PM/31000 Compact air bellows

Single acting - Ø 2 3/4 ... 12 inch

Frictionless operation

No maintenance or lubrication

Ideal for short stroke, high-force applications

High vibration isolation level

Easy, compact installation

Important instructions:

The design of these air bellows allows an operation at an angle of 5° ... 25°. The top and bottom plate can be out of alignment, depending on the height of the air bellow and the number of convolutions.

To avoid damage mechanical stops at **both** end positions have to be used. To return Air Bellows to their minimum height an external return force must be used. The thrust depends directly on the height of the air bellow: When height increases – the thrust decreases. As the outside diameter varies in operation there must be enough clearance around the air bellow.

TECHNICAL DATA

Medium:

Compressed air, non-lubricated

Operating pressure:

8 bar maximum

Operating temperature:

-40°C ... +70°C for PM/31000

-25°C ... +90°C for TPM/31000

-20°C ... +115°C for EPM/31000

Consult our Technical Service for use below +2°C

MATERIALS

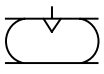
End plates: plastic Ø 2 3/4, 6 inch, aluminium Ø 4 inch; steel, chromated Ø 8, 9 1/4, 12 inch

Central ring: plastic, aluminium or steel, chromated

Bellow: PM/31000: fabric reinforced NR-, SBR-, BR-compound rubber

STANDARD MODELS

Nominal Ø (inch) x convolutions	Maximum stroke (mm)	Port size	MODELS Standard	Butyl	Epichlore
2 3/4 x 1	20	G1/4	**PM/31021**	**TPM/31021**	**EPM/31021**
2 3/4 x 2	45	G1/4	**PM/31022**	**TPM/31022**	**EPM/31022**
2 3/4 x 3	65	G1/4	**PM/31023**	**TPM/31023**	**EPM/31023**
4 1/2 x 1	40	G3/8	**PM/31041**	**TPM/31041**	**EPM/31041**
4 1/2 x 2	80	G3/8	**PM/31042**	**TPM/31042**	**EPM/31042**
6 x 1	55	G1/2	**PM/31061**	**TPM/31061**	**EPM/31061**
6 x 2	115	G1/2	**PM/31062**	**TPM/31062**	**EPM/31062**
8 x 1	95	G3/4	**PM/31081**	**TPM/31081**	**EPM/31081**
8 x 2	185	G3/4	**PM/31082**	**TPM/31082**	**EPM/31082**
9 1/2 x 1	105	G3/4	**PM/31091**	**TPM/31091**	**EPM/31091**
9 1/2 x 2	230	G3/4	**PM/31092**	**TPM/31092**	**EPM/31092**
12 x 1	105	G3/4	**PM/31121**	**TPM/31121**	**EPM/31121**
12 x 2	215	G3/4	**PM/31122**	**TPM/31122**	**EPM/31122**



Safety note: These actuators must not be pressurised when unrestrained.
For exact calculation for compact air bellows please contact our Technical Service.

OPTIONS SELECTOR

★PM/31★★★

Air bellow materials	Substitute
NR-, SBR-, BR-Materials	**None**
High temperature (Butyl)	**T**
Extreme temperature (Epichlore)	**E**

Number of convolutions	Substitute
1	**1**
2	**2**
3	**3**

Nominal diameters (inches)	Substitute
2 3/4	**02**
4 1/2	**04**
6	**06**
8	**08**
9 1/4	**09**
12	**12**

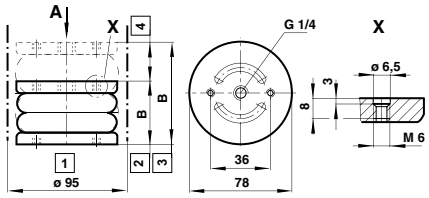
Note: If option is not required, disregard option position within part number e.g. PM/31023. For combinations of cylinder variants consult our Technical Service.
This options selector explains only the cylinder variants. Additional variants/options are not possible.
Information about variants see data sheet.

For further information

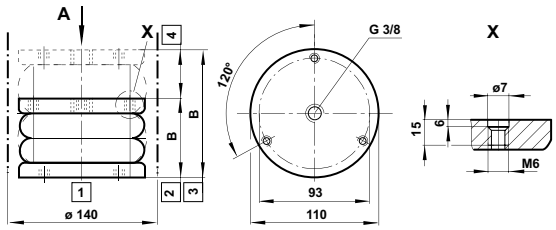
www.norgren.com/info/en1-246

BASIC DIMENSIONS

PM/31021, PM/31022, PM/31023



PM/31041, PM/31042



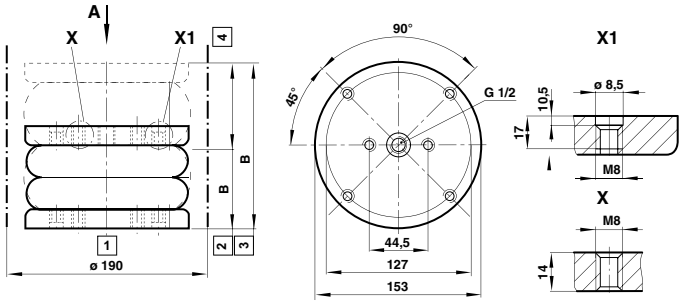
1 Installation diameter min.
2 Installation height min.
3 Installation height max.
4 Stroke

Table 1.1

MODELS	Nominal diameter (inch) x convolutions	Stroke (mm)	Installation height B min. (mm)	Installation height B max. (mm)	Weight (kg)
PM/31021	2 3/4 x 1	20	50	70	0,22
PM/31022	2 3/4 x 2	45	65	110	0,26
PM/31023	2 3/4 x 3	60	80	140	0,30
PM/31041	4 1/2 x 1	40	50	90	0,75
PM/31042	4 1/2 x 2	85	65	150	0,95
PM/31043	4 1/2 x 3	100	100	200	1,20

BASIC DIMENSIONS

PM/31061
to PM/31063



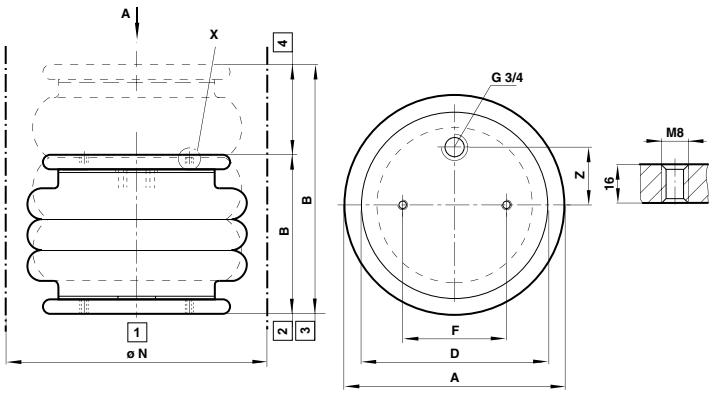
1 Installation diameter min.
2 Installation height min.
3 Installation height max.
4 Stroke

Table 1.2

MODELS	Nominal diameter (inch) x convolutions	Stroke (mm)	Installation height B min. (mm)	Installation height B max. (mm)	Weight (kg)
PM/31061	6 x 1	55	55	110	0,95
PM/31062	6 x 2	115	80	195	1,30
PM/31063	6 x 3	190	100	290	1,63

BASIC DIMENSIONS

PM/31081
to PM/31123



1 Installation diameter min.
2 Installation height min.
3 Installation height max.
4 Stroke

Table 1.3

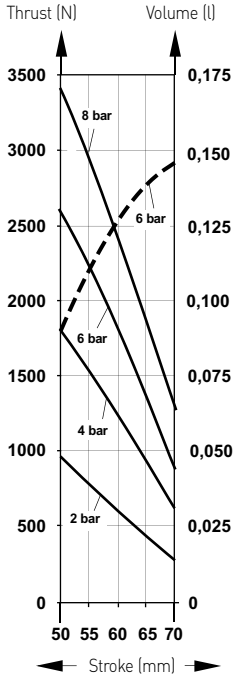
MODELS	Nominal Ø (inch) x convolutions	(mm)	Stroke B min. (mm)	Installation height B max. (mm)	Ø A	Ø D	Ø F	Ø N	Z	Weight (kg)
PM/31081	8 x 1	95	60	155	225	135	70	240	0	1,80
PM/31082	8 x 2	185	80	265	220	135	70	240	0	2,50
PM/31091	9 1/4 x 1	105	55	160	255	160	89	275	38,1	2,30
PM/31092	9 1/4 x 2	220	80	300	255	160	89	275	38,1	2,80
PM/31121	12 x 1	105	60	165	335	228	157,5	360	73	3,90
PM/31122	12 x 2	215	85	300	325	228	157,5	350	73	5,30
PM/31123	12 x 3	345	120	465	325	228	157,5	350	73	7,00

PM/31000 Compact air bellows

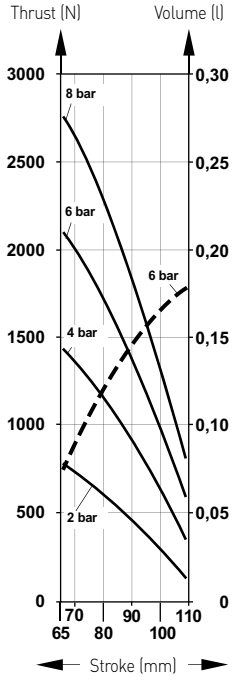
Single acting - Ø 2 3/4 ... 12 inch

Thrust (at 2, 4, 6, 8 bar), volume (at 6 bar)

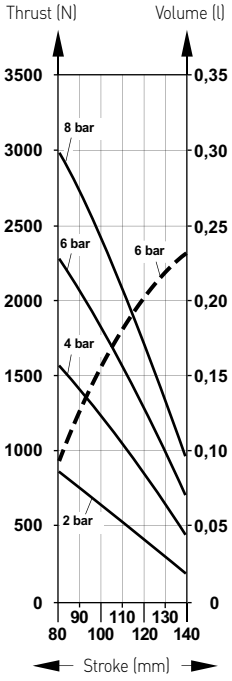
PM/31021



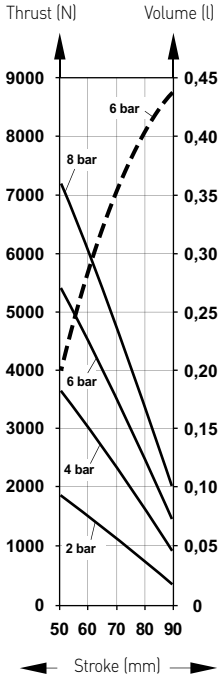
PM/31022



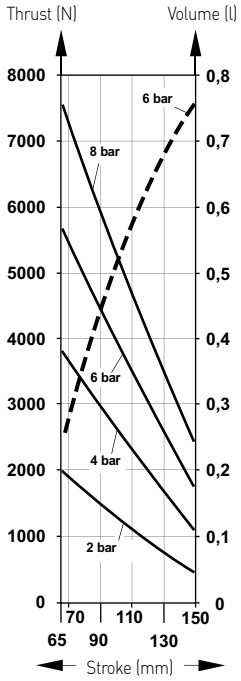
PM/31023



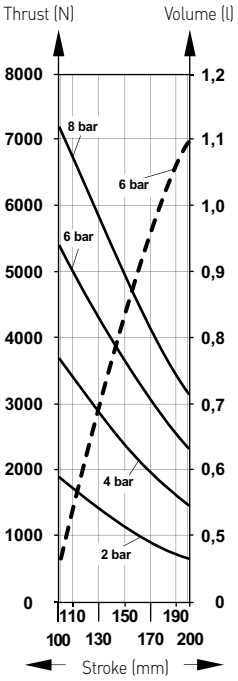
PM/31041



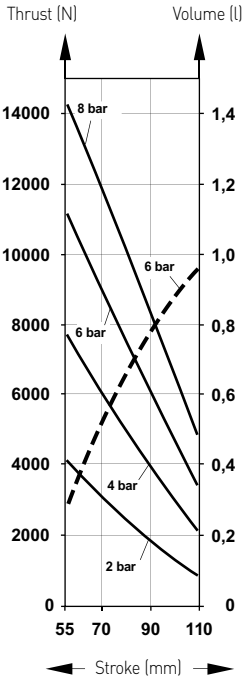
PM/31042



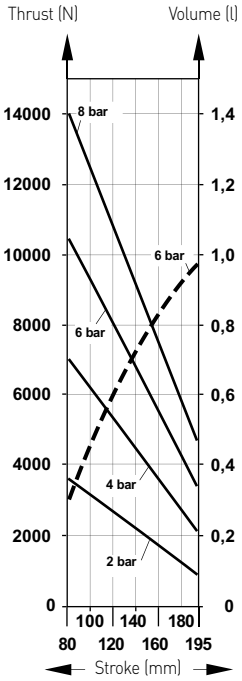
PM/31043



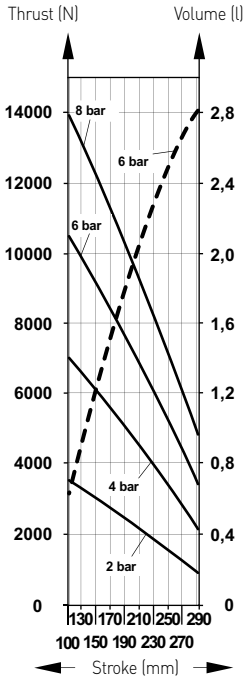
PM/31061



PM/31062



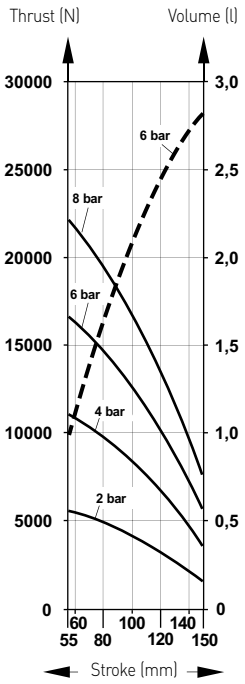
PM/31063



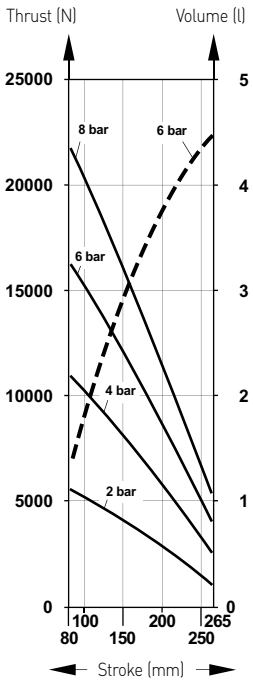
-- Thrust (N) - - Volume (l)

Thrust (at 2, 4, 6, 8 bar), volume (at 6 bar)

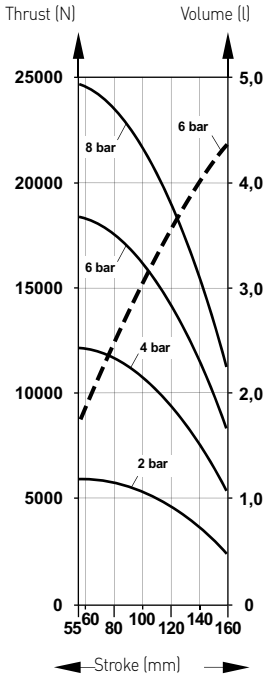
PM/31081



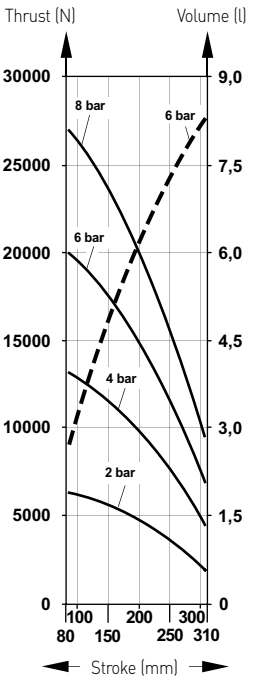
PM/31082



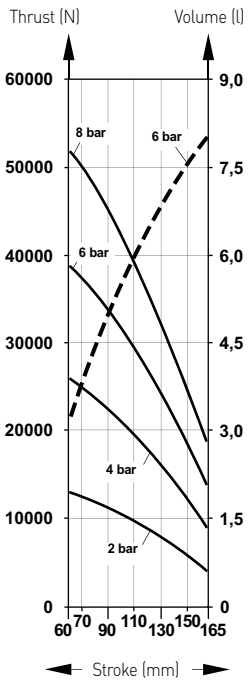
PM/31091



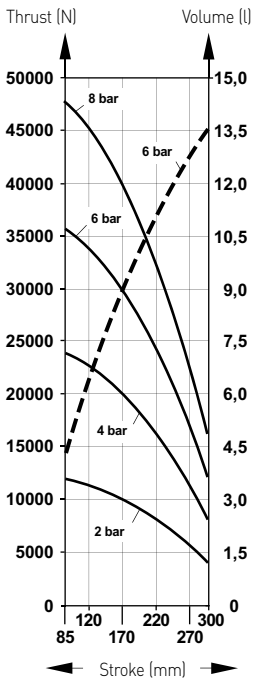
PM/31092



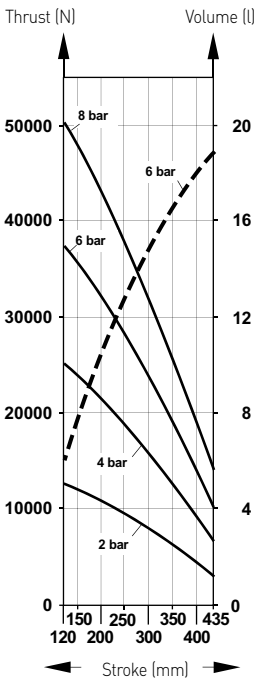
PM/31121



PM/31122



PM/31123



-- Thrust (N) - - Volume (l)

PM/31000 Compact air bellows

Single acting - Ø 2 3/4 ... 12 inch

CALCULATION OF COMPACT AIR BELLOWS USED AS ACTUATORS

Datasheet

a) Total weight to be lifted: F = (_____ kg) • 10 m/s^2 = _____ N

b) Number of air bellows: n = _____

c) Thrust per air bellow: f = $\frac{F}{n}$ = _____ N

d) Operating pressure: P = _____ bar

e) Required stroke: S = _____ mm

f) Vertical space: Xv = _____ mm

g) Horizontal space: Xh = _____ mm

h) Operating temperature: T = _____ °C

i) Operation angle: α = _____ °

j) Out of alignment: A = _____ mm

k) Chemical resistance: _____

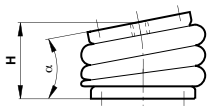
Important instructions

Thrust: The thrust depends on the height of the bellow. When height increases – the thrust decreases.
Stops: To avoid damage when the bellow is compressed or extended mechanical stops at both end positions have to be used.
Clearance: There must be enough clearance around the Air Bellow.

TABLE 2: THRUST, INSTALLATION HEIGHT, RETRACTING FORCE

MODELS	Nominal Ø (inch) x convolutions	Stroke (mm)	Installation height B min. (mm)	Thrust at 6 bar (N)	Retracting force to reach min. height (N)	Installation height B max. (mm)	Thrust at 6 bar (N)
PM/31021	2 3/4 x 1	20	50	2600	200	70	920
PM/31022	2 3/4 x 2	45	65	2130	310	110	540
PM/31023	2 3/4 x 3	60	80	23000	300	140	700
PM/31041	4 1/2 x 1	40	50	5500	120	90	1400
PM/31042	4 1/2 x 2	85	65	5750	240	150	1700
PM/31043	4 1/2 x 3	100	100	5350	220	200	2300
PM/31061	6 x 1	55	55	11400	200	110	3330
PM/31062	6 x 2	115	80	10600	220	195	3400
PM/31063	6 x 3	190	100	10550	250	290	2950
PM/31081	8 x 1	95	60	16300	60	155	4600
PM/31082	8 x 2	185	80	16500	110	265	3950
PM/31091	9 1/4 x 1	105	55	19600	150	160	8250
PM/31092	9 1/4 x 2	220	80	20150	170	300	4900
PM/31121	12 x 1	105	60	39000	50	165	13850
PM/31122	12 x 2	215	85	35800	100	300	11750
PM/31123	12 x 3	345	120	38100	140	465	6600

Operation angle



Out of alignment

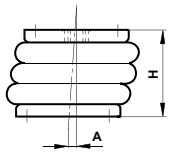


TABLE 3

MODELS	Nominal Ø (inches) x Convolutions	Height H (mm) at α = 5°	α = 10°	α = 15°	α = 20°	α = 25°
PM/31021	2 3/4 x 1	–	–	–	–	–
PM/31022	2 3/4 x 2	75 – 100	80 – 95	–	–	–
PM/31023	2 3/4 x 3	90 – 120	95 – 110	–	–	–
PM/31041	4 1/2 x 1	60 – 75	–	–	–	–
PM/31042	4 1/2 x 2	75 – 130	80 – 125	90 – 120	100 – 115	–
PM/31043	4 1/2 x 3	120 – 170	135 – 160	–	–	–
PM/31061	6 x 1	65 – 90	70 – 85	–	–	–
PM/31062	6 x 2	–	95 – 160	100 – 155	110 – 150	115 – 140
PM/31063	6 x 3	145 – 245	165 – 225	–	–	–
PM/31081	8 x 1	85 – 130	100 – 125	–	–	–
PM/31082	8 x 2	130 – 250	175 – 245	180 – 240	185 – 230	–
PM/31091	9 1/4 x 1	75 – 140	100 – 130	–	–	–
PM/31092	9 1/4 x 2	145 – 270	160 – 265	190 – 255	210 – 240	–
PM/31121	12 x 1	90 – 140	115 – 135	–	–	–
PM/31122	12 x 2	140 – 285	155 – 275	160 – 265	170 – 260	–
PM/31123	12 x 3	200 – 400	300 – 375	310 – 350	–	–

MODELS	Height H (mm) at A = 5 mm	A = 10 mm	A = 20 mm	A = 30 mm	A = 40 mm	A = 50 mm
PM/31021	–	–	–	–	–	–
PM/31022	80 – 100	85 – 95	–	–	–	–
PM/31023	90 – 125	100-115	–	–	–	–
PM/31041	60 – 80	–	–	–	–	–
PM/31042	85 – 135	95 – 130	–	–	–	–
PM/31043	110 – 170	120 – 160	–	–	–	–
PM/31061	–	75 – 85	–	–	–	–
PM/31062	–	115 – 170	130 – 160	–	–	–
PM/31063	120 – 255	125 – 245	130 – 235	–	–	–
PM/31081	–	95 – 140	110 – 135	–	–	–
PM/31082	–	130 – 250	160 – 240	170 – 235	180 – 230	–
PM/31091	–	70 – 150	115 – 145	–	–	–
PM/31092	–	150 – 270	165 – 265	180 – 260	190 – 250	–
PM/31121	–	100 – 155	115 – 150	120 – 140	–	–
PM/31122	–	135 – 280	160 – 270	180 – 265	190 – 260	–
PM/31123	–	170 – 3854	200 – 365	220 – 355	230 – 350	235 – 345

SELECTING COMPACT AIR BELLOWS

Example: used as actuators

A 1000 kg conveyor carrying a 550 kg pallet needs to be lifted by 80 mm (stroke) in order to transfer the pallet to another level. Four (4) air bellows should be used. The available operating pressure is 5 bar. The operating temperature is 60°C. There is a 270 mm square space to house each air bellow. Compression and extension stops are provided. The air bellows have to be mounted between in a space which are 85 mm apart. During the lifting operation the conveyor may tilt in the second half of the stroke by a max. of 9°.

Step 1: Fill in and complete the datasheet

a) Total weight to be lifted:
b) Number of air bellows:
c) Thrust per air bellow:

d) Operating pressure:
e) Required stroke:
f) Vertical space:
g) Horizontal space:
h) Operating temperature:
i) Operation angle:
j) Out of alignment:
k) Chemical resistance:

F = (1000 kg + 550 kg) • 10 m/s^2 = 15500 N
n = 4
f = $\frac{15500\ N}{4}$ = 3875 N
P = 5 bar
S = 80 mm
Xv = 85 mm
Xh = 270 mm
T = 60°C
a = 9°
A = 0 mm
normal environment

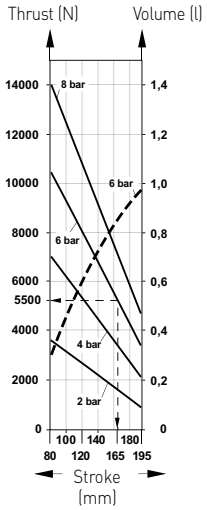
Step 2: From table 1.1. and 1.3. (page 1-002 +1-003) air bellows have to be selected, that have a min. 80 mm stroke and clearance around the air bellows smaller than Xh = 270 mm. We select: PM/31042, PM/31062, PM/31081 and M/31082

Step 3: Calculate the total height at which the air bellow should be used, see step 1:

Vertical space	Xv	85 mm
Stroke	S	80 mm
Total height		165 mm

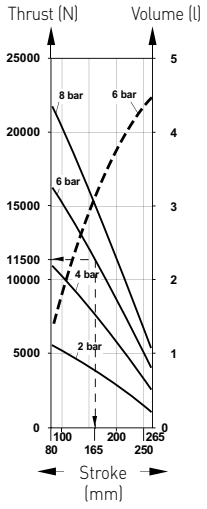
By refering to the total height of 165 mm and the vertical space of 85 mm, only PM/31062 (installation height 80 ... 195 mm) and PM/31082 (installation height 80 ... 265 mm) can be used from table 1.1 ... 1.3 (datasheet 2 and 3)

Step 4: Check the thrust at 6 bar at a height of 165 mm.
From the charts in the datasheet 4 and 5 we can see that:



PM/31062 will provide 5500 N at 6 bar. To get the figure for 5 bar, we have to calculate:

$\frac{55060\ N \bullet 5}{6}$ = 4580 N at 5 bar



PM/31082 will provide 11500 N at 6 bar. To get the figure for 5 bar, we have to calculate:

$\frac{115060\ N \bullet 5}{6}$ = 9200 N at 5 bar

Step 5: Check the angle acceptance when the air bellow can tilt during the second half of the stroke between 125 and 165 mm by approx. 10° from table 3 (page 1-006). At 9° we are well within the limits.

i) PM/31062 can sustain an angle of 9° between 70 and 85 mm
i) PM/31082 can sustain an angle of 9° between 140 and 220 mm
Only PM/31082 can be used in this application,
PM/31062 will not accept 9° at 165 mm.

Step 6: Check all remaining parameters

h) At 60°C Standard rubber material (-40 ... +70°C) can be used
j) No horizontal miss-alignmenta
k) No special chemical resistance is required

Result: PM/31082 is the chosen compact air bellow, because it meets all requirements.

Result:
Both air bellows can provide the required thrust of 3875 N.

PM/31000 Compact air bellows

Single acting - Ø 2 3/4 ... 12 inch

CALCULATION OF COMPACT AIR BELLOWS USED AS VIBRATION ISOLATORS

Datasheet

a) Total weight to be isolated: F = (_____ kg) • 10 m/s^2 = _____ N

b) Number of air bellows: n = _____

c) Thrust per air bellow: f = $\frac{F}{n}$ = _____ N

d) Operating pressure: P = _____ bar

f) Vertical space: Xv = _____ mm

g) Horizontal space: Xh = _____ mm

h) Operating temperature: T = _____ °C

k) Chemical resistance: normal environment

m) Isolation rate: I = _____ %

o) Airspring natural frequency: fn = _____ Hz

p) Excitation frequency: fe = _____ Hz

Important instructions

Air Bellows with two convolutions will provide better isolation because of the greater volume of air in comparison to air belows with one convolution. Air bellows used for vibration isolation should be operated at a «vibration height».

This height is the result of tests and represents the optimum height where the air bellow gives the best performance.

The airspring natural frequency (fn) remains nearly constant at the «vibration height». An increase of the height will result in less isolation, a lower height may influence the horizontal (lateral) stability. The optimum pressure for vibration isolation is from 4 ... 6 bar (60 ... 90 psi). The lower the airspring natural frequency (fn) of an Air Bellow the better the vibration isolation. The lateral stability of air bellows decreases with the number of convolutions. It is important to note:

air bellows with three convolutions should not be used without consulting Norgren. Ideally air bellows should be located at the same horizontal plane (at the same height) as the centre of gravity of the machine in order to be vibration isolated.

For the purpose of calculation the following assumptions have been made:

1. Vibrations are all vertical
2. The excitation frequency (fe) varies along a sine curve
3. The object and its base are rigid

TABLE 4:
PRESSURE, VIBRATION HEIGHT, THRUST, VOLUME, STIFFNESS, AIRSPRING NATURAL FREQUENCY, ISOLATION RATE

MODELS	Nominal Ø (inch) x convolutions	Pressure (bar)	Vibration height (mm)	Thrust (N)	Volume (l)	Stiffness (N/cm)	Airspring natural frequency fn (Hz)	Isolation rate I (%) at 10 Hz and 6 bar
PM/31021	2 3/4 x 1	4	62	1050	0,122	961	4,79	70,3
		6	62	1550	0,130	1337	4,60	73,1
PM/31022	2 3/4 x 2	4	90	900	0,140	525	3,76	83,6
		6	90	1400	0,145	725	3,60	85,1
PM/31041	4 1/2 x 1	4	72	2200	0,340	1318	3,87	82,4
		6	72	3350	0,365	1849	3,73	84,0
PM/31042	4 1/2 x 2	4	130	1700	0,655	495	2,71	92,1
		6	130	2600	0,683	714	2,62	92,6
PM/31043	4 1/2 x 3	4	195	1500	1,010	255	2,04	95,7
		6	195	2400	1,080	368	1,96	96,0
PM/31061	6 x 1	4	90	3950	0,750	1919	3,47	86,3
		6	90	6100	0,8780	2722	3,33	87,5
PM/31062	6 x 2	4	160	3650	1,610	794	2,33	94,3
		6	160	5600	1,660	1140	2,25	94,7
PM/31063	6 x 3	4	225	3600	2,300	527	1,91	96,2
		6	225	5450	2,420	755	1,85	96,5
PM/31081	8 x 1	4	115	7150	2,300	1857	2,54	93,1
		6	115	10800	2,360	2653	2,47	93,5
PM/31082	8 x 2	4	200	5800	3,700	873	1,93	96,1
		6	200	8750	3,760	1251	1,89	96,3
PM/31091	9 1/4 x 1	4	115	9850	3,300	2007	2,25	94,7
		6	115	6700	3,430	2814	2,17	95,0
PM/31092	9 1/4 x 2	4	215	8800	6,300	784	1,71	97,0
		6	215	13400	6,520	1206	1,65	97,2
PM/31121	12 x 1	4	125	17050	6,500	3700	2,32	94,3
		6	125	25750	6,640	5300	2,26	94,6
PM/31122	12 x 2	4	220	16250	10,68	1940	1,72	96,9
		6	220	24400	11,04	2760	1,68	97,1

Values for air bellows with three convolutions are not given as they cannot be used as vibration isolators.

Example for selecting compact air bellows used as vibration isolators

A hydraulic power unit with an excitation frequency (fe) between 1200 and 3000 cycles/min (= 20 Hz – 50 Hz) must be vibration isolated. The total weight of the power unit is 6000 kg. The supporting area under the unit is 1,2 m x 0,8 m.

The operating temperature is 50°C. The space for the installation is 220 mm high. Four air bellows will be used. The max. operating pressure is 6 bar. A minimum of 97% vibration isolation has to be reached.

Step 1: Fill in and complete the datasheet

a)	Total weight to be isolated:	F	=	6000 kg • 10 m/s^2 = 60000 N
b)	Number of air bellows:	n	=	4
c)	Thrust per air bellow:	f	=	$\frac{60000\ N}{4}$ = 15000 N
d)	Operating pressure:	P	=	6 bar
f)	Vertical space:	Xv	=	250 mm
g)	Horizontal space:	Xh	=	400 mm
h)	Operating temperature:	T	=	50°C
k)	Chemical resistance:			normal environment
m)	Isolation rate:	I	=	97%
o)	Airspring natural frequency:	fn	=	Hz
p)	Excitation frequency:	fe	=	min. 20 Hz, max. 50 Hz

Two types of air bellows are chosen. Each one has to carry 15000 N at the vibration height. From table 4 (page 1-008) we select:

1. PM/31121 – 25750 N at 6 bar – 2,26 Hz airspring natural frequency (fn)
2. PM/31122 – 24400 N at 6 bar – 1,68 Hz airspring natural frequency (fn)

Step 2:
Take the air bellow with the lowest airspring natural frequency fn = 1,68 Hz in order to get the highest isolation rate refering to fe min. = 20 Hz. Air Bellow PM/31122 is chosen.

Step 3:
Calculate the isolation rate (I) of the PM/31122 by using the formula:

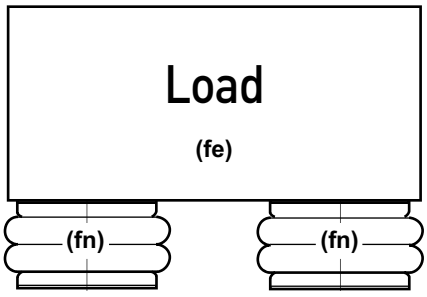
Formula:

$$I = 1 - \frac{1}{\left(\frac{fe}{fn}\right)^2 - 1}$$

Example:

$$I = 1 - \frac{1}{\left(\frac{20}{1,68}\right)^2 - 1} = 1 - \frac{1}{140,72} = 0,993$$

I = 99,3%



fe = Excitation frequency of load
fn = Airspring natural frequency

Step 4:
Check all remaining parameters

e) The installation height of the air bellow PM/31122 is between B min.= 85 mm and B max.= 300 mm (table 1). The vertical space for installation is 220 mm.
The 'vibration height' at which the air bellows operates best is 220 mm (table 4).

f) The clearance around the air bellows. The horizontal space for installation is 400 mm for each air bellows.
The clearance around the air bellow is 350 mm (table 1.3).

h) At 50°C Standard rubber material (-40 ... +70°C) can be used.

g) No special chemical resistance is required.

i) Isolation rate at 10 Hz and 6 bar is 97,1% (table 4). At 20 Hz and 6 bar I= 99,3% is reached.

Result: 4 x PM/31122 compact air bellows are chosen. They will provide 99,3% vibration isolation.