

# AIRSTROKE<sup>®</sup>

ACTUATORS

# AIRMOUNT<sup>®</sup>

ISOLATORS



# Firestone **AIRSTROKE**<sup>®</sup>

ACTUATORS

# **AIRMOUNT**<sup>®</sup>

ISOLATORS

The first successful application of airsprings for vibration isolation occurred during the late nineteen thirties. Airstroke actuators were developed by Firestone to fill a need for a more efficient suspension system for highway trucks, trailers, and buses. Airide<sup>®</sup> springs, as they were named, provided the means for a suspension that reduced the amount of road shock and vibration transmitted into the vehicle. Millions of kilometers of actual use have proven the dependability and effectiveness of the air suspension concept using Airide springs by Firestone.

Airmount isolators and Airstroke actuators are a further application and refinement of the Airide spring. They are basically the same product with the use of the product determining which name is applied to it. Some parts, however, are designed for

a particular application, and all parts are not necessarily compatible with all three applications.

Airsprings are highly engineered elastomeric bellows with specially designed metal end closures.

The bellows itself is constructed from plies of cord-reinforced rubber with standard construction utilizing two plies of special cord fabric. High strength versions designed to handle greater loads and pressures are also available on many of the styles. Airmount isolators and Airstroke actuators are capable of handling loads up to 450 kN and can be designed into systems to utilize up to 355 mm of stroke.

The standard airspring will operate in temperatures from -37°C to 57°C and special compounds are available on some parts to extend this range.



## TYPICAL APPLICATIONS

### AIRSTROKE ACTUATORS

Airstroke actuators are used primarily in place of pneumatic or hydraulic cylinders. A few of the typical applications currently include:

- Large surface area presses
- Stamping presses
- Conveyors
- Clamping devices
- Assembly equipment
- Irrigation equipment
- Automotive alignment equipment
- Paper and textile machinery
- Sawmill machinery
- Material handling
- Valves
- Commercial laundry

Due to the unique capabilities of Airstroke and Airmount products, many applications are in use where the product is used for both actuation and isolation, or for a completely different purpose. Just a few of these applications include:

- Protective boots
- Flexible connectors
- Vacuum devices
- Shock absorbers
- Expansion chambers
- Drive couplings

### AIRMOUNT ISOLATORS

Airmount isolators are used as vibration isolators on many different types of equipment. Following is a partial list of just a few of the typical types of installations.

<b>Lasers</b>	<b>Fans</b>
Holographs	Anechoic chambers
Electron microscopes	Vibrating screens and sifters
Optical benches	Earthquake simulator
Spectrometers	Vibrating conveyors and feeders
Interferometers	Inertial mass mountings
Test bed shakers	Vibrating test equipment
Shock test equipment	Seat springs
Forging hammers	
Generator sets	
Industrial machinery	



# Firestone Selection Guide

## END CLOSURE OPTIONS

Style Number	Maximum Diameter at 7 BAR (mm)	High Strength Number
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### SHAPED SLEEVES

1M1A-0	86	
1M1A-1	86	
2M1A	88	
2M2A	59	

### SINGLE CONVOLUTION

16	152	
16ST	152	
131	165	
160	186	
110	211	
116	231	117
116-1	244	
115	257	124
19	328	
19-75	343	
113	386	128
113-1	404	128-1
153-2	460	
119**	442	
121**	516	
126**	569	
138-1.5	709	
148-1	950	

### DOUBLE CONVOLUTION

25	163	
255-1.5	165	
224	203	
26	218	
20	252	202
20-2	264	
22	328	210
22-1.5	348	
21	384	205
21-2	406	
233-2	394	
28**	442	201
203**	508	218
29**	577	207
200	660	
215	709	
248-2	950	

### TRIPLE CONVOLUTION

352	333	
313	384	39
333	386	
312**	462	314
323**	521	324
320**	569	328
321	709	
348-3	950	

### REVERSIBLE SLEEVE

1X84D-1	NOT AN AIRSTROKE ACTUATOR	
4001	79	
7002	107	
7010	102	
7012	127	
110/70	147	
1T12E-3	127	
1T14C-1	231	
1T14C-3	229	
1T14C-7	229	1T28C-7
1T15T-1	285	
1T15S-6	282	
1T15L-4	297	
1T15M-0	325	
1T15M-2	320	
1T15M-4	320	
1T15M-6	320	
1T15M-9	323	
1T19L-7	361	
1T19L-11	361	

Bead Plate Type	Dim. A (blind nut centers) (mm)	Dim. B (mm)	Bead Ring Type	Dim. C (bolt circle diameter) (mm)	Number of Bolts (each ring)
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SEE INDIVIDUAL DATA PAGE

1	45		4	114	6
1	44		N/A	N/A	N/A
1	45		4	114	6
1	45		4	114	6
1	45		4	114	6
1	70		4	135	6
1	70		4	135	6
3	89	45*	4	160	8
3	158	73	4	229	12
3	158	73	4	229	12
2	159		4	287	12
2	159		4	287	12
2	159		N/A	N/A	N/A
5	229	350	4	350	18
5	305	419	4	419	24
5	381	483	4	483	24
			4	597	32
			4	830	40

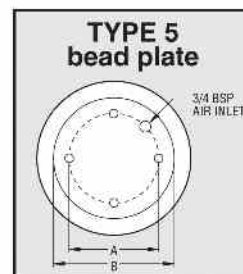
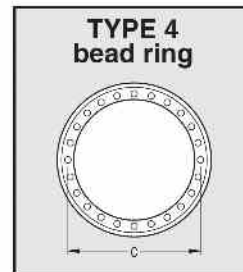
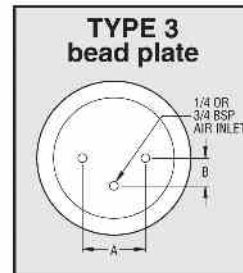
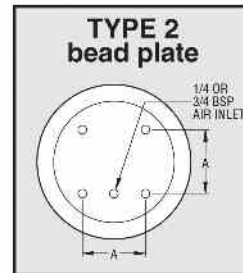
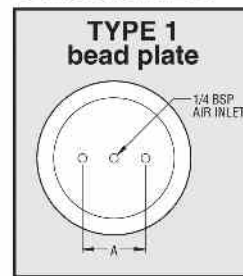
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1	45		4	114	6
1	70		4	135	6
1	70		4	135	6
3	89	45*	4	160	8
3	89	45*	4	160	8
3	158	73	4	229	12
3	158	73	4	229	12
2	159		4	287	12
2	159		4	287	12
2	159		4	287	12
5	229	350	4	351	18
5	305	419	4	419	24
5	381	483	4	483	24
			4	559	24
			4	597	32
			4	830	40

3	158	73	4	229	12
2	159		4	287	12
2	159		4	287	12
5	229	350	4	351	18
5	305	419	4	419	24
5	381	483	4	483	24
			4	597	32
			4	830	40

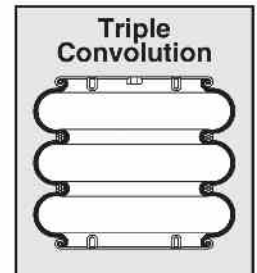
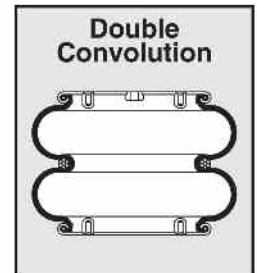
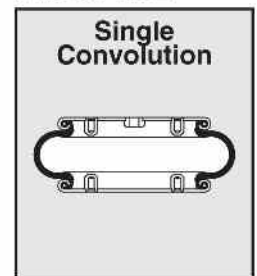
SEE INDIVIDUAL DATA PAGE

1	45		4	114	6
3	89	45*	4	160	8
3	89	45*	4	160	8
3	89	45*	4	160	8
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
3	158	73	4	229	12
2	159		4	287	12
2	159		4	287	12

## END CLOSURES



## SIDE PROFILE



Threads conform to ISO 228-1; gauge to ISO 228-2.

\*38 mm with 3/4 BSP airfitting.

\*\*When using the rolled plate end closure option, add 17.5 mm to heights shown.



## AIRSTROKE® ACTUATORS

Style Number	Minimum Height (mm)	Maximum Stroke (mm)	5 BAR Force* at Stroke of		
			25 mm (kN)	50% of Maximum Stroke	Maximum Stroke (kN)

### SHAPED SLEEVE

1M1A-0	38	36	1.8	—	1.7
1M1A-1	38	60	2	—	1.5
2M1A	64	86	2.0	1.9	1.4
2M2A	30	26	0.6	—	0.5

### SINGLE CONVOLUTION

16	48	36	3.8	—	2.6
16ST	53	28	2.9	—	2.6
131	51	53	5.6	—	3.7
160	54	111	7.5	6.8	4.6
110	51	79	8.5	7.7	3.8
116	51	79	11.0	10.3	5.2
116-1	51	107	12.3	11.1	6.2
115	51	79	14.6	13.2	6.9
19	51	89	27.2	24.8	13.7
19-75	51	99	28.5	25.7	13.9
113	51	97	40.2	36.6	20.2
113-1	51	117	44.0	37.1	23.1
153-2	65	120	52.6	46.1	32.1
119**	51	107	56.9	52.9	33.5
121**	51	91	79.6	73.2	47.7
126**	51	112	105.2	97.6	67.8
138-1.5	51	135	175.0	160.9	96.7
148-1	64	122	315.5	287.5	218.7

### DOUBLE CONVOLUTION

25	71	84	5.5	4.9	2.8
255-1.5	76	112	6.4	5.8	3.6
224	72	125	9.5	7.9	3.9
26	76	145	11.0	9.1	5.8
20	76	155	15.5	13.0	7.3
20-2	76	203	16.1	12.4	8.9
22	76	180	29.1	25.1	15.5
22-1.5	76	198	31.3	26.4	16.3
21	76	180	41.8	36.7	23.7
21-2	76	221	46.1	39.2	24.0
233-2	76	264	44.7	39.8	23.8
28**	84	173	59.9	50.9	35.2
203**	84	183	85.5	75.1	52.2
29**	84	191	107.8	96.2	70.5
200	84	185	142.3	130.3	97.8
215	84	224	171.6	153.3	116.5
248-2	107	231	314.5	282.0	219.4

### TRIPLE CONVOLUTION

352	114	267	33.2	26.2	17.6
313	114	267	43.2	35.7	22.7
333	114	305	42.5	36.0	25.2
312**	114	264	63.5	52.5	36.8
323**	114	277	85.5	73.2	51.0
320**	114	300	115.4	98.1	72.9
321	114	361	176.5	150.0	106.5
348-3	140	351	310.5	285.8	216.1

### REVERSIBLE SLEEVE

1X84D-1	DO NOT USE 1X84D-1 AS AN AIRSTROKE ACTUATOR				
4001	92	92	1.1	1.5	1.3
7002	51	102	2.8	2.6	2.8
7010	127	127	2.3	2.5	2.8
7012	102	140	2.9	3.2	2.7
110/70	115	122	4.0	3.7	3.6
1T12E-3	152	193	3.0	2.5	2.2
1T14C-1	127	196	11.4	10.5	7.1
1T14C-3	147	208	11.8	10.5	7.2
1T14C-7	203	239	12.4	10.5	7.0
1T15T-1	102	170	20.3	17.7	12.0
1T15S-6	152	254	20.5	17.3	12.1
1T15L-4	152	252	23.0	22.4	14.8
1T15M-0	105	178	23.0	22.5	15.5
1T15M-2	127	211	24.9	24.2	16.5
1T15M-4	152	267	25.3	23.2	16.5
1T15M-6	178	310	25.6	22.6	16.6
1T15M-9	216	384	26.0	23.0	17.6
1T19L-7	167	303	33.5	29.0	19.6
1T19L-11	203	385	34.7	28.1	22.2

\* To determine Airstroke force at other pressures, divide force shown by 5 BAR and multiply result by new pressure.

\*\* When using the rolled plate end closure option, add 17.5 mm to heights shown.

## Advantages of:

# AIRSTROKE®

ACTUATORS

*Why use an Airstroke actuator (rather than air or hydraulic cylinder) for actuation?*

### LOW COST

Generally, the initial cost of an Airstroke actuator is one-half or less than that of a conventional pneumatic or hydraulic cylinder of the same force capabilities. This initial cost advantage is many times greater in the larger sizes.

### WIDE SIZE RANGE

Airstroke actuators are available in sizes ranging from 90 mm to 940 mm in diameter. The force capability is 450 kN. Strokes of up to 355 mm are possible.

### DURABLE FOR LONG LIFE

Airstroke actuators are another application of the proven Firestone Airide® spring used on truck and bus suspensions. Airide springs have proven longevity and durability to perform under adverse environmental conditions – a critical factor in machine design.

### NO MAINTENANCE OR LUBRICATION REQUIRED

Airstroke actuators have no internal rods, pistons, or sliding seals that would require lubrication or maintenance. This allows for the design of Airstroke actuators into applications where dirt or grit would destroy the seals on conventional cylinders.

### FRICTION FREE FOR IMMEDIATE RESPONSE

Since Airstroke actuators have no sliding seals, there is no break-away friction as with conventional cylinders.

### FLEXIBLE MEDIA

An Airstroke actuator can do its work with either a liquid or gas. (Please see page 14 in our Engineering Manual for acceptable media choices.)

### ANGULAR CAPABILITY

An Airstroke actuator possesses the unique capability of stroking through an arc without a clevis. Angular motion of up to 30 degrees is possible, along with the design advantage of generally less complex linkages.

### SIDE LOADING CAPABILITY

Airstroke actuators, within certain limits, are not affected by side loads as are conventional cylinders. This misalignment capability eliminates potential rod bending, scoring, and excessive seal wear common to conventional cylinders.

### COMPACT STARTING HEIGHT

Airstroke actuators have a low profile compared to conventional cylinders. Our smallest Airstroke actuator (90 mm/dia.) collapses to just 38 mm in height, while our largest triple convoluted Airstroke (940 mm/dia.) will collapse to a very compact 140 mm.

### FACTORY SEALED AND TESTED

Most Airstroke actuators feature Firestone's proven concept of crimped end plates. The crimped design allows for pre-shipment testing and quicker installation on equipment.



# Airstroke® actuator Selection Procedure

Refer to the **selection guide** on page 4 for Airstroke actuator force and stroke capabilities. This information is intended to give a general guide to part capabilities. Before selecting the correct Airstroke actuator you need to know certain attributes of your application. Once this data is known, the selection is relatively easy. For more detailed information please obtain a copy of Firestone's [Engineering Manual and Design Guide](#).

## 1. STROKE:

The maximum STROKE CAPABILITY of an Airstroke actuator is the difference between the maximum useable height and the minimum height. This entire stroke, OR ANY PORTION THERE-OF, may be used. If an internal rubber bumper is required, please note that the **minimum height is increased**, and therefore, the total stroke is decreased. Once this is determined, you can choose the general style of part you would need. For strokes of less than 77 mm to 105 mm, the Single Convolution parts are generally the most efficient. Use the shortest style that will give you the necessary stroke for your application.

## 2. FORCE:

Read the forces from the chart for 5 BAR at 25 mm, 50% of Maximum Stroke, and Maximum Stroke. Notice that the force

generally decreases as height increases. If you have less than 5 BAR available, divide the force by 5 BAR and multiply by your available pressure. If your stroke is between these values a straight line interpolation will approximate the value. You should always check our [Engineering Manual and Design Guide](#) for more exact information. Select the smallest part with the necessary stroke to meet your force requirements.

## 3. DIMENSIONAL DATA CAN BE FOUND ON PAGE 3:

It is important to make sure that the part you select will fit in the available space. The higher the force required the larger in diameter the part. The longer the stroke, the higher the minimum height. Make sure that you follow all of the guidelines shown in the Do's and Don'ts section below.

## 4. SELECT THE END CLOSURES AND AIR INLET SIZE:

Most Airstroke actuators are available with either permanently attached plates or bead ring (flange) attachments. (See end closure options chart for attachments, air fittings, and attachment locations.) Most parts with plates are available with either 1/4 or 3/4 BSP air fittings.

# Do's and Don'ts

## DOWN AND UP STOPS

Positive stops in both directions (compression *and* extension) should always be used with Airstroke actuators.

1. In COMPRESSION the minimum height shown for each air spring is at, or slightly above the PINCH POINT of the bellows. The bellows can be damaged if allowed to constantly bottom out; therefore, a downstop is required to prevent this. An external downstop can be something as simple as a steel block and should be sized at or slightly greater than the minimum height of the Airstroke actuator. If an external downstop cannot be used, many parts are available with internal rubber bumpers. See [Engineering Manual and Design Guide](#).
2. In EXTENSION an upstop is required to prevent the air spring from overextending. Failure to install an upstop could result in a reduced bellow life, and allow the end crimp seal to open up. There are many ways to design-in an upstop, including a) a chain, b) a cable, or c) contacting a metal stop, etc.

## RETURN

An Airstroke actuator is a *single acting* device. To return the actuator to its minimum height for another cycle or stroke, some return force must be used. Gravity acting on the load may be all that's required. (Refer to the order block section in the [Engineering Manual](#) for the force required to return convoluted Airstroke actuators to minimum height.) If the load is not sufficient, then a second actuator, or coil spring may be required.

## GUIDING

An Airstroke actuator follows the path of least resistance; therefore, the actuator should always be guided. This is often easily accomplished in the mounting geometry.

## ANGULAR CAPABILITY

An Airstroke actuator can stroke through an arc without a clevis. Angular motion of up to 30 degrees is possible. When using an actuator with the mounting plates at an angle to each other, observe the following:

- a. Measure force at the height between the plate centers.
- b. Measure maximum height at the side separated the furthest.
- c. Measure minimum height at the side collapsed the most.

These measurements must fall within the guidelines for that particular part.

Reversible sleeve type (1T) parts may also stroke through an arc. In this case, care must be taken to prevent the bellows from rubbing (internally) against itself where it rolls over the piston.

## HORIZONTAL MISALIGNMENT

The upper and lower bead plate centers (or mounting plate centers in the case of a bead ring type attachment) may be out of line somewhat without injury to the bellows. Our "rule of thumb" for convoluted type actuators is 25 mm misalignment allowed per convolution. So, a single convoluted air spring may be out of line by as much as 25 mm, a double convoluted by 50 mm, and a triple convoluted air spring by 75 mm.

## DESIGN ENVELOPE

Adequate clearance should be provided around the Airstroke actuator to prevent puncturing or rubbing of the bellows. (Refer to the selection guide on page 3 for the maximum diameter at 7 BAR for each Airstroke bellows.)

## STACKING

It is permissible to stack actuators, one on top of another, to increase stroke; however, the center plate (or plates) connecting the two or more Airstroke actuators **MUST BE GUIDED**. Please note that the air spring forces are *not* additive in this configuration.

## FAIL SAFE DEVICES

Some applications require the use of fail safe mechanisms (such as a mechanical lock-out on a scissors lift) to prevent damage or injury in the event of an air system failure.

## VACUUM

An Airstroke actuator can withstand a small amount of vacuum without injury to the bellows. The maximum amount of acceptable vacuum is dependent upon the bellow's size, the height in use, and whether it is a two ply or high strength (fabric) air spring. (A high strength Airstroke bellows has a "stiffer" wall than a two ply; therefore, it is less susceptible to dimpling and deformation inward). It is generally best to use only single convoluted air springs under vacuum.



## Advantages of:



*Why use an Airmount isolator, rather than a coil spring or other type of isolator?*

### UNSURPASSED ISOLATION CAPABILITY

Airmount isolators can provide the highest degree of isolation of any type vibration isolator. System natural frequencies as low as 1 Hertz are available. Lower system frequencies can be accomplished by the use of an additional reservoir. In order to achieve similar results from a conventional coil spring isolator, a real deflection of 230 mm would be required.

### CONSTANT ISOLATION EFFICIENCY

Airmount isolators are unique in that the system's natural frequency does not change significantly with changes in load. This unique feature, combined with accurate height control, will allow the use of the same Airmount isolator at each mounting point of an unevenly loaded machine.

### ACCURATE HEIGHT CONTROL

Airmount isolators provide accurate height control through regulation of internal air pressure. This feature eliminates the reduction in isolation efficiency caused by fatigue and permanent set found in other types of vibration isolators.

### WIDE SIZE RANGE

Airmount isolators are capable of isolating loads of 45 kg per mounting point to over 38,000 kg per mounting point.

### COMPACT INSTALLED HEIGHT

Airmount isolators can carry the loads and provide the isolation described above at installed heights as low as 75 mm. Coil springs providing equal isolation would require a free height of 125 mm to 650 mm.

### EXTENDED EQUIPMENT LIFE

Airmount isolators extend equipment life through their superior isolation capabilities.

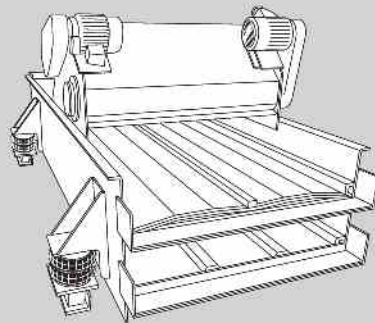
### EFFECTIVE NOISE REDUCTION

Airmount isolators reduce structurally transmitted noise. They are also quiet in themselves, since there is no spring chatter as found in conventional coil springs.

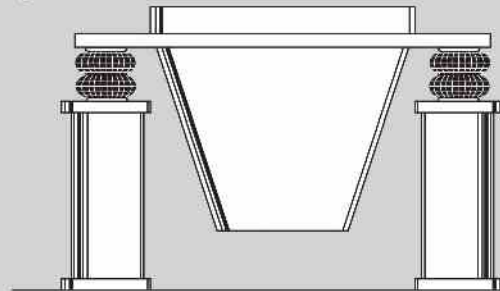
### VERSATILE

Airmount isolators can be used not only to protect structural members from vibrating machinery, but are also widely used to protect delicate equipment from structurally transmitted vibration.

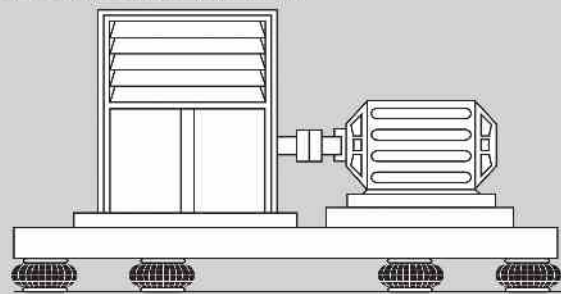
**VIBRATING  
SCREEN**



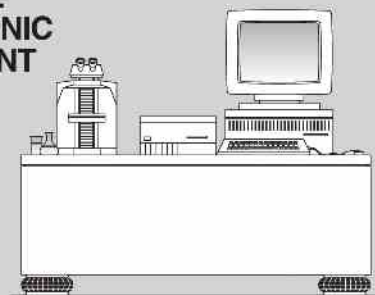
**BIN HOPPER**



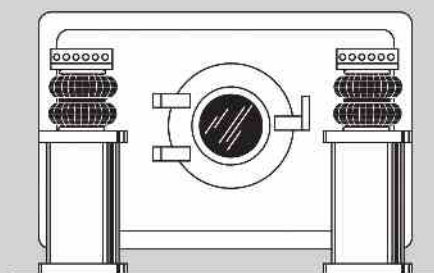
**BLOWER AND MOTOR**



**DELICATE  
ELECTRONIC  
EQUIPMENT**



**WASHING MACHINE**





# Airmount® isolator Basics

A detailed discussion of vibration isolation is beyond the scope of this brochure, but the general theory and terms bear some explanation.

In any vibration isolation application, there will be some source of vibration, or disturbance, that generates concern. This disturbance may be coming from the environment. An example would be a coordinate measuring machine in a metal stamping plant whose floor vibrations make delicate measurement impossible. The disturbance may also be generated by a device that affects the surroundings. An example of this could be a vibrating screen or power unit in an office setting.

Although these situations would appear to be distinctly different, they are analytically equivalent.

In any vibration isolation application, the disturbing (forcing) frequency,  $f_i$ , is the key parameter in question, and is necessary to select an isolator. The disturbing frequency is typically related in some way to the equipment, usually a rotational speed. This is normally expressed in cycles per minute (cpm) or cycles per second (hertz, Hz).

Common examples would be a power unit, where the disturbing frequency would be the motor rotational speed; a vibrating screen, where  $f_i$  would be the speed of the eccentrics, or a fan unit where it would be the fan speed. Care must be taken to insure that the lowest unbalanced disturbing speed is used for isolator selection.

Just as the disturbing frequency is a characteristic of the application, the natural frequency,  $f_n$ , is a characteristic of the isolation system. In general, the natural frequency is determined by the spring rate of the isolator and the load supported by the isolator. With reference to the Firestone line of air springs, the natural frequency is dependent upon the specific part selected. Natural frequencies are listed on the selection chart for each Firestone air spring.

A good rule of thumb is to select an isolator whose natural frequency is less than or equal to one-third of the disturbing frequency. The lower the natural frequency compared to the disturbing frequency, the greater the effectiveness of the isolation system.

## Sample Problem

Consider the example of a fan and motor mounted on a common base. The combined weight of the unit is 2700 kg. However, due to offset positioning, the loads per mounting point show two at 640 kg each and two at 710 kg. The motor speed is 27.5 Hz, however, the fan is only going at 13.3 Hz due to the reduction in the fan drive system. The system is to be mounted on a flat roof top so there are no space constraints.

1. First, we need to determine the smallest diameter part capable of supporting the load at each point.

- The #110 Airmount isolator will carry 812 kg so it will easily do the job. (Note that the 131 would support the lower requirement of 640 kg, but would not handle the 710 kg. load. It is usually best to use the same isolator in all mounting locations if possible.)
  - We could also use the #224 Airmount isolator in the double convolution section. In the next step we will look at both parts.
2. From the discussion above and the information in the sample problem, we know that the lowest disturbing frequency needs our attention. That would be the speed of the fan at 13.3 Hz. Comparing the Isolation percentage in the far right column of the selection guide on page 8, we see the following:
- At 13.3 Hz the #110 isolator will yield a 95.8% isolation.
  - The #224 Airmount isolator will provide 97.5%. While this doesn't seem like a big difference, the 224 will

transmit 40% less energy through to the roof. (95.8% isolation is 4.2% transmission, 97.5% isolation is 2.5% transmission. 2.5 is 40% less than 4.2) This is often the difference between a satisfactory isolation system and one that will not be appreciated.

- It should be noted here that if we had used a disturbing frequency other than 13.3 Hz, we could have used the graph on page 9. Let's suppose that the forced frequency was 10 Hz. Our natural frequency for a #224 is shown as 2.1 Hz on the selection chart. Rounding this off to 2 Hz, we can find where these two values intersect on the graph. This point is very near the diagonal line referencing 95% isolation. We would use this number to determine our approximate effectiveness.
3. A quick check of the selection chart shows that the design height of a #224 is 165 mm. This value should be used in designing the surrounding equipment. Paying specific attention to the Do's and Don'ts, we see that we should provide safety stops at 152 and 178 mm to prevent the system from over-traveling in case of some extreme disturbance.
4. Although for the purposes of this discussion it is not necessary to be extremely exact, in many designs it will be more important. If you are designing an isolation system, we strongly urge you to obtain our [Engineering Manual and Design Guide](#).

Contact Firestone, or your local Firestone distributor, to discuss any more complicated problems.



## AIRMOUNT® ISOLATORS

Style Number	Design Height (mm)	Load (at Design Height) at 7 BAR (kg)	Natural Frequency (@ 5 BAR) $f_n$ (Hz)	% of Isolation at Forced Frequency	
				7 Hz	13 Hz

### SHAPED SLEEVE

1M1A-0	65	254	3.5	—	92.8
1M1A-1	75	285	2.8	—	95.1
2M1A	DO NOT USE 2M1A AS AN AIRMOUNT ISOLATOR				
2M2A	45	97	3.25	—	93.3

### SINGLE CONVOLUTION

16	76	508	3.9	—	90.6
16ST	75	468	4.1	—	89.0
131	89	685	3.0	74.6	94.7
160	140	798	2.1	90.3	97.4
110	114	812	2.7	80.9	95.8
116	114	1071	2.7	80.9	95.8
116-1	140	1148	2.4	85.6	96.8
115	114	1365	2.7	80.4	95.7
19	127	2576	2.5	83.1	96.3
19-75	140	2386	2.6	82.6	96.2
113	127	3992	2.4	85.6	96.8
113-1	140	4627	2.3	86.9	97.0
153-2	150	5768	2.1	90.1	97.3
119**	127	6586	2.2	87.4	97.1
121**	127	8369	2.4	85.4	96.7
126**	127	12832	2.3	87.2	97.1
138-1.5	152	18878	2.0	90.3	97.7
148-1	140	38646	2.0	90.3	97.7

### DOUBLE CONVOLUTION

25	140	535	2.6	81.8	96.0
255-1.5	165	622	2.2	87.6	97.2
224	165	880	2.1	88.6	97.4
26	203	971	1.9	91.3	98.0
20	216	1234	1.9	91.3	98.0
20-2	254	1469	1.6	93.7	98.5
22	241	2449	1.8	92.1	98.1
22-1.5	267	2409	1.8	92.3	98.2
21	241	3778	1.8	92.6	98.3
21-2	267	4178	1.6	94.0	98.5
233-2	286	4498	1.4	95.2	98.8
28**	241	5498	1.7	92.8	98.3
203**	241	8568	1.6	93.9	98.5
29**	241	11499	1.6	94.2	98.6
200	241	15703	1.6	94.2	98.6
215	267	18588	1.4	95.2	98.8
248-2	279	36165	1.4	95.6	98.9

### TRIPLE CONVOLUTION

352	343	2913	1.3	95.9	99.0
313	330	4064	1.4	95.5	98.9
333	373	4055	1.3	96.3	99.1
312**	330	6137	1.4	95.5	98.9
323**	330	8918	1.3	95.8	99.0
320**	356	12129	1.3	96.2	99.1
321	381	19005	1.2	96.8	99.2
348-3	381	37439	1.1	97.0	99.3

### REVERSIBLE SLEEVE

1X84D-1	203	308	1.3	96.4	99.1
4001	140	172	1.7	93.2	98.4
7002	114	372	1.8	92.0	98.1
7010	203	367	1.1	97.0	99.3
7012	216	454	1.3	95.8	99.0
110/70	185	540	1.6	94.5	98.5
1T12E-3	267	349	1.3	96.2	99.1
1T14C-1	254	1461	1.4	95.2	98.8
1T14C-3	279	1470	1.3	96.4	99.1
1T14C-7	343	1470	1.1	97.4	99.4
1T15T-1	178	2490	2.0	90.3	97.7
1T15S-6	305	2422	1.2	96.5	99.1
1T15L-4	279	3143	1.4	95.5	98.9
1T15M-0	191	3171	1.6	93.9	98.5
1T15M-2	241	3407	1.4	95.0	98.8
1T15M-4	318	3252	1.3	96.3	99.1
1T15M-6	381	3175	1.1	97.1	99.3
1T15M-9	470	3230	1.0	97.7	99.4
1T19L-7	380	3951	1.2	96.8	99.2
1T19L-11	455	4853	1.0	97.6	99.4

# Airmount® isolator Selection Procedure

Refer to the **selection guide** on this page for Airmount isolator capabilities.

## 1. LOAD CAPACITY

Select one or two Airmount isolators that can support the load at each mounting point. It is normally best to design for pressures in the 4 to 6 BAR range. Consider only the 1M1A and the single and double convoluted types at first. Please notice that in the range of 1 to 285 kN you will, in most cases, find both a single and double convoluted style part which will support the load.

## 2. DETERMINE ISOLATION EFFECTIVENESS

Locate the forced frequency on the vertical axis of the chart on page 9. Locate the natural frequencies of the parts selected above and find these values on the horizontal axis of the Isolation Chart. At the intersection of the forced frequency and natural frequency lines you will be able to determine the approximate percentage of isolation by comparing this point with the diagonal lines representing these percentages.

## 3. DETERMINE DESIGN HEIGHT

The Airmount isolator **SHOULD BE USED AT THE DESIGN HEIGHT GIVEN**. The double convoluted part is used at a design height somewhat higher than its single convolution equivalent. Make sure that the design height falls within the height restrictions. Also, the double convoluted part will show a higher percentage of isolation (less transmitted vibration) than the single convoluted air spring. The reason for this is that the double convoluted part has a greater internal volume of air than the single convoluted version of the same size. At disturbing frequencies in the 7 to 13 Hz range, the double convoluted part is a significantly better vibration isolator than the single convoluted part. At disturbing frequencies of 13 to 25 Hz the gap closes considerably. At frequencies of 25 Hz and above, the difference is negligible.

## 4. DETERMINE EXACT INTERNAL PRESSURE AND ISOLATION EFFECTIVENESS

The chances are that your specific vibration problem does not fall neatly into the load and disturbing frequency criteria as presented in the selection guide. Therefore, once a preliminary part selection has been made, turn to the individual data page in the Engineering Manual and Design Guide for that part in order to determine the specific internal pressure required and the percentage of isolation attainable.

\* Do not inflate above 5 BAR.

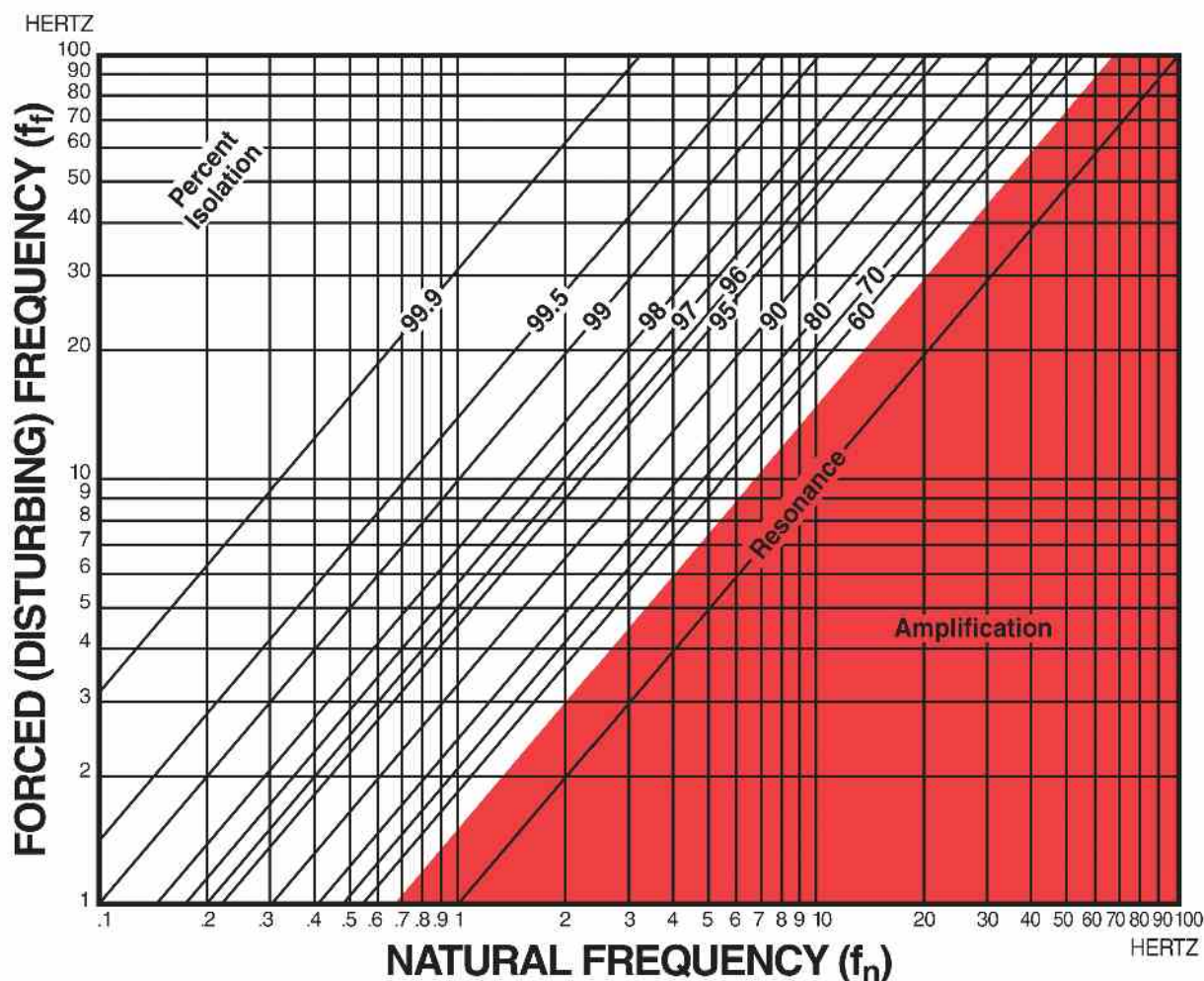
† Except for 1X84D-1 and 1M1A.

\*\* When using the rolled plate end closure option, add 17.5 mm to heights shown.

CONSULT FIRESTONE FOR USE AS AN AIRMOUNT†



# Airmount Vibration Isolation Chart



## Airmount Vibration Isolator Do's and Don'ts

### CENTER OF GRAVITY

Airmount isolator systems are inherently soft (easily deflected); therefore, precautions must be taken to ensure that the system is stable. First, consider the location of the center of gravity (c.g.). Ideally, the Airmount isolators should be located on the same plane (parallel to the ground) as the center of gravity. Where this is not possible, follow this guideline: The distance between the narrowest mounting points should be at least twice the height of the center of gravity above the mounting points.

### LATERAL RATES AND STABILITY

A single and double convoluted air spring **SHOULD BE USED AT THE DESIGN HEIGHT GIVEN**, because that is the point of maximum lateral rate or stability. The lateral rate *decreases* as the isolator's height *decreases*. Consider a #22 at 6 BAR:

Height	Lateral Rate	Vertical Rate
241 mm (design height)	62 kN/m	267 kN/m
216 mm	41 kN/m	286 kN/m
191 mm	Unstable	—

Notice that the #22 becomes unstable in the horizontal, or lateral, direction when moving down only 50 mm from design height.

At design height and without an auxiliary reservoir, the single and double convoluted parts follow this pattern; i.e., the lateral rate varies from 1/5 to 1/2 of the vertical rate (only the larger high strength parts get as high as 1/2).



## PLUMBING SYSTEMS

There are three basic ways of controlling an air suspended isolation system:

1. **Tank Valve System**—With a tank valve in each isolator, each air spring can be inflated individually. The pressure in each must be checked periodically, because air will permeate through the bellows.

For an idea of the permeation rate, a #116 will lose approximately 2 BAR over a period of one year (from 7 BAR to 5 BAR).

2. **Three Point Regulated System**—The Airmount isolators can be connected directly to the factory compressed air system using pressure regulating valves. This eliminates the need for periodic inspections. The air springs should always be connected in clusters so the mass is supported with only THREE REGULATORS.
3. **Three Point Leveled System**—Automatic height control can be provided by adding height control valves to the system. Again, there should be only THREE POINTS OF CONTROL, or in this case, three leveling valves. Attempting to use more than three control points often results in the valves “hunting” or “fighting one another”. There are sensing systems available to control heights within  $\pm 0.03$  mm. Truck type leveling valves can provide accuracy to  $\pm 1.6$  mm.

## DESIGN ENVELOPE

Adequate clearance should be provided around the isolator to prevent puncturing or rubbing of the bellows. (Refer to the selection guide on page 3 for the maximum diameter at 7 BAR for each Airmount bellows.)

## SAFETY STOPS

It is normally recommended that positive stops be installed *in all directions*; (i.e., in compression, in extension, and for lateral displacements.) Positioning of the vertical stops depends upon the amplitude of movement, both during normal operation and during startup and shutdown. A good “rule of thumb” is  $\pm 15$  mm from design height for vertical stops and also  $\pm 15$  mm (horizontally) for lateral stops.

## INITIAL INSTALLATION

*Never* use Airmount isolators to lift the equipment into place, due to the lateral instability at lower air spring heights as discussed previously. The equipment should be rested on stops set *slightly* below design height and raised into position for isolation.

## TRIPLE CONVOLUTED AND REVERSIBLE SLEEVE TYPE PARTS

Both of these types are unstable laterally (except for the 1M1A). Due to low natural frequencies, both can be excellent isolators; however, do not use these two types as Airmount isolators without consulting Firestone (for special guidelines and precautions).

## STARTUP AND SHUTDOWN/ RESONANCE AND AMPLIFICATION

Resonance is the condition where the forced frequency of the vibrating system is at the natural frequency of the suspension. When this happens, amplification of movement occurs. So, while a machine is building up to speed and slowing down, the amplitude of movement may be exaggerated. The longer the machine takes to go through resonance (to build up to, or slow down from full operating speed), the larger the amplitude of movement.

## ISOLATING AN UNBALANCED MASS

The primary concern in this case is the amplitude of movement. It is dependent on:

- 1) The ratio of the unbalanced moving mass to the total suspended mass and,
- 2) The ratio of the speed of the unbalanced moving mass (forced frequency) to the natural frequency of the Airmounts.

The addition of damping to the isolation system (shock absorbers) will reduce the large amplitude of movement experienced during resonance.

If the amplitude of movement is too great, one possible solution would be to add an inertia base in order to increase the ratio of the total suspended mass to the moving unbalanced mass. A good “rule of thumb” is 10:1, respectively.

## LOW PRESSURE OPERATION

The lateral rate of a single and double convoluted style isolator *decreases* with decreasing internal air pressure (becomes unstable). Consult Firestone if you plan on operating an Airmount isolator at less than 3 BAR.

## EFFECT OF AN AUXILIARY RESERVOIR

There is a direct relationship between natural frequency and isolation effectiveness. Generally, the lower the natural frequency, the better the isolator (or higher percentage of isolation). As previously mentioned, a double convoluted Airmount isolator has a lower natural frequency than a single convoluted type (of the same size) because it has more internal air volume. We can use this principle to lower the natural frequency of an air spring by adding an auxiliary reservoir (pressure vessel) externally to the isolator. This effectively increases the air spring volume and reduces its natural frequency.

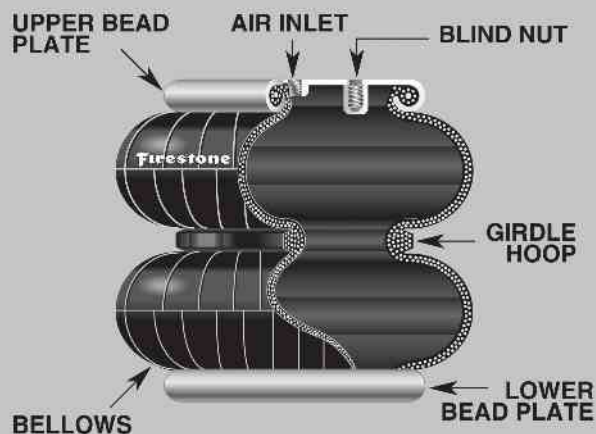
In order for the reservoir to work properly, there must be a free flow of air between the air spring and reservoir. Therefore, it should be mounted as close as possible to the isolator. A bead ring attachment is the best end closure choice for this, as the hole in the mounting plate can be sized as large as the inside diameter of the bellows. A 3/4" BSP air inlet will restrict the flow of air somewhat on large parts, but it can be used where amplitudes are small.

## DAMPING

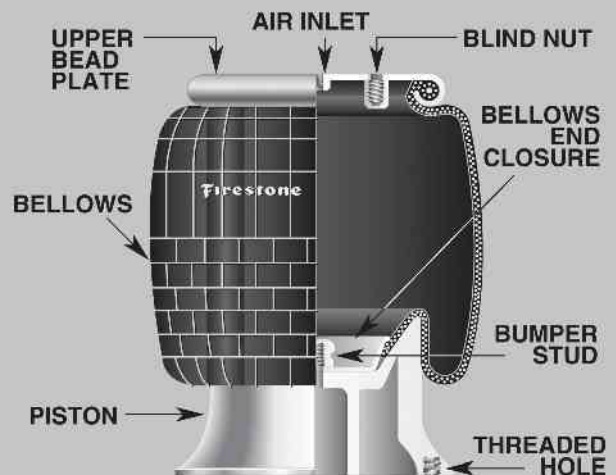
Damping is defined as a ratio of System Damping to Critical Damping. The damping ratio inherent in an Airmount isolator is in the order of .03. This damping number is so small that the formulas we use assume it to be zero.



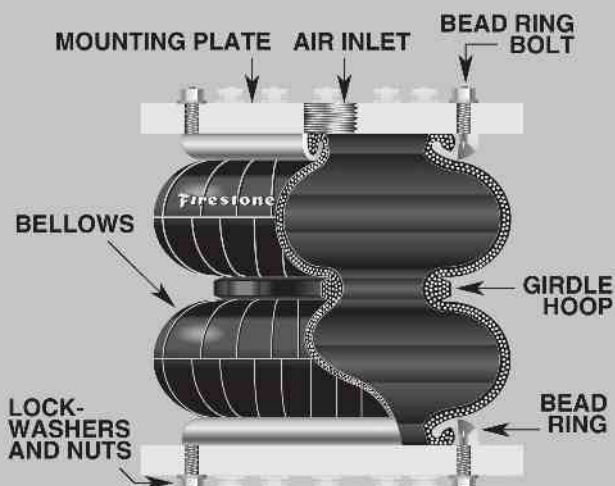
# Standard Types



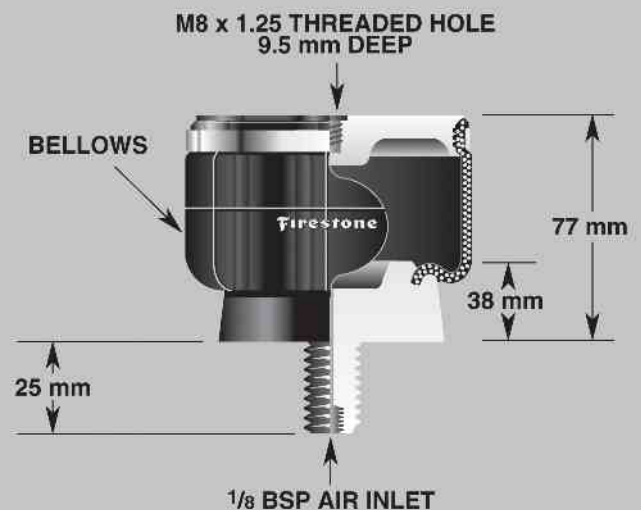
**CONVOLUTED AIR SPRING WITH CRIMPED BEAD PLATES**  
(#22 is shown)



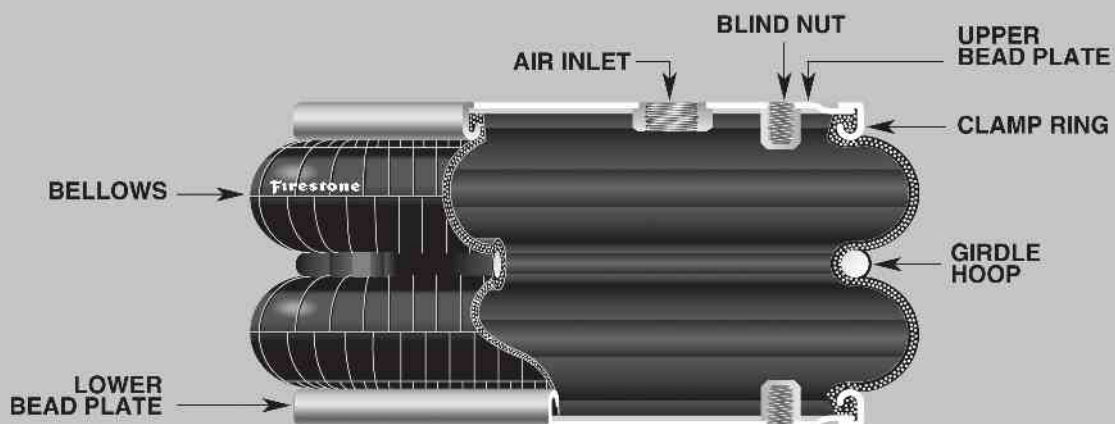
**REVERSIBLE SLEEVE AIR SPRING WITH CRIMPED BEAD PLATES**  
(1T15M-6 is shown)



**CONVOLUTED AIR SPRING WITH STEEL BEAD RINGS**  
(#22 is shown, with bead rings instead of crimped bead plate)



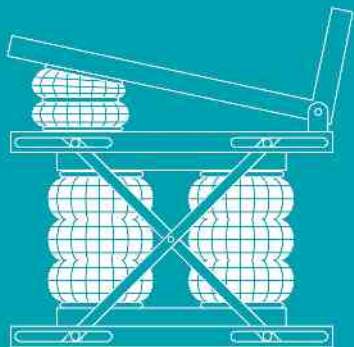
**1M1A AIRSTROKE actuator**



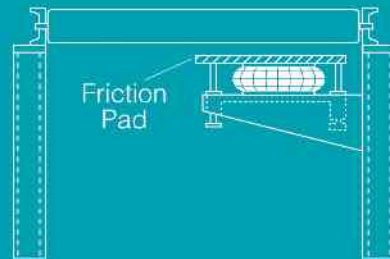
**LARGE CONVOLUTED AIR SPRING WITH ROLLED PLATES**  
(#203 is shown, with rolled plates instead of bead rings)



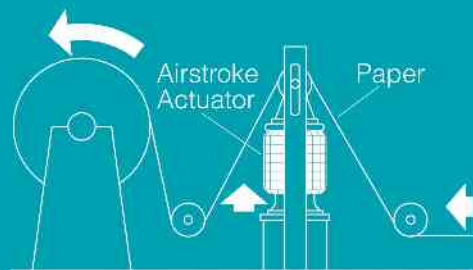
# TYPICAL APPLICATIONS



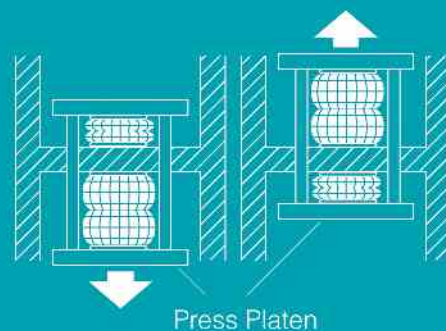
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