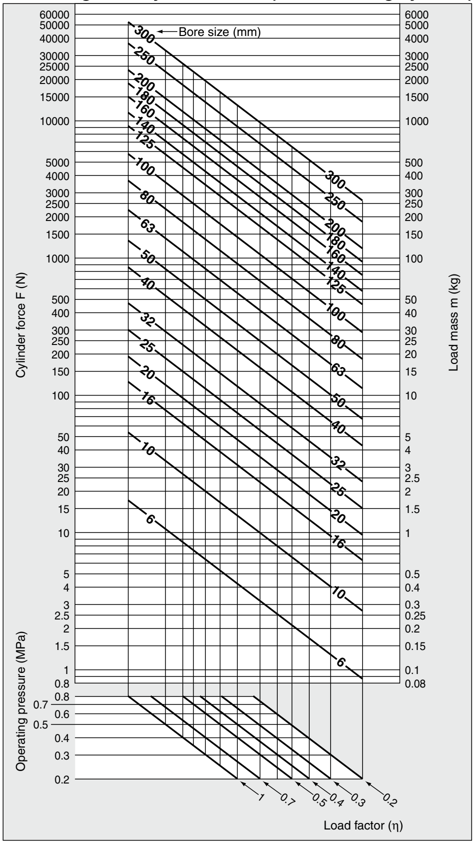
Step
1

Obtain the bore of the cylinder tube. → Refer to Graph (1) and (2).

Graph (1)
Extending Side Cylinder Force (Double acting cylinder)



Graph (2)
Retracting Side Cylinder Force (Double acting cylinder)



(Example)

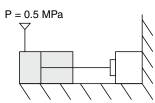


Fig. (1)

(Example)

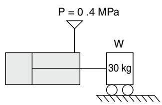


Fig. (2)

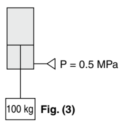


Fig. (3)

Example 1: If the minimum force of 1000 N is necessary to keep the workpiece pressed as shown in Fig. (1), because this is the extending side, use Graph (1) to determine the load factor of 0.7 and the operating pressure of 0.5 MPa.
Then, seek the point at which the cylinder force of 1000 N intersects, and this will result in a bore size of 63 mm.

Conversion to gravitational units

1 MPa ≈ 10.2 kgf/cm²	1 N ≈ 0.102 kgf
1 kgf/cm² ≈ 0.098 MPa	1 kgf ≈ 9.8 N

Example 2: To move a load with a 30 kg mass horizontally on a guide as shown in Fig. (2), because the load is the same for both the extending and retracting sides, use Graph (2), which is the retracting side with a smaller force. Determine the load factor of 1, and the operating pressure of 0.4 MPa. Then, seek the point at which it intersects with the load mass of 30 kg, and this will result in a bore size of 40 mm.

Example 3: To pull a load with a 100 kg mass vertically upward as shown in Fig. (3), use Graph (2) to determine the load factor of 0.5 and the operating pressure of 0.5 MPa.
Then, seek the point at which it intersects with the load mass of 100 kg, and this will result in a bore size of 80 mm.

Air Cylinders Model Selection

Step
2

Take the impact at the stroke end into consideration.

How to Read the Graph

Example 1: According to Graph (3), to move a load mass of 50 kg using a cylinder with an air cushion, CM2□40, it is necessary to set the maximum speed at 300 mm/s or less, considering the capacity of the air cushion.

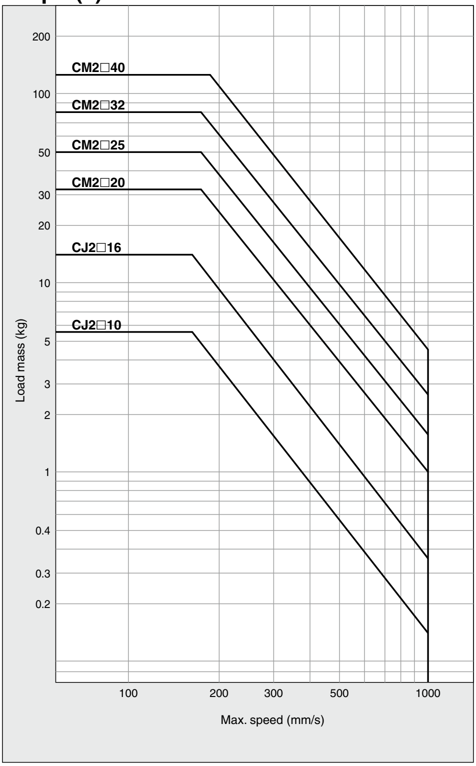
Cylinders with Air Cushion


CJ2

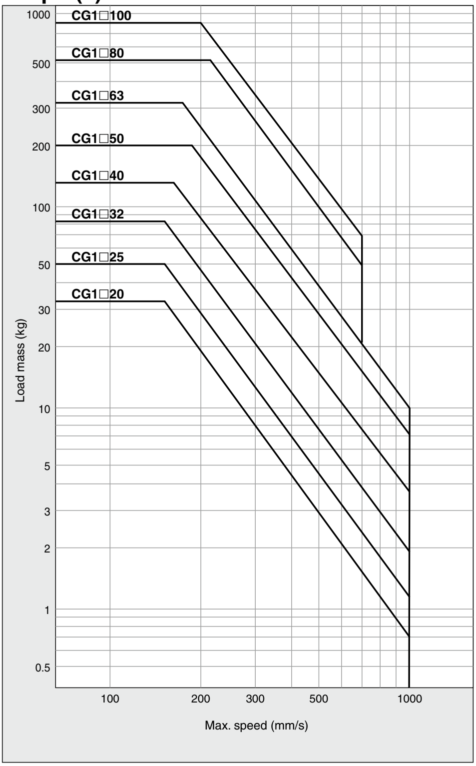

CM2


CG1

Graph (3) CJ2/CM2 Series



Graph (4) CG1 Series



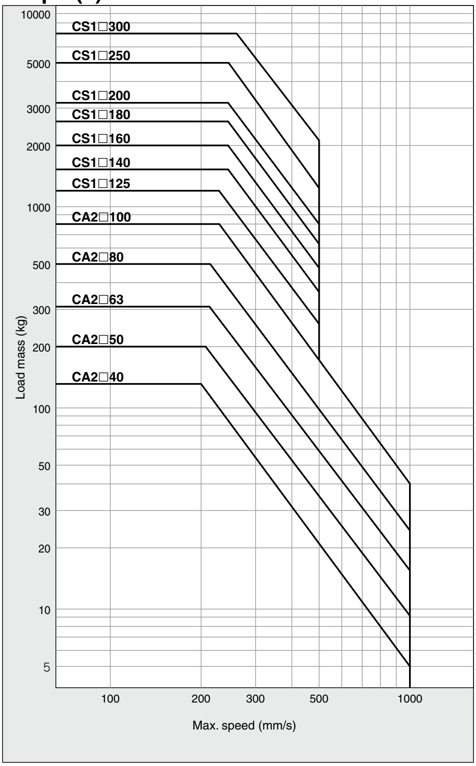
Cylinders with Air Cushion

CA2

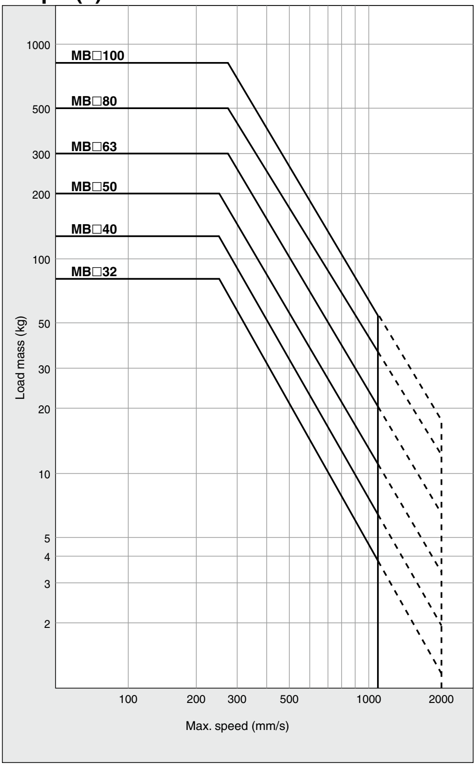
CS1

MB

Graph (5) CA2/CS1 Series



Graph (6) MB Series



Air Cylinders Model Selection

Step
2 Take the impact at the stroke end into consideration.

How to Read the Graph

Example 2: According to Graph (8), to move a load mass of 50 kg at a maximum speed of 500 mm/s, in the CG1 series, a bore size of ø80 can be selected.

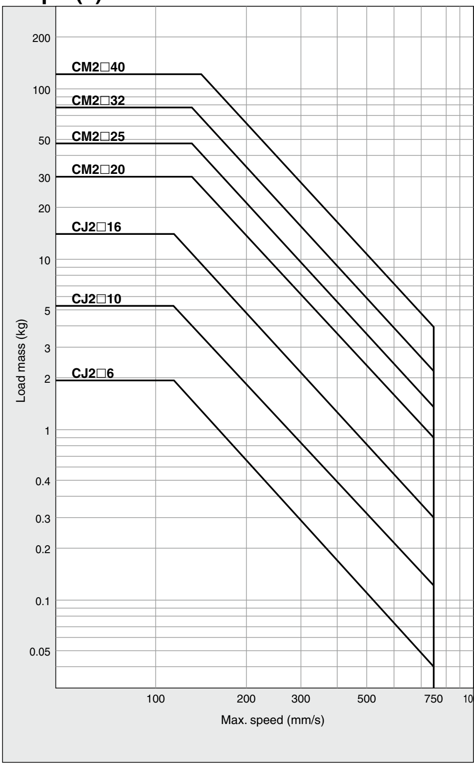
Cylinders with Rubber Bumper


CJ2

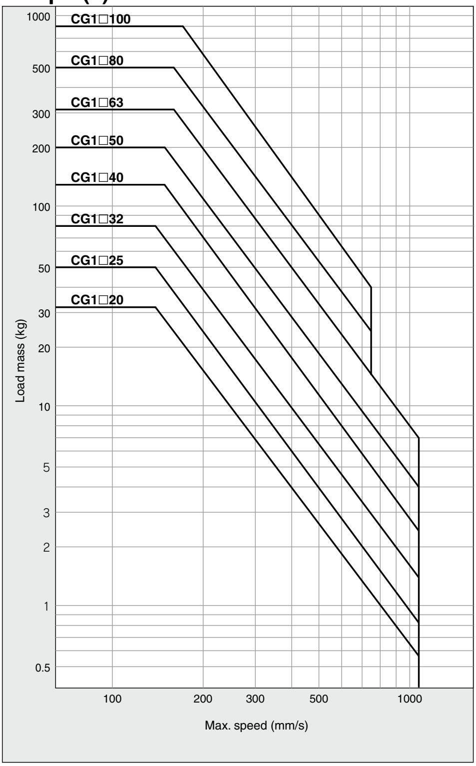

CM2


CG1

Graph (7) CJ2/CM2 Series

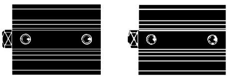


Graph (8) CG1 Series



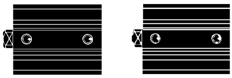
SMC

Cylinders with Rubber Bumper



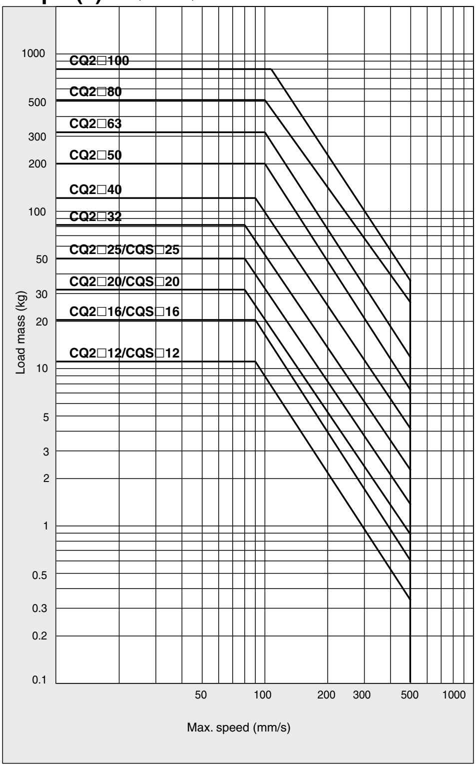
CQ2 CQS

Cylinders without Rubber Bumper

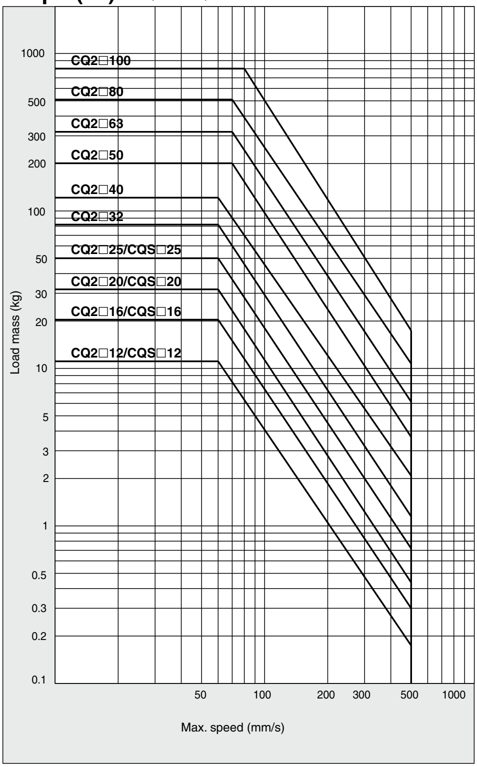


CQ2 CQS

Graph (9) CQ2/CQS Series



Graph (10) CQ2/CQS Series



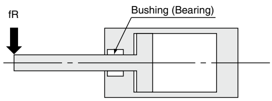
Air Cylinders Model Selection

Step
3

The aspects indicated below may need to be taken into consideration, depending on how the

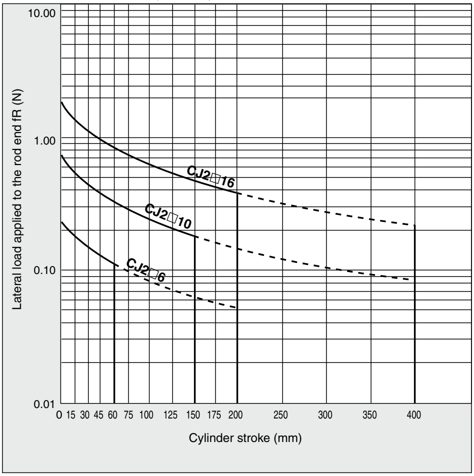
① **The maximum stroke at which the cylinder can be operated under a lateral load.**

The region that does not exceed the bold solid line represents the allowable lateral load in relation to the cylinder of a given stroke length. In the graph, the range of the broken line shows that the long stroke limit has been exceeded. In this region, as a rule, operate the cylinder by providing a guide along the direction of movement.



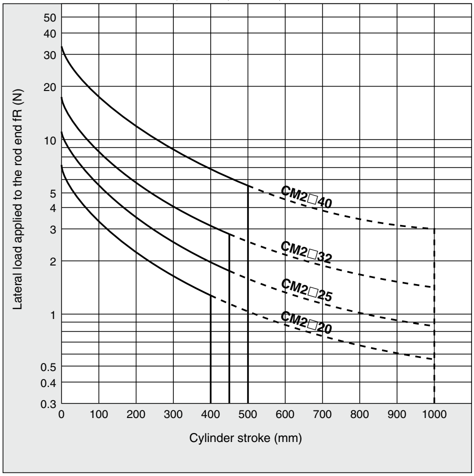
Graph (11)

CJ2 Series: ø6, ø10, ø16



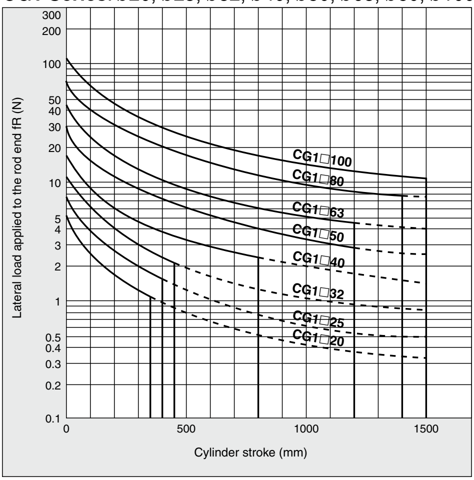
Graph (12)

CM2 Series: ø20, ø25, ø32, ø40



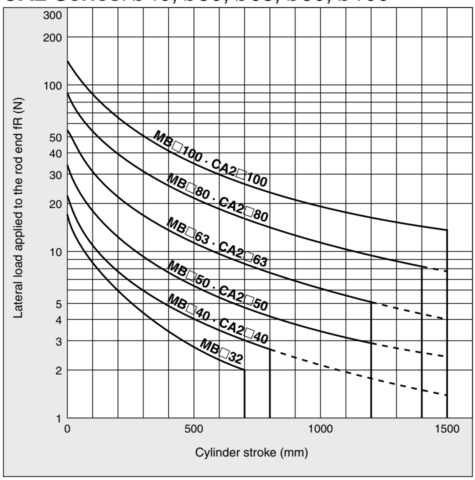
Graph (13)

CG1 Series: ø20, ø25, ø32, ø40, ø50, ø63, ø80, ø100



Graph (14)

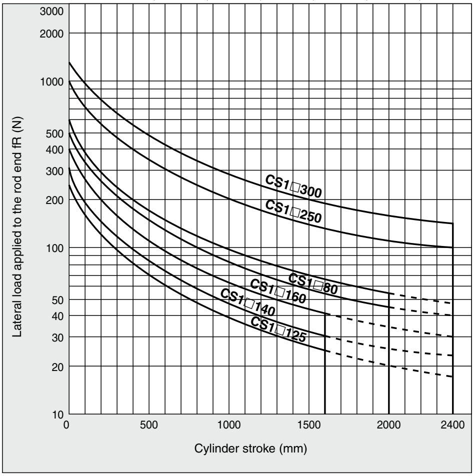
MB Series: ø32, ø40, ø50, ø63, ø80, ø100
CA2 Series: ø40, ø50, ø63, ø80, ø100



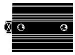
cylinder is operated.

Graph (15)

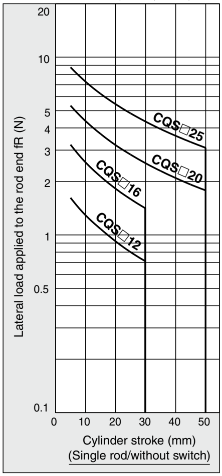
CS1 Series: ø125, ø140, ø160, ø180, ø200, ø250, ø300



Graph (16)

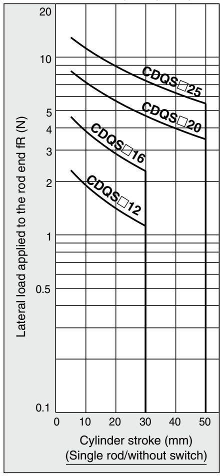


CQS Series: ø12, ø16, ø20, ø25

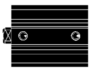


Graph (17)

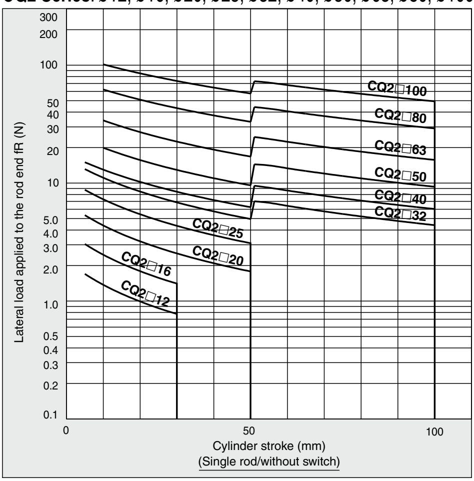
CDQS Series: ø12, ø16, ø20, ø25



Graph (18)

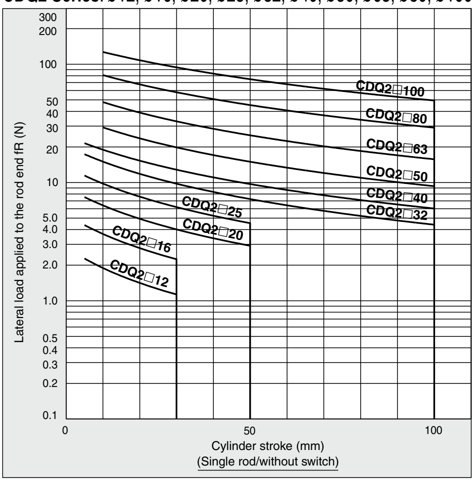


CQ2 Series: ø12, ø16, ø20, ø25, ø32, ø40, ø50, ø63, ø80, ø100



Graph (19)

CDQ2 Series: ø12, ø16, ø20, ø25, ø32, ø40, ø50, ø63, ø80, ø100



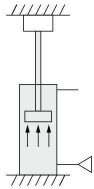
Air Cylinders Model Selection

Step
3 The aspects indicated below may need to be taken into consideration, depending on how the

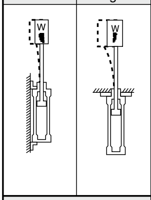
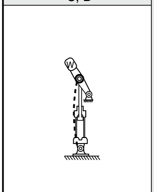
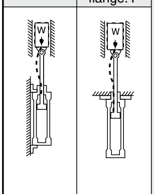
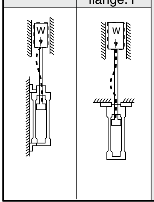
② The relation between the cylinder size and the maximum stroke depending on the mounting type.

Assuming that the force that is generated by the cylinder itself acts as a buckling force on the piston rod or on the piston rod and the cylinder tube, the table below indicates in centimeters the maximum stroke that can be used, which was obtained through calculation. Therefore, it is possible to find the maximum stroke that can be used with each cylinder size according to the relationship between the level of the operating pressure and the type of cylinder mounting, regardless of the load factor.

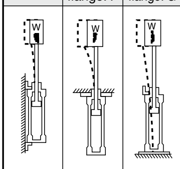
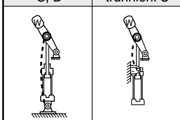
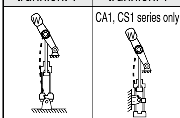
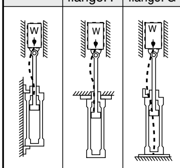
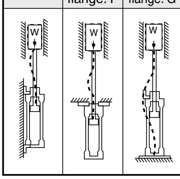
Reference: Even under a light load, if the piston rod has been stopped by an external stopper at the extending side of the cylinder, the maximum force generated by the cylinder will act upon the cylinder itself.



(cm)

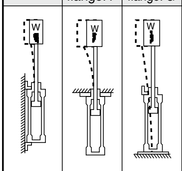
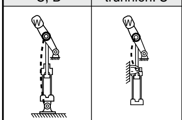
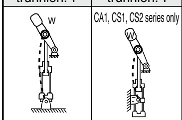
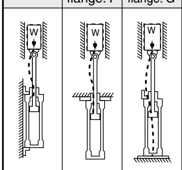
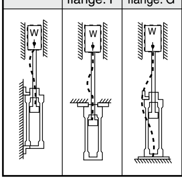
Mounting type / Mounting bracket diagram	Nominal symbol	Operating pressure (MPa)	Maximum stroke that can be used according to buckling strength: CJ2 6	CJ2 10	CJ2 16
Foot: L, Rod side flange: F 	B L F	0.2	20	29	29
		0.3	20	23	23
		0.5	16	17	17
		0.7	13	14	14
Clevis: C, D 	D	0.2	—	40	40
		0.3	—	40	40
		0.5	—	32	31
		0.7	—	26	25
Foot: L, Rod side flange: F 	B L F	0.2	20	40	40
		0.3	20	40	40
		0.5	20	40	40
		0.7	20	40	40
Foot: L, Rod side flange: F 	B L F	0.2	20	40	40
		0.3	20	40	40
		0.5	20	40	40
		0.7	20	40	40

(cm)

Mounting type / Mounting bracket diagram	Nominal symbol	Operating pressure (MPa)	CM2 20	CM2 25	CM2 32	CM2 40	CG1 20	CG1 25	CG1 32	CG1 40	CG1 50	CG1 63	CG1 80	CG1 100
Foot: L, Rod side flange: F, Head side flange: G 	L F	0.3	39	49	56	61	38	49	55	80	100	78	96	112
		0.5	29	37	42	46	29	36	42	60	76	59	73	85
		0.7	24	31	35	38	24	30	34	50	63	49	60	71
	G	0.3	16	20	24	25	15	21	24	36	45	34	42	50
		0.5	11	14	17	17	11	14	17	26	33	25	31	37
		0.7	8	11	13	13	8	11	13	21	27	20	24	29
Clevis: C, D; Rod side trunnion: U 	C D	0.3	36	46	53	56	37	47	53	78	98	76	94	109
		0.5	26	34	39	42	27	35	40	59	74	57	70	82
		0.7	21	28	32	34	22	28	32	48	61	46	58	68
	U	0.3	82	103	116	126	81	102	115	150	150	150	–	–
		0.5	62	79	89	97	61	78	88	126	159	124	–	–
		0.7	52	66	75	81	51	65	73	106	133	104	–	–
Head side trunnion: T; Center trunnion: T (CA1, CS1 series only) 	T	0.3	37	47	54	58	38	48	55	79	100	78	–	–
		0.5	27	35	40	43	28	36	41	60	76	59	–	–
		0.7	22	29	33	35	23	30	34	50	63	48	–	–
Foot: L, Rod side flange: F, Head side flange: G 	L F	0.3	100	147	166	181	117	147	150	150	150	150	150	150
		0.5	90	113	128	139	89	112	127	150	150	150	150	150
		0.7	76	95	107	117	75	94	107	150	150	150	150	150
	G	0.3	55	69	79	85	55	70	79	114	143	112	138	150
		0.5	41	52	60	64	41	52	60	87	109	85	105	122
		0.7	34	43	49	53	34	43	50	72	91	71	87	102
Foot: L, Rod side flange: F, Head side flange: G 	L F	0.3	100	150	200	200	150	150	150	150	150	150	150	150
		0.5	100	150	183	199	128	150	150	150	150	150	150	150
		0.7	100	136	154	167	108	135	150	150	150	150	150	150
	G	0.3	80	101	114	123	80	101	114	150	150	150	150	150
		0.5	61	77	87	94	61	77	87	126	150	124	150	150
		0.7	50	64	72	78	50	64	73	105	132	103	127	148

cylinder is operated.

(cm)

Mounting type / Mounting bracket diagram	Nominal symbol	Operating pressure (MPa)	Maximum stroke that can be used according to buckling strength															
			MB	MB, CA2					CS1							CS2		
			32	40	50	63	80	100	125	140	160	180	200	250	300	125	140	160
Foot: L, Rod side flange: F, Head side flange: G 	L F	0.3	71	81	102	79	98	114	131	117	126	141	158	182	206	103	92	113
		0.5	56	63	78	61	75	88	101	89	96	108	121	140	158	79	70	86
		0.7	46	52	65	50	62	73	84	74	80	89	101	115	131	66	58	72
	G	0.3	31	35	46	34	42	50	57	49	53	60	68	79	90	45	38	47
		0.5	23	26	34	25	31	37	42	35	38	44	50	58	66	33	27	34
		0.7	19	21	27	19	24	29	34	28	30	34	40	45	53	26	22	27
Clevis: C, D, Rod side trunnion: U 	C D	0.3	67	76	96	73	91	105	122	106	118	130	146	167	190	96	83	106
		0.5	50	57	72	54	68	78	91	78	85	96	109	124	141	71	61	76
		0.7	41	46	60	44	55	64	75	64	69	78	89	101	115	59	50	62
	U	0.3	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
Head side trunnion: T, Center trunnion: T (CA1, CS1, CS2 series only) 		0.5	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
		0.7	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	T	0.3	93	105	134	103	128	149	171	151	163	183	206	235	267	135	119	147
		0.5	71	80	102	78	97	113	129	113	123	139	156	178	203	101	89	111
		0.7	58	66	85	65	81	93	107	94	101	115	129	147	168	84	74	91
Foot: L, Rod side flange: F, Head side flange: G 	L F	0.3	206	234	295	231	287	330	382	339	366	412	459	527	598	301	267	330
		0.5	158	179	226	177	219	253	293	263	281	315	252	403	458	231	207	253
		0.7	132	150	190	148	184	212	245	218	235	265	296	339	385	193	172	212
	G	0.3	99	112	142	116	136	158	183	160	173	196	218	251	286	144	126	156
		0.5	75	85	108	83	102	119	138	120	131	147	165	189	216	109	94	118
		0.7	62	70	90	68	85	99	114	99	108	122	137	157	179	90	78	97
Foot: L, Rod side flange: F, Head side flange: G 	L F	0.3	280	318	423	313	412	476	549	489	528	594	661	762	863	433	386	476
		0.5	234	266	339	257	317	367	423	377	407	457	509	587	665	334	297	367
		0.7	194	220	275	216	267	309	356	317	343	385	429	494	561	281	250	309
	G	0.3	136	154	206	151	199	231	266	235	254	287	320	369	419	210	185	229
		0.5	110	125	158	123	152	176	203	179	194	218	244	281	320	160	141	175
		0.7	93	105	132	102	127	147	170	149	144	182	204	235	268	134	117	129

Air Cylinders Model Selection

Step
4
Obtain the cylinder's air consumption and its required air volume.

Cylinder's air consumption and its required air volume.
In equipment that used a cylinder, air consumption is the volume of air that is consumed in the cylinder, or in the piping between the cylinder and the switching valve, every time the switching valve operates.
This is necessary for selecting a compressor and for calculating the running cost. The required air volume is the volume of air that is necessary for operating a specified load at a specified speed, and it is necessary for selecting the F.R.L equipment or the size of the upstream piping.

How to Obtain the Air Consumption/How to Read Graphs (20), (21)

Step 1 By using Graph (20), obtain the air consumption of the air cylinder.
① Seek the point at which the operating pressure (diagonal line) intersects with the cylinder stroke, and from that point, perpendicularly extend a vertical line upward.
② From the point at which it intersects with the bore size (diagonal line) of the cylinder to be used, look sideways (either to the right or left) to obtain the air consumption that is required by one cycle of the air cylinder.

Step 2 By using Graph (21), obtain the air consumption of the piping tube or steel pipe in the same way as in Step 1.

Step 3 Obtain the total air consumption per minute as described below.
(Air consumption of air cylinder + Air consumption of piping tube or steel pipe) x Number of cycles per minute x Number of cylinders being used = Total air consumption [Unit: L/min (ANR)]

Note) In selecting a compressor, the temperature drop, leakage, and consumption by the intermediary equipment must be taken into consideration. Thus, select one with a generous capacity, with a discharge that exceeds the total air consumption indicated above. (Reference: At a minimum, select one with 1.4 times the volume; select one with a higher volume as needed.)

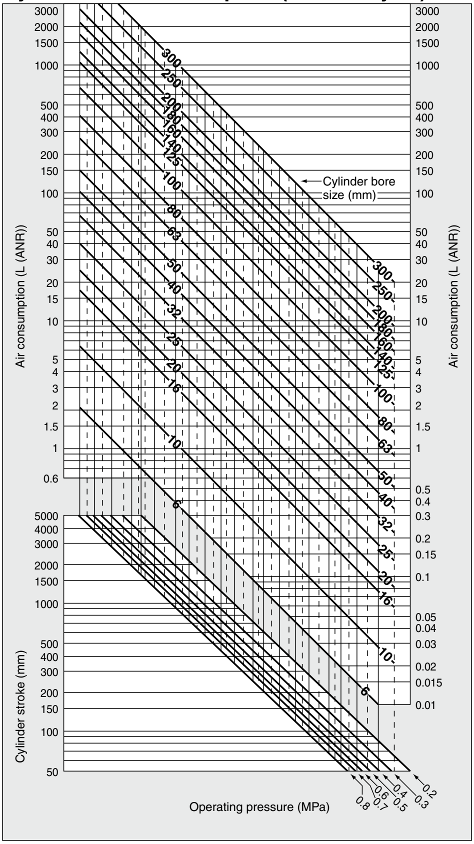
Example: When 10 air cylinders with a 50 mm cylinder bore size and a 600 mm stroke are used at a pressure of 0.5 MPa, what is the air consumption of their 5 cycles per minute? (A 2 m piping tube with a 6 mm bore is used for piping between the cylinders and the switching valve.)
1. Operating pressure 0.5 MPa → Cylinder stroke 600 mm → Bore size 50 mm → Air consumption ≈ 13 L (ANR)
2. Operating pressure 0.5 MPa → Piping length 2 m → Bore 6 mm → Air consumption ≈ 0.56 L (ANR)
3. Total air consumption = (13 + 0.56) x 10 x 5 = 678 L/min (ANR)

How to Obtain the Required Air Volume/How to Read Graph (22)

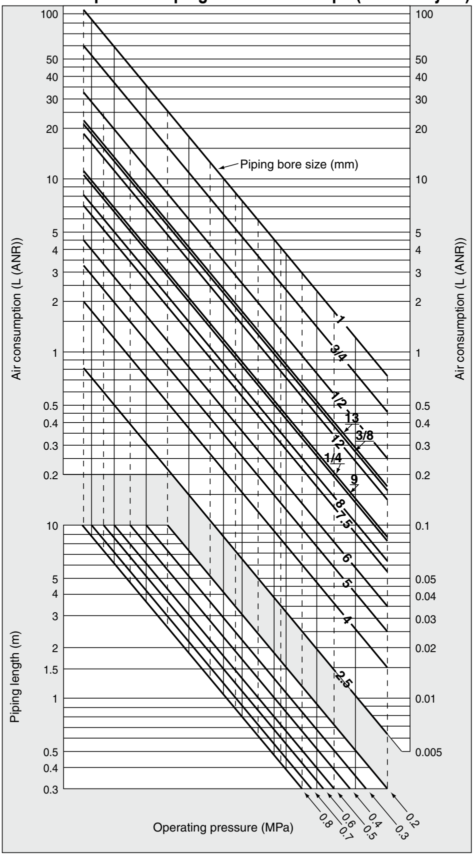
Step 3 By using Graph (22), obtain the air cylinder's required air volume.
① Seek the point at which the operating pressure (diagonal line) intersects with the cylinder stroke, and from that point, perpendicularly extend a vertical line upward.
② From the point at which it intersects with the bore size (diagonal line) of the cylinder to be used, look sideways (either to the right or left) to obtain the air consumption that is required by one cycle of the air cylinder.

Example: What is the required air volume for operating a cylinder with a bore size of 50 mm, at pressure of 0.5 MPa, and at a speed of 500 mm/s?
How to read: Operating pressure 0.5 MPa → Maximum piston speed 500 mm/s → Cylinder bore size 50 mm → Then, a required air volume 350 L/min (ANR) can be obtained.

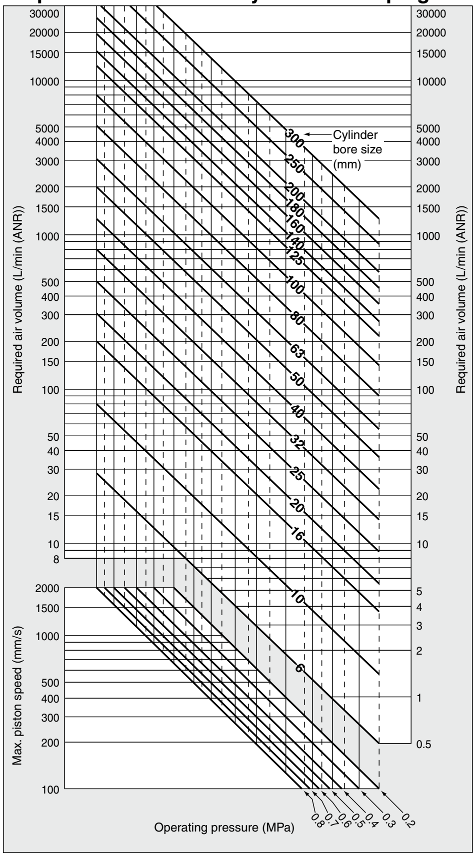
Graph (20)
Cylinder's Air Consumption (For one cycle)



Graph (21)
Air Consumption of Piping Tube or Steel Pipe (For one cycle)



Graph (22)
Required Air Volume of Cylinder and Piping



∗ The piping length is the length of the steel pipe or piping tube that connects the cylinder with the switching valve (solenoid valve, etc.)
∗ For the dimensions (bore size and O.D.) of the steel tubing, refer to page 1574.

Technical Data 1:
Bore Size Selection

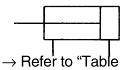
Data 1 Bore Size Selection

① Double Acting Cylinder

The relation of cylinder force, bore size and operating pressure is the following.

Formula

$$\mathbf{F_1} = \eta \times \mathbf{A_1} \times \mathbf{P} \quad \cdots\cdots\cdots (1)$$
$$\mathbf{F_2} = \eta \times \mathbf{A_2} \times \mathbf{P} \quad \cdots\cdots\cdots (2)$$



F_1: Cylinder force at extension side [N]
F_2: Cylinder force at retraction side [N]
η: Load ratio
A_1: Piston area at extension side [mm^2] → Refer to "Table (1)".
A_2: Piston area at retraction side [mm^2] → Refer to "Table (1)".
P: Operating pressure [MPa]

Note) As shown in the diagram below, the pressure receiving area on the retraction side of the double acting single rod cylinder is reduced by the amount of the cross sectional area of the piston rod.

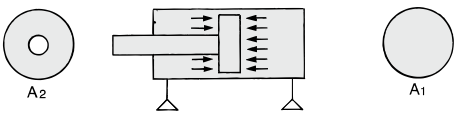


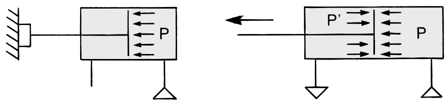
Table (1) Cylinder Piston Area

Bore size **D** [mm]	Piston rod size **d** [mm]	Piston area at extension side **A1** [mm^2]	Piston area at retraction side **A2** [mm^2]
4	2	12.6	9.4
6	3	28.3	21.2
8	5	50.3	30.6
10	4	78.5	66.0
12	6	113	84.8
16	5	201	181
	6	201	173
	8	201	151
20	8	314	264
	10	314	236
25	10	491	412
	12	491	378
32	12	804	691
	16	804	603
40	14	1260	1100
	16	1260	1060
50	20	1960	1650
63	20	3120	2800
80	25	5030	4540
100	30	7850	7150
125	32	12300	11500
	36	12300	11300
140	32	15400	14600
	36	15400	14400
160	38	20100	19000
	40	20100	18800
180	40	25400	24200
	45	25400	23900
200	40	31400	30200
	50	31400	29500
250	60	49100	46300
300	70	70700	66800

∗ Refer to the "Dimensions" section for the piston rod size.

Load ratio η

In selecting a cylinder, do not forget that in addition to the load, there are many forces that act upon the cylinder. Even in the stationary state shown in the diagram below, the resistances of the seals and the bearings in the cylinder must be subtracted. Furthermore, during operation, recoil due to the exhaust pressure also come into play.



Stationary **Operation**

These forces that act against the cylinder vary according to the conditions of the cylinder such as its size, pressure, and speed. Therefore, it is recommended to always select a cylinder of a larger size. Thus, select an air cylinder so that the load factor, which is a factor that is used in the selection process, will be as shown below.

1) To use a cylinder for stationary operations:
   load factor η = 0.7 or below (Fig.1)
2) To use a cylinder for dynamic operations:
   load factor η = 0.5 or below (Fig.2)
3) To use a cylinder with a guide for horizontal operations:
   load factor η = 1 or below (Fig. 3)

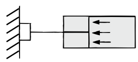


Fig. 1 η = 0.7 or less

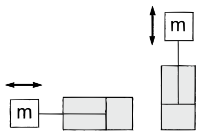


Fig. 2 η = 0.5 or less

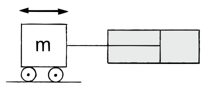
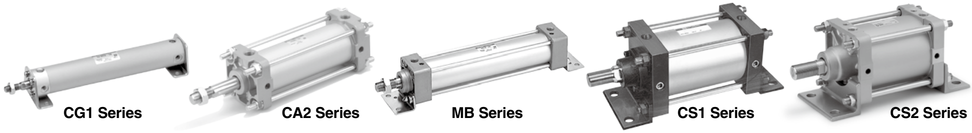


Fig. 3 η = 1 or less

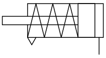
Note) If a dynamic high-speed operation is particularly needed, further reduce the load factor. Then, the cylinder will have power to spare for the amount by which the load factor has been reduced, which will make it easier to produce speed.

Meanwhile, a cylinder force that has been calculated by multiplying only the operating pressure by the pressure receiving area, assuming that no resistance exists in the cylinder, is called a "theoretical output".
For details about the theoretical output, refer to Data 3, page 1575.



② Single Acting Cylinder

1. Single acting, Spring return type



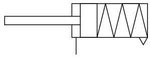
Formula

$$F_1 = \eta \times (A_1 \times P - f_2) \quad \cdots\cdots (3)$$
$$F_2 = \eta \times f_1 \quad \cdots\cdots (4)$$

F_1: Cylinder force at extension side [N]
F_2: Cylinder force at retraction side [N]
η: Load ratio (Same as double acting type cylinder. Refer to page 1570.)
A_1: Piston area at extension side [mm^2]
P: Operating pressure [MPa]
f_2: Spring reaction force (Outlet) [N] → Refer to "Table (2)".
f_1: Spring reaction force (Inlet) [N] → Refer to "Table (2)".

Note) Avoid applying a load on the cylinder as much as possible, because the value of the output force of a cylinder at the retraction side could be small.

2. Single acting, Spring extend type



Formula

$$F_1 = \eta \times f_1 \quad \cdots\cdots (5)$$
$$F_2 = \eta \times (A_2 \times P - f_2) \quad \cdots\cdots (6)$$

A_2: Piston area at retraction side [mm^2]

Note) Avoid loading the cylinder since the cylinder force at the extension side is a small value.

Table (2) Spring Reaction Force/Single Acting

(N)

Series	Bore size (mm)	Spring reaction force (N)	
		Outlet	Inlet
CJ1 Note)	2.5	1.13	0.64
	4	3.04	1.47
CJP Note)	4	2.80	1.00
	6	3.92	1.42
	10	5.98	2.45
	15	10.8	4.41
CJ2 Note) **CVJ3***	6	3.72	1.77
	10	6.86	3.53
	16	14.2	6.86

* Use the same spring for the spring return type.
* CVJ3: ø10, ø16 only.
Note) The spring reaction force is the same for each standard stroke.

CQ2 Series/Single Acting, Spring Return (N)

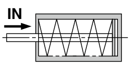
Bore size (mm)	Stroke (mm)	Spring reaction force (N)	
		Outlet	Inlet
12	5	13	8.6
	10	13	3.9
16	5	15	10.3
	10	15	5.9
20	5	15	10
	10	15	5.9
25	5	20	16
	10	20	11
32	5	30	23
	10	30	16
40	5	30	13
	10	39	21
50	10	50	30
	20	54	24

CQ2 Series/Single Acting, Spring Extend (N)

Bore size (mm)	Stroke (mm)	Spring reaction force (N)	
		Outlet	Inlet
12	5	11	2.9
	10	9.7	2.8
16	5	20	3.9
	10	20	3.9
20	5	27	5.3
	10	27	5.9
25	5	29	9.8
	10	29	9.8
32	5	29	20
	10	29	20
40	5	29	20
	10	29	20
50	10	83	24
	20	83	24

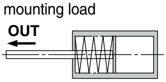
1. Single acting, Spring return

Spring in pre-loaded condition



When the spring is set in the cylinder

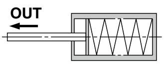
Spring of outlet mounting load



When the spring is contracted by supplying air

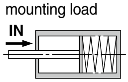
2. Single acting, Spring extend

Spring in pre-loaded condition



When the spring is set in the cylinder

Spring of outlet mounting load



When the spring is contracted by supplying air

Technical Data 1:
Bore Size Selection

Data 1 Bore Size Selection

Table (3) Spring Reaction Force/Single Acting

CU Series/Single Acting, Spring Return (N)

Bore size (mm)	Stroke (mm)	Spring reaction force (N)	
		Outlet	Inlet
6	5	3.5	2.9
	10	3.5	2.2
	15	3.5	1.6
10	5	6.9	5.0
	10	6.9	3.0
	15	6.9	3.3
16	5	14.7	10.3
	10	14.7	5.9
	15	14.7	9.3
20	5	15	11
	10	15	6
	15	21	10
25	5	21	16
	10	21	11
	15	28	14
32	5	30	23
	10	30	16
	15	34	17

∗ Use the same spring for the spring return type.

CM2 Series
CVM3 Series (N)

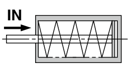
Bore size (mm)	Stroke (mm)	Spring reaction force (N)	
		Outlet	Inlet
20	25	39	24
	50		7.8
	75		17
	100		9.8
	125		14
	150		8.8
25	25	47	30
	50		14
	75		25
	100		17
	125		21
	150		16
32	25	67	41
	50		15
	75		31
	100		20
	125		26
	150		18
	175		25
	200		20
40	25	76	50
	50		24
	75		36
	100		24
	125		32
	150		24
	175		30
	200		24
	225		29
	250		24

CG1 Series (N)

Bore size (mm)	Stroke (mm)	Spring reaction force (N)	
		Outlet	Inlet
20	25	39	24
	50		7.8
	75		17
	100		9.8
	125		14
25	25	47	30
	50		14
	75		24
	100		17
	125		21
	150		24
	200		17
32	25	67	40
	50		15
	75		31
	100		20
	125		25
	150		31
	200		20
40	25	76	50
	50		24
	75		36
	100		24
	125		32
	150		36
	200		24

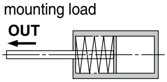
1. Single acting, Spring return

Spring in pre-loaded condition



When the spring is set in the cylinder

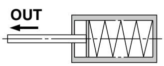
Spring of outlet mounting load



When the spring is contracted by supplying air

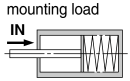
2. Single acting, Spring extend

Spring in pre-loaded condition

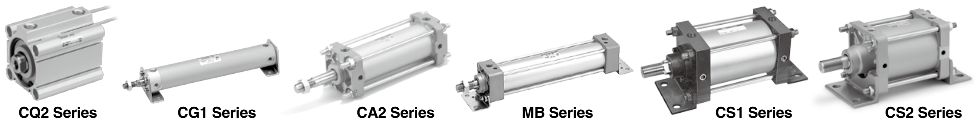


When the spring is set in the cylinder

Spring of outlet mounting load



When the spring is contracted by supplying air



CQ2 Series CG1 Series CA2 Series MB Series CS1 Series CS2 Series

③ Cushion

When a load that is operated by a cylinder must be stopped at the end of the stroke, the piston in the cylinder will collide with the cover unless an external stopper is provided. A built-in function that cushions the impact and the sound that are generated at this time is the cushion mechanism.
There are two types in the cushion mechanism as below.

Rubber bumper: Dampens the impact sound and prevents the installation area from becoming loosened or damaged by the impact.

Air cushion: Similar to a rubber bumper, but achieves a higher level of effectiveness. It cushions the vibrations that are generated by collision.

Note) Depending on the model of the cylinder, it might not be possible to have either of the above two cushions built into the cylinder.

Even if the one of the cushion mechanisms described above is used for stopping a load, it might not be possible to completely absorb the impact if the kinetic energy of he load is too large. Therefore, be careful of overloading or excessive speed.
The kinetic energy of a load for linear motion can be expressed by the formula given below.

Formula

$$E = \frac{m}{2} \times V^2 \cdots\cdots (7)$$

E: Kinetic energy [J]
m: Load mass [kg]
V: Max. piston speed [m/s]

Kinetic energy absorbable by the cushion mechanism is the table at right. When the values are exceeded, following countermeasures are required like using a bigger bore size cylinder or mounting an external stopper, etc.

CQ2 Series

Bore size (mm)	Allowable kinetic energy (J)	
	Standard type	With rubber bumper
12	0.022	0.043
16	0.038	0.075
20	0.055	0.11
25	0.09	0.18
32	0.15	0.29
40	0.26	0.52
50	0.46	0.91
63	0.77	1.54
80	1.36	2.71
100	2.27	4.54
125	—	7.4
140	—	9.8
160	—	12.4
180		
200		

RQ Series

Bore size (mm)	Effective cushion length (mm)	Kinetic energy absorbable (J)
20	5.8	0.40
25	6.1	0.63
32	6.6	1.00
40	6.6	1.60
50	7.1	2.50
63	7.0	4.00
80	7.5	6.40
100	8.0	10.00

Kinetic Energy Absorbable by the Cushion Mechanism

CJ2 Series

Bore size (mm)	Rubber bumper	Air cushion	
	Allowable kinetic energy (J)	Effective cushion length (mm)	Kinetic energy absorbable (J)
6	0.012	—	—
10	0.035	9.4	0.07
16	0.090	9.4	0.18

CM2 Series (Male thread type)

Bore size (mm)	Rubber bumper	Air cushion	
	Allowable kinetic energy (J)	Effective cushion length (mm)	Kinetic energy absorbable (J)
20	0.27	11.0	0.54
25	0.4	11.0	0.78
32	0.65	11.0	1.27
40	1.2	11.8	2.35

CG1 Series (Male thread type)

Bore size (mm)	Rubber bumper	Air cushion	
	Allowable kinetic energy (J)	Effective cushion length (mm)	Kinetic energy absorbable (J)
20	0.28	R: 7.0, H: 7.5	R: 0.35, H: 0.42
25	0.41	R: 7.0, H: 7.5	R: 0.56, H: 0.65
32	0.66	7.5	0.91
40	1.2	8.7	1.8
50	2.0	11.8	3.4
63	3.4	11.8	4.9
80	5.9	17.3	11.8
100	9.9	15.8	16.7

R: Rod side, H: Head side

CA2, CS1, CS2 Series

Bore size (mm)	Effective cushion length (mm)	Kinetic energy absorbable (J)
40	15.0	2.8
50	15.0	4.6
63	15.0	7.8
80	24.0	16
100	29.0	29
125	21.0	32.3
140	21.0	44.6
160	21.0	58.8
180	22.5	78.4
200	22.5	98.0
250	28.5	147
300	28.5	265

MB Series

Bore size (mm)	Effective cushion length (mm)	Kinetic energy absorbable (J)
32	18.8	2.2
40	18.8	3.4
50	21.3	5.9
63	21.3	11
80	30.3	20
100	29.3	29
125	R: 31.4 H: 29.4	43

R: Rod side, H: Head side

Technical Data 2: Air Consumption and Required Air Volume

Data 2 Air Consumption and Required Air Volume

The air consumption is the volume of air that is consumed in the cylinder or in the piping between the cylinder and the switching valve during the reciprocal movement of an air cylinder. It is necessary for selecting a compressor and for calculating the running cost.
The required air volume is the volume of air that is required for operating the cylinder at a specified speed, and it is necessary for selecting the diameter ofthe piping upstream from switching valve or the FRL equipment.

1. Air Consumption

Formula

$$qc1 = A_1 \times L \times \frac{(P_1 + 0.1)}{0.1} \times 10^{-6} \quad \cdots\cdots (8)$$

$$qc2 = A_2 \times L \times \frac{(P_2 + 0.1)}{0.1} \times 10^{-6} \quad \cdots\cdots (9)$$

$$qp1 = a_1 \times \ell_1 \times \frac{P_1}{0.1} \times 10^{-6} \quad \cdots\cdots (10)$$

$$qp2 = a_2 \times \ell_2 \times \frac{P_2}{0.1} \times 10^{-6} \quad \cdots\cdots (11)$$

Double acting cylinder

$$q = qc_1 + qp_1 + qc_2 + qp_2 \quad \cdots\cdots (12)$$

Single acting, Spring return type cylinder

$$q = qc_1 + qp_1 \quad \cdots\cdots (13)$$

Single acting, Spring extend type cylinder

$$q = qc_2 + qp_2 \quad \cdots\cdots (14)$$

q_c	= Air consumption of air cylinder	[dm³ (ANR)]
q_p	= Air consumption of tubing or piping	[dm³ (ANR)]
q	= Air consumption required for one stroke of air cylinder	[dm³ (ANR)]
A	= Piston area at extension side	[mm²]
L	= Cylinder stroke	[mm]
P	= Operating pressure	[MPa]
ℓ	= Piping length	[mm]
a	= Piping internal sectional area	[mm²]

Subscript 1: Extension side
Subscript 2: Retraction side

Internal Sectional Area of Tubing and Steel Piping

Nominal size	O.D. (mm)	I.D. (mm)	Internal sectional area **a** (mm²)
T□0425	4	2.5	4.9
T□0604	6	4	12.6
TU0805	8	5	19.6
T□0806	8	6	28.3
1/8B	—	6.5	33.2
T□1075	10	7.5	44.2
TU1208	12	8	50.3
T□1209	12	9	63.6
1/4B	—	9.2	66.5
TS1612	16	12	113
3/8B	—	12.7	127
T□1613	16	13	133
1/2B	—	16.1	204
3/4B	—	21.6	366
1B	—	27.6	598

2. Required Air Volume

Formula

$$Q_1 = \frac{(qc_1 + qp_1)}{t_1} \times 60 \quad \cdots\cdots (15)$$

$$Q_2 = \frac{(qc_2 + qp_2)}{t_2} \times 60 \quad \cdots\cdots (16)$$

Q = Bigger one between Q_1 and Q_2

Q	= Required air	[dm³/min (ANR)]
t	= Time for whole stroke	[s]

Subscript 1: Extension side
Subscript 2: Retraction side

For calculating the volume of air consumption and required air in accordance with each condition, please make use of our "Equipment Selection Program" and "Energy Saving Program".

Technical Data 3:
Theoretical Output Table

Data 3 Theoretical Output

Applicable cylinder: **CJ2, CM2, CG1, CA2, MB, CS1, CS2 Series**

CJ2 Series (ø6 to ø16) **CM2 Series (ø20 to ø40)** **CG1 Series (ø20 to ø100)** **CA2 Series (ø40 to ø100)** **MB Series (ø32 to ø125)** **CS1 Series (ø125 to ø300)** **CS2 Series (ø125 to ø160)**

∗ Even the theoretical output of non-applicable cylinders can be calculated using the bore and rod sizes in the table below.

OUT IN

Double Acting Cylinder

(N)

Bore size (mm)	Rod size (mm)	Operating direction	Piston area (mm²)	Operating pressure (MPa)								
				0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
6	3	OUT	28.3	5.66	8.49	11.3	14.2	17.0	19.8	—	—	—
		IN	21.2	4.24	6.36	8.48	10.6	12.7	14.8	—	—	—
10	4	OUT	78.5	15.7	23.6	31.4	39.3	47.1	55.0	—	—	—
		IN	66.0	13.2	19.8	26.4	33.0	39.6	46.2	—	—	—
16	5	OUT	201	40.2	60.3	80.4	101	121	141	—	—	—
		IN	181	36.2	54.3	72.4	90.5	109	127	—	—	—
20	8	OUT	314	62.8	94.2	126	157	188	220	251	283	314
		IN	264	52.8	79.2	106	132	158	185	211	238	264
25	10	OUT	491	98.2	147	196	246	295	344	393	442	491
		IN	412	82.4	124	165	206	247	288	330	371	412
32	12	OUT	804	161	241	322	402	482	563	643	724	804
		IN	691	138	207	276	346	415	484	553	622	691
40	14	OUT	1260	252	378	504	630	756	882	1010	1130	1260
		IN	1100	220	330	440	550	660	770	880	990	1100
	16	OUT	1260	252	378	504	630	756	882	1010	1130	1260
		IN	1060	212	318	424	530	636	742	848	954	1060
50	20	OUT	1960	392	588	784	980	1180	1370	1570	1760	1960
		IN	1650	330	495	660	825	990	1160	1320	1490	1650
63	20	OUT	3120	624	936	1250	1560	1870	2180	2500	2810	3120
		IN	2800	560	840	1120	1400	1680	1960	2240	2520	2800
80	25	OUT	5030	1010	1510	2010	2520	3020	3520	4020	4530	5030
		IN	4540	908	1360	1820	2270	2720	3180	3630	4090	4540
100	30	OUT	7850	1570	2360	3140	3930	4710	5500	6280	7070	7850
		IN	7150	1430	2150	2860	3580	4290	5010	5720	6440	7150
125	32	OUT	12300	2460	3690	4920	6150	7380	8610	9840	11100	12300
		IN	11500	2300	3450	4600	5750	6900	8050	9200	10400	11500
	36	OUT	12300	2460	3690	4920	6150	7380	8610	9840	11100	12300
		IN	11300	2260	3390	4520	5650	6780	7910	9040	10200	11300
140	32	OUT	15400	3080	4620	6160	7700	9240	10800	12300	13900	15400
		IN	14600	2920	4380	5840	7300	8760	10200	11700	13100	14600
	36	OUT	15400	3080	4620	6160	7700	9240	10800	12300	13900	15400
		IN	14400	2880	4320	5760	7200	8640	10100	11500	13000	14400
160	38	OUT	20100	4020	6030	8040	10100	12100	14100	16100	18100	20100
		IN	19000	3800	5700	7600	9500	11400	13300	15200	17100	19000
	40	OUT	20100	4020	6030	8040	10100	12100	14100	16100	18100	20100
		IN	18800	3760	5640	7520	9400	11300	13200	15000	16900	18800
180	45	OUT	25400	5080	7620	10200	12700	15200	17800	20300	22900	25400
		IN	23900	4780	7170	9560	12000	14300	16700	19100	21500	23900
200	50	OUT	31400	6280	9420	12600	15700	18800	22000	25100	28300	31400
		IN	29500	5900	8850	11800	14800	17700	20700	23600	26600	29500
250	60	OUT	49100	9820	14700	19600	24600	29500	34400	39300	44200	49100
		IN	46300	9260	13900	18500	23200	27800	32400	37000	41700	46300
300	70	OUT	70700	14100	21200	28300	35400	42400	49500	56600	63600	70700
		IN	66800	13400	20000	26700	33400	40100	46800	53400	60100	66800

Single Acting, Spring Return Cylinder

(N)

Bore size (mm)	Rod size (mm)	Operating direction	Piston area (mm²)	Operating pressure (MPa)								
				0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
2.5	1	OUT	4.90	—	0.34	0.83	1.32	1.81	2.30	—	—	—
		IN	—	0.64								
4	2	OUT	12.6	—	0.74	2.00	3.26	4.52	5.78	—	—	—
		IN	—	1.47								
6	3	OUT	28.3	1.94	4.77	7.60	10.4	13.3	16.1	—	—	—
		IN	—	1.77								
10	4	OUT	78.5	8.84	16.7	24.5	32.4	40.2	48.1	—	—	—
		IN	—	3.53								
16	5	OUT	201	26.0	46.1	66.2	86.3	106.4	126.5	—	—	—
		IN	—	6.86								
20	8	OUT	314	23.8	55.2	87	118	149	181	212	244	275
		IN	—	7.8								
25	10	OUT	491	51.2	100	149	199	248	297	346	395	444
		IN	—	14								
32	12	OUT	804	94	174	255	335	415	496	576	657	737
		IN	—	15								
40	14, 16	OUT	1260	176	302	428	554	680	806	934	1054	1184
		IN	—	24								

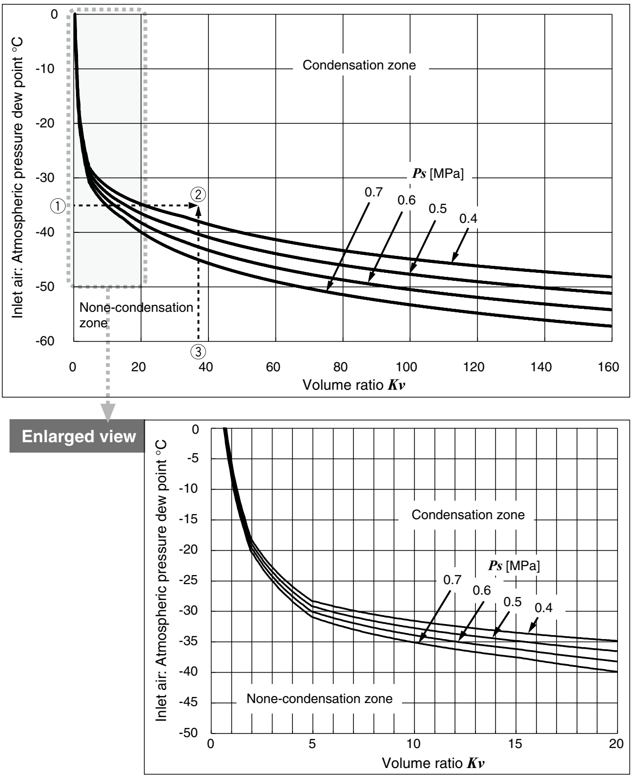
1. In the case of the extension side, theoretical output of single acting cylinder is a value taken secondary mounting load of the spring off theoretical output of double acting cylinder. In the case of the retraction side, take primary mounting load of the spring.
2. Avoid loading the cylinder on the retraction side.

Technical Data 4:
Condensation

Data 4 Condensation

In pneumatic systems, the generation of waterdrops in piping may affect the equipment's operation and service life.
Thus, compressed air that is supplied is normally dehumidified by an air dryer, and is then sent to the system. However, when a compact actuator is used in order to downsize the equipment and correspond to the demand of high speed, condensation may occur and cause damage even if dehumidified air is used.
When selecting cylinders, check the generation of condensation based on the control graph below.

Condensation Control Graph



Conditions
Solenoid vale switching interval: ON 1 sec., OFF 1 sec.
Piping tube material: Polyurethane

How to analyze the control graph

(1) Determine the volume ratio Kv ③.
Determine the volume Kv using the following formula.

$$Kv = \frac{Vt}{Vc} \times \frac{0.1}{Ps + 0.1}$$

Vt: Piping volume [cm^3]
Vc: Cylinder volume [cm^3]
Ps: Supply air gauge pressure [MPa]

(2) Determine the intersection point ② of the atmospheric pressure dew point of supply air ① and volume ratio Kv ③.
(3) Determine whether condensation is generated depending on where the intersection point ② falls.

Refer to a separate catalog, "Condensation Measures of Pneumatic Systems" (Refer to the SMC website.) for the details of measures.
Condensation control can also be determined based on SMC's Pneumatic Equipment Model Selection Program Ver. 3.5.