Compact Air Bellows
Single Acting
Ø 2 3/4 to 12 inches

- **Frictionless operation**
- **No maintenance or lubrication**
- **Ideal for short stroke, high-force applications**
- **High isolation level for vibrating machines**
- **Very easy to install – no alignment problems**
- **Bellows fit into small, narrow gaps**

Ordering Example
See page N **1.8.**001.02

Technical Data

Medium:
Compressed air, non-lubricated

Operation:
Single acting

Operating Pressure:
8 bar maximum

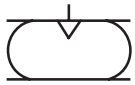
Operating Temperature
-40°C to + 70°C for PM/31000 (Standard)
-25°C to + 90°C for TPM/31000 (Butyl)
-20°C to + 115°C for EPM/31000 (Epichlore)

Nominal Diameters:
2 3/4, 4 1/2, 6, 8, 9 1/4, 12 inches

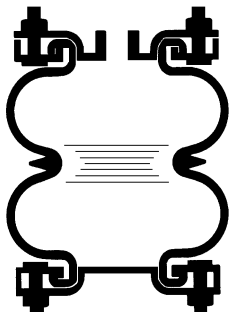
Stroke Lengths:
From 20 to 315 mm max., depending on diameters and number of convolutions

Materials:

End plates:	Plastic Ø 2 3/4, 6 inches Aluminium Ø 4 inches Zinc-chromated steel Ø 8, 9 1/4, 12 inches	
Central ring:	Plastic, aluminium or zinc-chromated steel	
Rubber part:	PM/31000	fabric reinforced NR-, SBR-, BR-compound rubber
	TPM/31000	fabric reinforced Butyl
	EPM/31000	fabric reinforced Epichlore



Important Instructions:
The design of these Air Bellows allows an operation at an angle of 5° to 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.



Air Bellow Variants

Symbol	Model	Description		Dimensions Page
	**PM/31000**	Standard rubber material	Ø 2 3/4 to 12 inches	2 and 3
	TPM/31000	Butyl rubber material	Ø 2 3/4 to 12 inches	2 and 3
	EPM/31000	Epichlore rubber material	Ø 4 1/2 to 12 inches	2 and 3

Model Codes

✶PM/31✶✶✶

Air Bellow Materials	Substitute
High temperature (Butyl)	**T**
Extreme temperature (Epichlore)	**E**

Type	Substitute
Compact	**P**

Threads	
Metric	Port: ISO 228 (BSP)

Series
31000

Number of Convolutions	Substitute
1	**1**
2	**2**
3	**3**

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

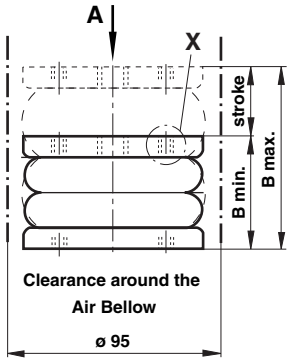
Note: Please fill in only the numbers of digits required e.g. PM/31023

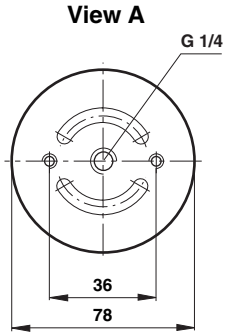
Ordering Example

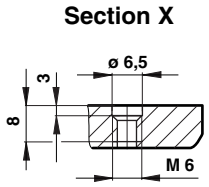
Compact Air Bellows

To order a Compact Air Bellow
in standard rubber material,
a nominal diameter of 8 inches
and 2 convolutions
quote: **PM/31082**

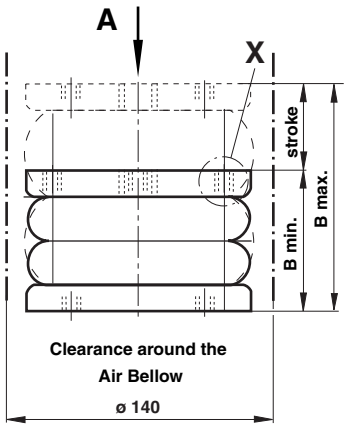
BASIC DIMENSIONS
PM/31021
PM/31022
PM/31023

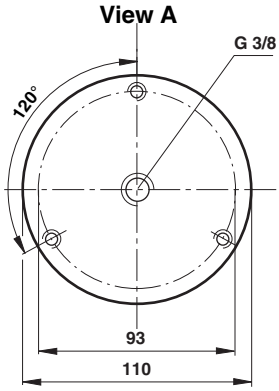






PM/31041
PM/31042





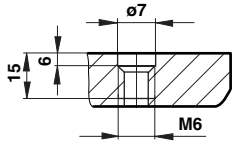


Table 1.1

Model	Nominal Ø (inches) 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	0,21
PM/31022	2 3/4 x 2	45	65	110	0,26
PM/31023	2 3/4 x 3	65	80	145	0,30
PM/31041	4 1/2 x 1	40	50	90	0,73
PM/31042	4 1/2 x 2	80	65	145	0,91

BASIC DIMENSIONS

PM/31061
PM/31062

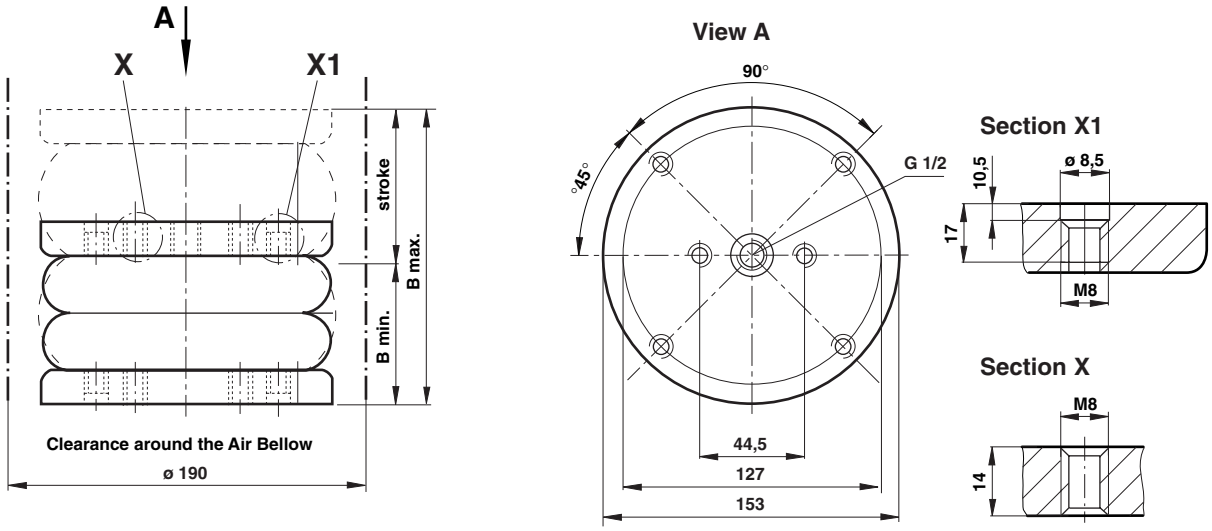


Table 1.2

Model	Nominal Ø (inches) x Convolutions	Stroke (mm)	Installation Height B min. (mm)	Installation Height B max. (mm)	Weight (kg)
PM/31061	6 x 1	55	55	110	0,97
PM/31062	6 x 2	115	80	195	1,30

PM/31081 to PM/31123

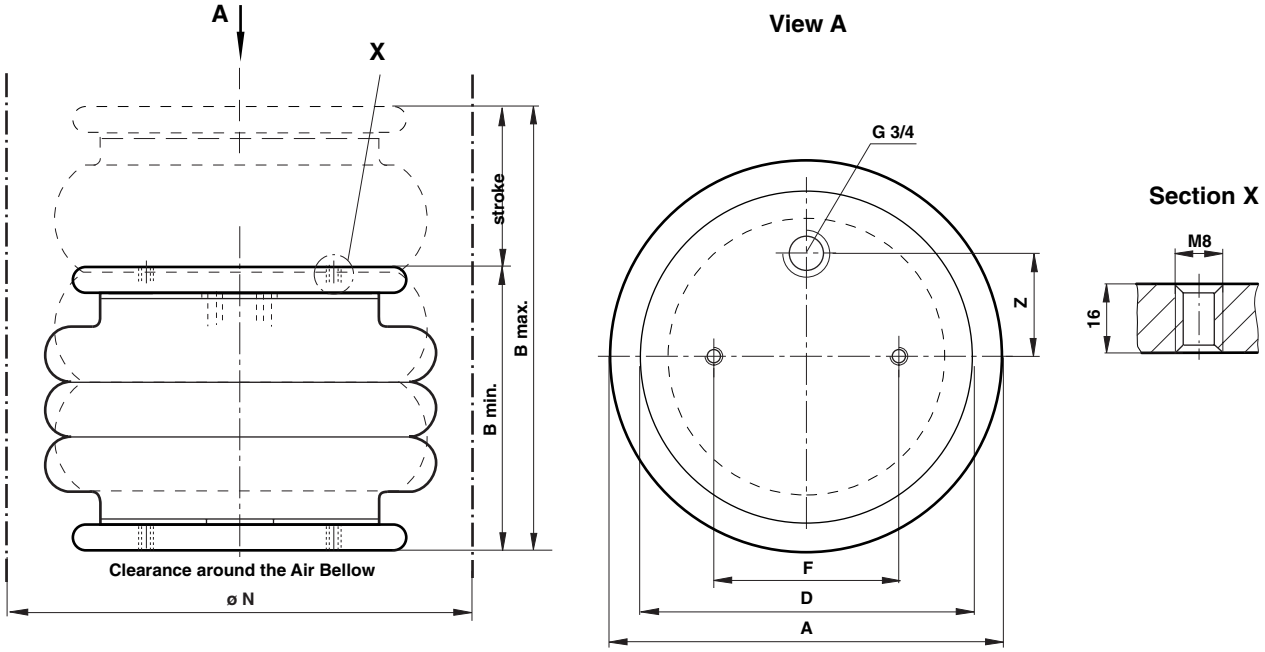


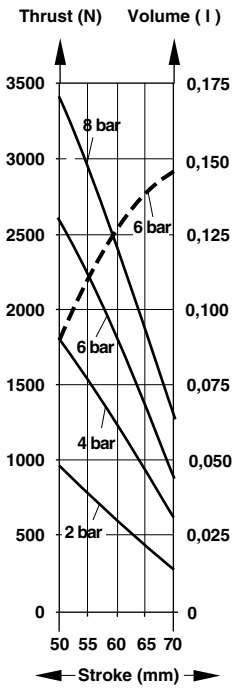
Table 1.3

Model	Nominal Ø (inches) x Convolutions	Stroke (mm)	Installation Height 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	55	150	225	135	70	240	Centric	1,80
PM/31082	8 x 2	185	80	265	220	135	70	240	Centric	2,30
PM/31091	9 1/4 x 1	105	55	160	255	160	89	275	38	2,30
PM/31092	9 1/4 x 2	230	80	310	255	160	89	275	38	3,10
PM/31121	12 x 1	105	60	165	335	228	157,5	360	73	3,80
PM/31122	12 x 2	215	85	300	325	228	157,5	350	73	5,20
PM/31123	12 x 3	315	120	435	325	228	157,5	350	73	7,00

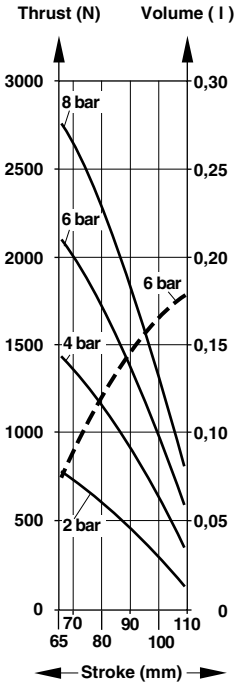
Thrust (at 2, 4, 6, 8 bar), Volume (at 6 bar)

— Thrust (N) – – Volume (l)

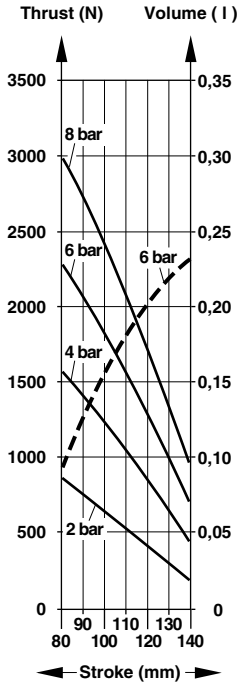
PM/31021



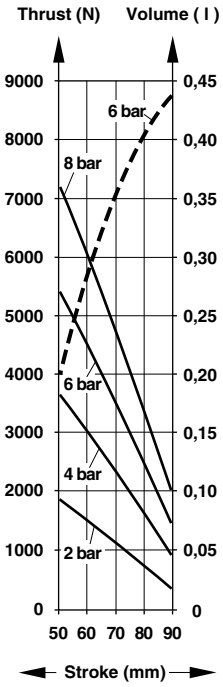
PM/31022



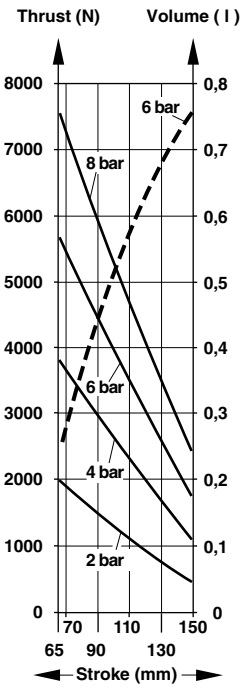
PM/31023



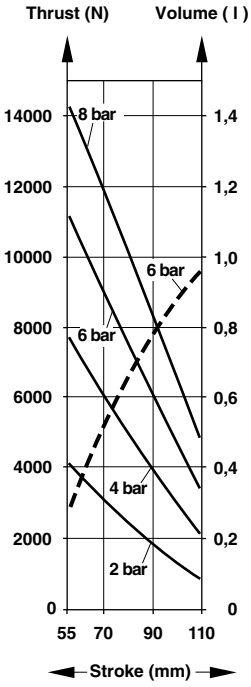
PM/31041



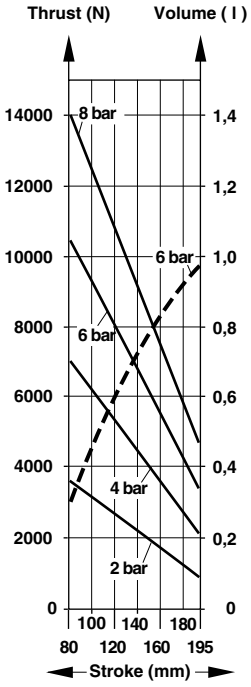
PM/31042



PM/31061



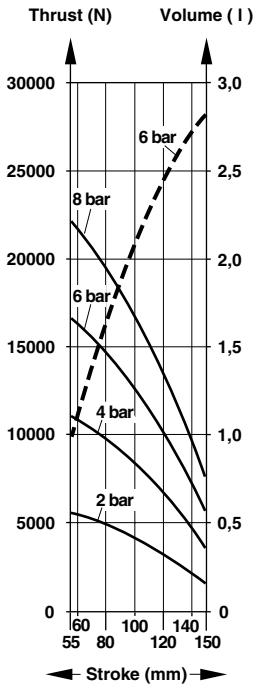
PM/31062



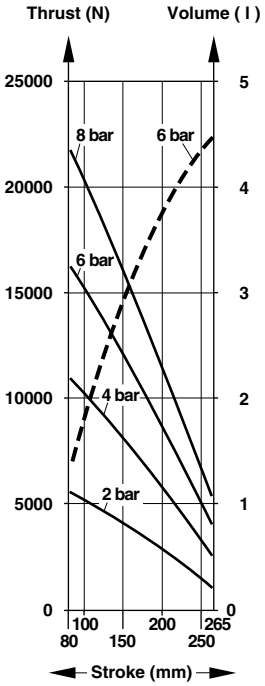
Thrust (at 2, 4, 6, 8 bar), Volume (at 6 bar)

— Thrust (N) – – Volume (l)

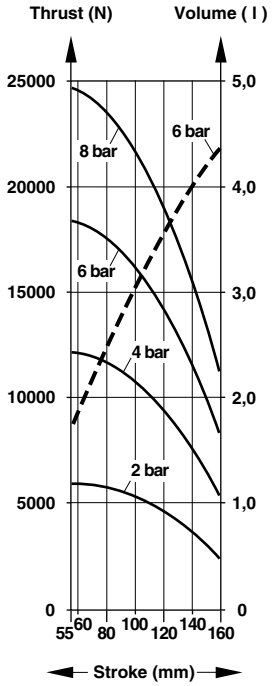
PM/31081



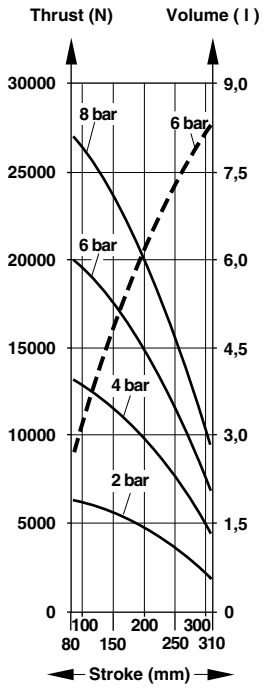
PM/31082



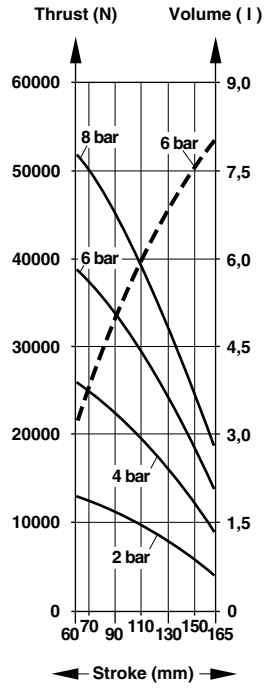
PM/31091



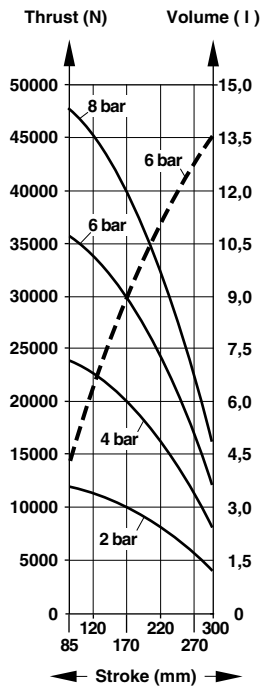
PM/31092



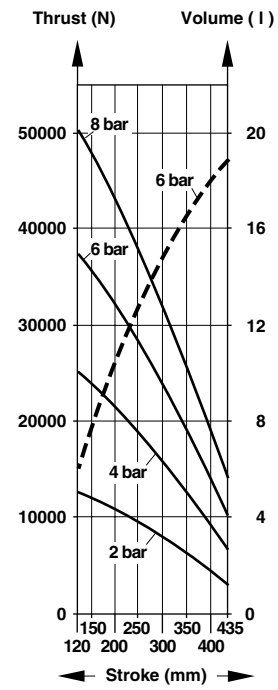
PM/31121



PM/31122



PM/31123



Calculation of Compact Air Bellows used as Actuators

Datasheet

a) Total weight to be lifted: F = ... kg • 10 m/s² = ... [N]
b) Number of Air Bellows: n = ...
c) Thrust per Air Bellow: $f = \frac{F}{n} = \frac{\quad}{\quad} =$ ..... [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 .....

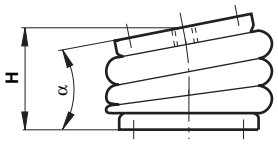
Important Instructions

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, Vibration Height, Retracting Force

Model	Nominal Ø (inches) 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	50	70	920
PM/31022	2 3/4 x 2	45	65	2150	140	110	550
PM/31023	2 3/4 x 3	65	80	2150	160	145	700
PM/31041	4 1/2 x 1	40	50	5500	120	90	1400
PM/31042	4 1/2 x 2	80	65	5750	130	145	1650
PM/31061	6 x 1	55	55	11400	140	110	3300
PM/31062	6 x 2	115	80	10600	170	195	3400
PM/31081	8 x 1	95	55	16650	70	150	5500
PM/31082	8 x 2	185	80	16650	80	265	3950
PM/31091	9 1/4 x 1	105	55	18400	60	160	8150
PM/31092	9 1/4 x 2	230	80	20200	70	310	6750
PM/31121	12 x 1	105	60	39000	60	165	13850
PM/31122	12 x 2	215	85	35800	60	300	11750
PM/31123	12 x 3	315	120	38100	150	435	10050

Operation Angle



Out of Alignment

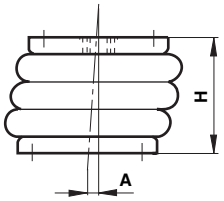


Table 3

Model	Nominal Ø (inches) x Convolutions	Range of Height H (mm) when α=5°	α=10°	α=15°	α=20°	α=25°	Range of Height H (mm) when A=5 mm	A=10 mm	A=20 mm	A=30 mm	A=40 mm	A=50 mm
PM/31021	2 3/4 x 1	—	—	—	—	—	—	—	—	—	—	—
PM/31022	2 3/4 x 2	75-100	80-95	—	—	—	80-100	85-95	—	—	—	—
PM/31023	2 3/4 x 3	90-120	95-110	—	—	—	90-125	100-115	—	—	—	—
PM/31041	4 1/2 x 1	60-75	—	—	—	—	60-80	—	—	—	—	—
PM/31042	4 1/2 x 2	75-130	80-125	90-120	100-115	—	85-135	95-130	—	—	—	—
PM/31061	6 x 1	65-90	70-85	—	—	—	—	75-85	—	—	—	—
PM/31062	6 x 2	90-165	95-160	100-155	110-150	115-140	—	115-170	130-160	—	—	—
PM/31081	8 x 1	75-130	100-120	—	—	—	70-130	100-125	105-120	—	—	—
PM/31082	8 x 2	120-235	140-220	190-215	—	—	—	155-225	170-220	185-215	—	—
PM/31091	9 1/4 x 1	75-140	100-130	—	—	—	70-140	100-135	105-130	—	—	—
PM/31092	9 1/4 x 2	—	140-265	190-260	195-255	200-245	—	155-270	170-265	185-260	205-255	—
PM/31121	12 x 1	80-140	105-130	—	—	—	75-150	100-140	115-135	—	—	—
PM/31122	12 x 2	130-270	135-260	140-250	150-240	170-230	—	135-260	160-255	180-250	190-245	—
PM/31123	12 x 3	165-365	280-330	290-305	—	—	—	205-380	230-365	245-350	260-340	270-335

Example for Selecting Compact Air Bellows 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) F = (1000 kg + 550 kg) • 10 m/s² = 15500 N

b) n = 4

c) f $= \frac{F}{n} = \frac{15500\ N}{4} = 3875\ N$

d) P = 5 bar

e) S = 80 mm

f) Xv = 85 mm

g) Xh = 270 mm

h) T = 60°C

i) α = 9°

j) A = 0 mm

k) Normal environment

Step 2: From table 1.1 to 1.3 (catalogue sheet N 1.8.001.02 + 3) Air Bellows have to be selected that have a min. 80 mm stroke and clearance around the Air Bellows smaler than Xh = 270 mm.

We select: PM/31042, PM/31062, PM/31081 and M/31082

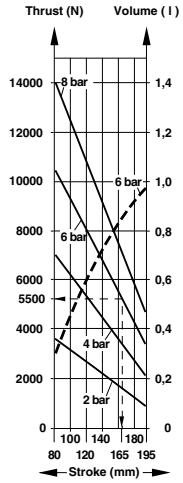
Step 3: Calculate the total height at which the Air Bellow should be used, see step 1:

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 to 1.3 (catalogue sheet N 1.8.001.02 +3)

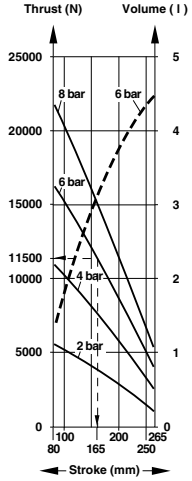
Step 4: Check the thrust at 6 bar at a height of 165 mm.

From the charts in the catalogue sheet N 1.8.001.04 + 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:

$\frac{5500\ N \bullet 5}{6}$ = 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:

$\frac{11500\ N \bullet 5}{6}$ = 9200 N at 5 bar

Conclusion: Both Air Bellows can provide the required thrust of 3875 N.

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 (catalogue sheet N 1.8.001.06). 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° to +70°C) can be used

j) No horizontal mis-alignment

k) No special chemical resistance is required

Result: <u>PM/31082 is the chosen Compact Air Bellow, because it meets all requirements.</u>

Calculation of Compact Air Bellows used as Vibration Isolators

Datasheet

a) Total weight to be isolated: F = ... kg • 10 m/s² = ... [N]
b) Number of Air Bellows: n = ...
c) Thrust per Air Bellow: $f = \frac{F}{n}$ = —— = ... [N]
d) Operating pressure: P = ... [bar]
e) Vertical space: Xv = ... [mm]
f) Horizontal space: Xh = ... [mm]
g) Operating temperature: T = ... [°C]
h) Chemical resistance: .....
i) Isolation rate: I = ... [%]
j) Airspring natural frequency: fn = ... [Hz]
k) 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 3 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

Model	Nominal Ø (inches) 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	75	2000	0,356	1188	3,87	82,4
		6	75	3000	0,381	1685	3,73	83,9
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/31061	6 x 1	4	95	3450	0,810	1633	3,42	86,7
		6	95	5400	0,830	2353	3,29	87,8
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/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	14800	3,430	2814	2,17	95,0
PM/31092	9 1/4 x 2	4	225	8800	6,570	958	1,64	97,2
		6	225	13400	6,800	1370	1,60	97,4
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 3 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) F = 6000 kg • 10 m/s² = 60000 N
b) n = 4
c) f = $\frac{F}{n} = \frac{60000\ N}{4}$ = 15000 N
d) P = 6 bar
e) Xv = 250 mm
f) Xh = 400 mm
g) Normal environment
h) T = 50°C
i) I = 97%
j) fn = select from table 4
k) fe min. = 20 Hz, fe max. = 50 Hz

Two types of Air Bellows are chosen. Each one has to carry 15000 N at the vibration height. From table 4 (catalogue sheet N 1.8.001.08) 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:

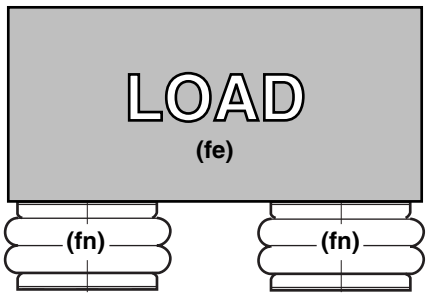
Formula

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

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 the 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° to +70°) 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***

Warning

These products are intended for use in industrial compressed air systems only. Do not use these products where pressures and temperatures can exceed those listed under **'Technical Data'**.

Before using these products with fluids other than those specified, for non-industrial applications, life-support systems, or other applications not within published specifications, consult NORGREN.

Through misuse, age, or malfunction, components used in fluid power systems can fail in various modes.

The system designer is warned to consider the failure modes of all component parts used in fluid power systems and to provide adequate safeguards to prevent personal injury or damage to equipment in the event of such failure.
System designers must provide a warning to end users in the system instructional manual if protection against a failure mode cannot be adequately provided.
System designers and end users are cautioned to review specific warnings found in instruction sheets packed and shipped with these products.