NEW!

See **pg.101** for more information

AIRSTROKE™ ACTUATORS

AIRMOUNT™ ISOLATORS

Engineering Manual & Design Guide

Firestone

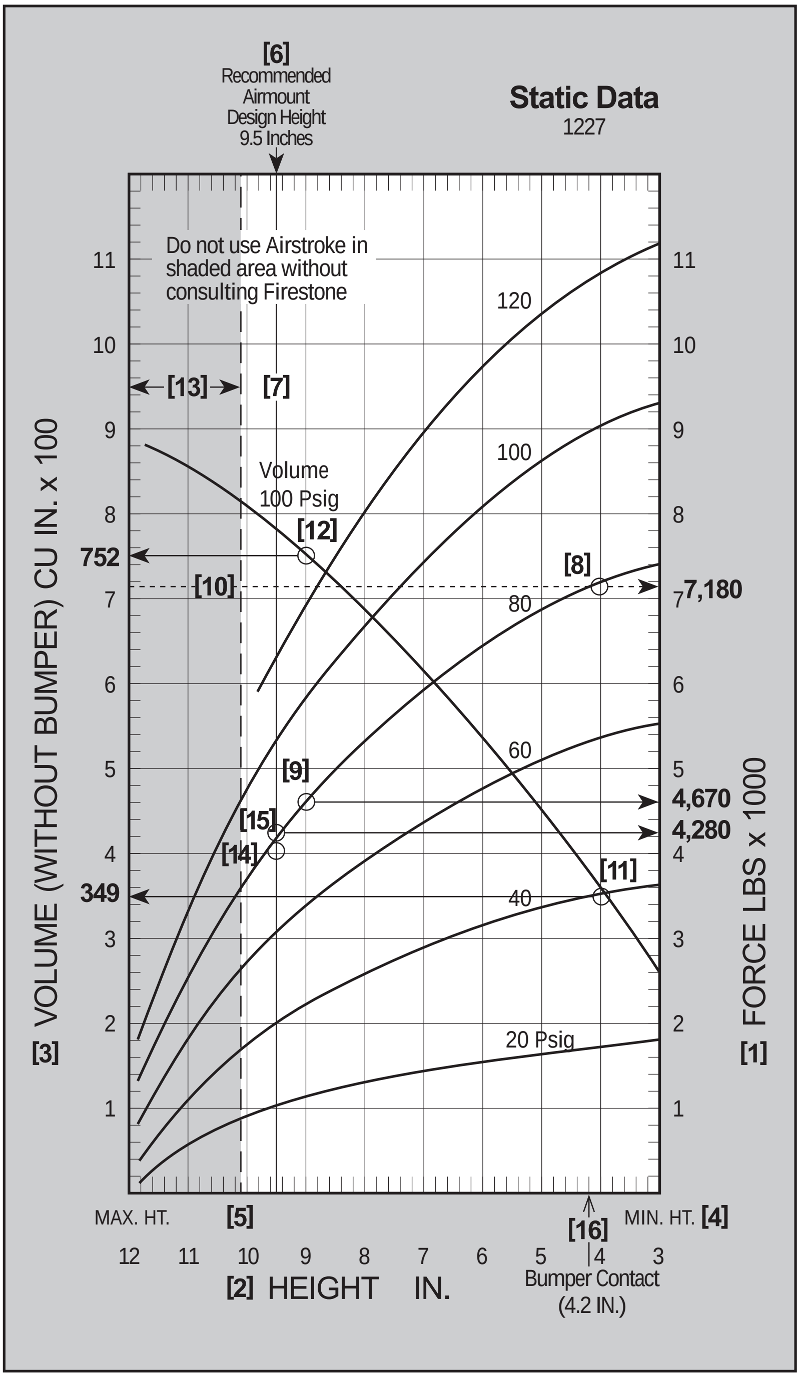
World's Number 1 Air Spring.

FIRESTONE INDUSTRIAL PRODUCTS COMPANY

EMDG_604

HOW TO USE THE STATIC DATA CHART

We also refer to this chart as the load/deflection (L/D) curve for an air spring. The force **[1]** is given on the right hand axis vs. the air spring height **[2]** as shown along the bottom axis; thus, load vs. deflection. The internal volume **[3]** is also given along the left hand axis, again vs. height **[2]**. It is called static data because the air spring is in a static, or non-moving, constant pressure condition. In almost all cases the static curves were run using a two ply bellows; however, *where a four ply bellows is available, use the two ply chart for it also.*



AIRSTROKE ACTUATION

The important considerations are minimum height **[4]** (3.0 inches) and maximum recommended height **[5]** (10.1 inches). Subtracting one from the other gives the stroke potential for this part (10.1 – 3.0 = 7.1 inches). As an actuator, the entire stroke may be used, *or any potion thereof. Ignore recommended airmount design height* [6] *and the corresponding darkened line* [7]. This height is important in using the air spring as an isolator (AIRMOUNT). It has nothing to do with the concern here of actuation. To determine the force at any given height, simply move up the height line to where it intersects any of the static pressure curves. Then move to the right and read from the force scale **[1]**.

EXAMPLE: At 80 psig, what is the force using a #22 from 4.0 to 9.0 inches, or 9.0 – 4.0 = 5.0 inch stroke? See **[8]** for force at 4.0 inches (7,180 #) and **[9]** for force at 9.0 inches (4,670 #). This example illustrates the primary difference between Firestone Airstrokes and conventional air cylinders. Air cylinders have a constant area for the pressure to work against, or constant effective area. *the effective area and force of an air spring changes as the height changes.(There is one exception: notice the plateau section of reversible sleeve 1T type curves.)*

In the example the effective area of a #22, at 4.0 inches using the 80 psi curve, is:

$$\frac{7{,}180 \text{ lbs.}}{80 \text{ lbs/in}^2} = 89.8 \text{ in}^2$$

at 9.0 inches in height it is:

$$\frac{4{,}670 \text{ lbs.}}{80 \text{ lbs/in}^2} = 58.4 \text{ in}^2$$

An air cylinder with 89.8 in^2 of area would have an 80 psi curve as shown by dotted line **[**10**]**.

The volume curve **[**3**]** may also be of importance:

a. If one needs to know the amount of free air (then compressed by the compressor) to perform a desired operation.

b. If the actuation must be completed quickly and calculations of flow through the air inlet (orifice) are required.

In each case above, the change in internal volume is required. Read up from the two heights involved to the intersecting point with the volume curve. Then move to the left and read from the volume scale. In the example at 4.0 a #22 (notice most volume curves are at 100 psig) has an internal volume of 349 in^3 **[11]** and at 9.0 the volume is 752 in^3 **[**12**]**. The change in volume is then 752 in^3 – 349 in^3, or 403 in^3. The volume at minimum height (349 in^3) would not be subtracted if exhausting the air spring to atmospheric pressure.

Notice the shaded area **[**13**]**. We do not recommend that an air spring be used at heights extending into this section. The “beginning of the shaded area” for a #22 is at 101 inches **[**5**]**.

SEE PAGE 15 FOR A MORE DETAILED DISCUSSION OF ACTUATION.

AIRMOUNT ISOLATION

Because of lateral stability considerations (see page 23 for more details) we recommend that each air spring be used at a *specific height* when used as an *isolator*. This specific height is called the “Airmount design height” **[**6**]**. The vertical line running through this height **[**7**]** is darkened so that it is easy to see where it intersects the static curves for load readings.

EXAMPLE: Support a 4,100 pound load with an air spring. Would a #22 be appropriate, and if so, at what height? The height isn’t much of a problem, as this part SHOULD BE USED AT 9.5 INCHES. Simply move up the darkened line to where it intersects 4,100 lbs **[**14**]**. That point falls between the 80 and 60 psig curves. Exactly what pressure would be required? Use the formula:

$$\text{Effective Area} = \frac{\text{Load (lbs.)}}{\text{Pressure (lbs/in}^2\text{)}}$$

Determine the effective area at 9.5 inches (using the 80 psig curve, since 80 psig would be closer to our exact pressure than 60 psig), or:

$$\text{Effective Area} = \frac{4{,}280 \text{ lbs. } \mathbf{[15]}}{80 \text{ lbs/in}^2} = 53.5 \text{ in}^2$$

Then divide the actual load by the effective area:

$$\frac{4{,}100 \text{ lbs.}}{53.5 \text{ in}^2} = 76.6 \text{ PSIG}$$

The pressure required to support 4,100 lbs. with a #22 at a design height of 9.5 inches is therefore 76.6 PSIG.

Please note that the static data can be converted to dynamic data (the air spring is in motion) by applying the formulas that are presented in the Airmount isolation section on page 22.

SEE PAGE 21 FOR A MORE DETAILED DISCUSSION OF VIBRATION ISOLATION.

INTERNAL RUBBER BUMPERS

Some parts are available with internal rubber bumpers. Where a bumper is available, it is shown as a dotted line in the cross sectional view of the air spring. Additionally, please note that:

1. the minimum height is increased to the “bumper contact” point **[**16**]** (this reduces the total available stroke somewhat, by 4.2 – 3.0 = 12 inches in our #22 example), and

2. the order block contains the proper ordering numbers for parts with bumpers.

BASIC PARAMETERS APPLICABLE TO BOTH AIRSTROKE™ ACTUATORS AND AIRMOUNT™ ISOLATORS

MEDIA

Air springs are designed for use with compressed air. Nitrogen is also acceptable. Air springs may be filled with water or water-glycol (automotive antifreeze) solutions. If water is to be used, rust inhibitors should be added to protect the end closures. Two reasons for liquid filling an air spring are:

1. To reduce the internal volume of air (and therefore, *increase* the natural frequency of the air spring) and,

2. To use a media which is incompressible. Accurate positioning would be one reason to do this.

Petroleum base fluids (most hydraulic oils fall into this category) are NOT RECOMMENDED. Moderately lubricated air will not harm the bellows.

PRESSURE

1. 100 PSIG MAXIMUM FOR 2 PLY.
2. 175 PSIG MAXIMUM FOR HIGH STRENGTH.

We recommend that there be a minimum three times safety factor between maximum internal air pressure and burst pressure. So, as an example, if 100 psig is required, the burst should be at 300 psig or greater. For convoluted air springs, the burst pressure decreases as height increases. Therefore, the determining factors are twofold: What is the maximum height into extension and what is the internal pressure at that point? Please see the Airstroke Inflation Pressure Chart (for single, double, and triple convoluted air springs) on page 17 for specific pressure vs. height information.

For AIRMOUNT applications (where the part is used at a height very close to the shaded area), it is best to stay within 100 psig maximum for a two ply, and 150 psig maximum for a four ply or high strength cord air spring.

TEMPERATURE

1. **STANDARD BELLOWS.** Our standard industrial air springs should be limited to use in the range:

   – 35° F to + 135° F.

2. **ALL NATURAL RUBBER (LOW TEMPERATURE COMPOUND).** A few of our industrial air springs are available in all natural rubber construction. This increases the acceptable cold or low end of the scale to – 65° F. The range then becomes – 65° F to +135° F.

3. **EPICHLOROHYDRIN (HIGH TEMPERATURE COMPOUND).** Most convoluted parts are available in this material. The operating temperature range for it is: 0° F to 225° F. Additionally, Epichlorohydrin has very good oil resistance. ALL EPICHLOROHYDRIN APPLICATIONS MUST BE APPROVED BY FIRESTONE. For more information on Epichlorohydrin (also known as Herclor), ask for Technigram number 111.

CONTAMINATES

Shielding should be used to protect the bellows from exposure to hot metal, sand, petroleum base fluids, acids, etc. Please consult Firestone if you wish to know how the bellows will withstand a specific contaminant (For liquids such as acids, it is important to know both concentration and temperature).

STORAGE

The best storage environment is a dark, dry area at normal room temperature.

WARNING

DO NOT INFLATE ASSEMBLY WHEN IT IS UNRESTRICTED. ASSEMBLY MUST BE RESTRICTED BY SUSPENSION OR OTHER ADEQUATE STRUCTURE. DO NOT INFLATE BEYOND PRESSURES RECOMMENDED IN DESIGN LITERATURE (CONTACT FIRESTONE FOR INFORMATION). IMPROPER USE OR OVERINFLATION MAY CAUSE ASSEMBLY TO BURST CAUSING PROPERTY DAMAGE OR SEVERE PERSONAL INJURY.

AIRSTROKE ACTUATION

SELECTION

1. Refer to the selection guide on page 32 for Airstroke force and stroke capabilities. After your list of possibilities has been reduced to one or two air springs, then turn to the individual data page for more detailed information on those parts.

2. STROKE: The maximum STROKE CAPABILITY is the difference between the height corresponding to the "start of the shaded area" minus the minimum height. This entire stroke, *or any portion thereof*, 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.

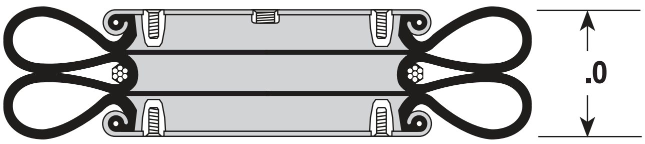
3. FORCE: Read the forces directly from the static data chart, or, use the force table located under the chart. Notice that the force generally decreases as height increases. This feature is discussed in detail on page 12 in the section entitled "How to Use the Static Data Chart."

4. SELECT THE END CLOSURES AND AIR INLET SIZE: Most Airstroke actuators are available with permanently attached plates or bead ring attachments. If an alternate end closure option is available, it is so stated under the cross sectional view of the part. Please refer to page 6 for a detailed discussion of end closure options.

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. Here is a #22 shown in the collapsed or "pinch point" condition:



The bellows can be damaged if allowed to constantly bottom out as shown above; 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. In our #22 example, the block would need to be at least 3.0 inches high. If an external downstop cannot be used, many parts are available with internal rubber bumpers (shown as a dotted line in the cross-sectional view of the air spring where available).

2. In EXTENSION, an upstop is required to prevent the air spring from overextending at heights into the shaded area of the graph. The reasons for this are twofold: **a)** the life of the bellows may be reduced and **b)** the crimp may open up, allowing the bellows bead to blow out of the metal end closure. There are many ways to design-in an upstop, including

- **a.** a chain,
- **b.** a cable,
- **c.** contacting a metal stop, etc.

RETURN

An Airstroke actuator is a *single acting* device. To return the Airstroke 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. The force to collapse the convoluted type Airstrokes to minimum height is given in the order block section for each part. If the load is not sufficient, then a second Airstroke or coil spring may be required.

GUIDING

An Airstroke follows the path of least resistance; therefore, the actuator should be guided in most instances. 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.

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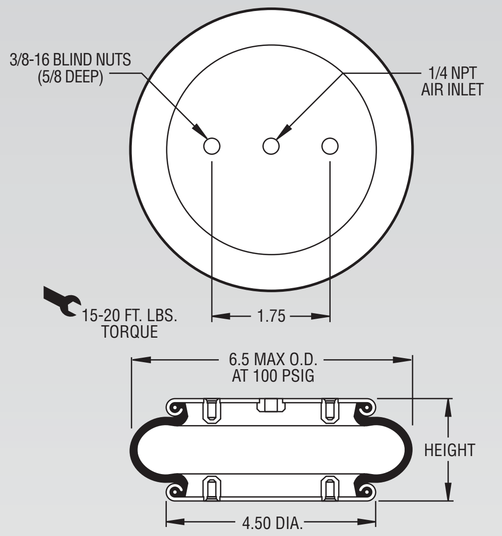
Description		Assembly Order No.
Style 131	Blind nuts, 1/4 NPT	WO1-358-7731
	Blind nuts, 3/4 NPT	WO1-358-7742
Two Ply Bellows	Socket head aluminum bead rings (bolts, nuts, washers not included-use 1/4 cap screws)	WO1-358-0127
	3/4 NPT (only) upper plate, blind nuts lower plate	WO1-358-7729
	Rubber bellows only	WO1-358-0131
Assembly weight .... 2.8 lbs.		
Force to collapse to minimum height (@ 0 PSIG)...... 32 lbs.		



NOTE: A bead plate part is shown. This part is also available with bead rings. Bolts are not included. See pages 8-10 for explanation.

Static Data
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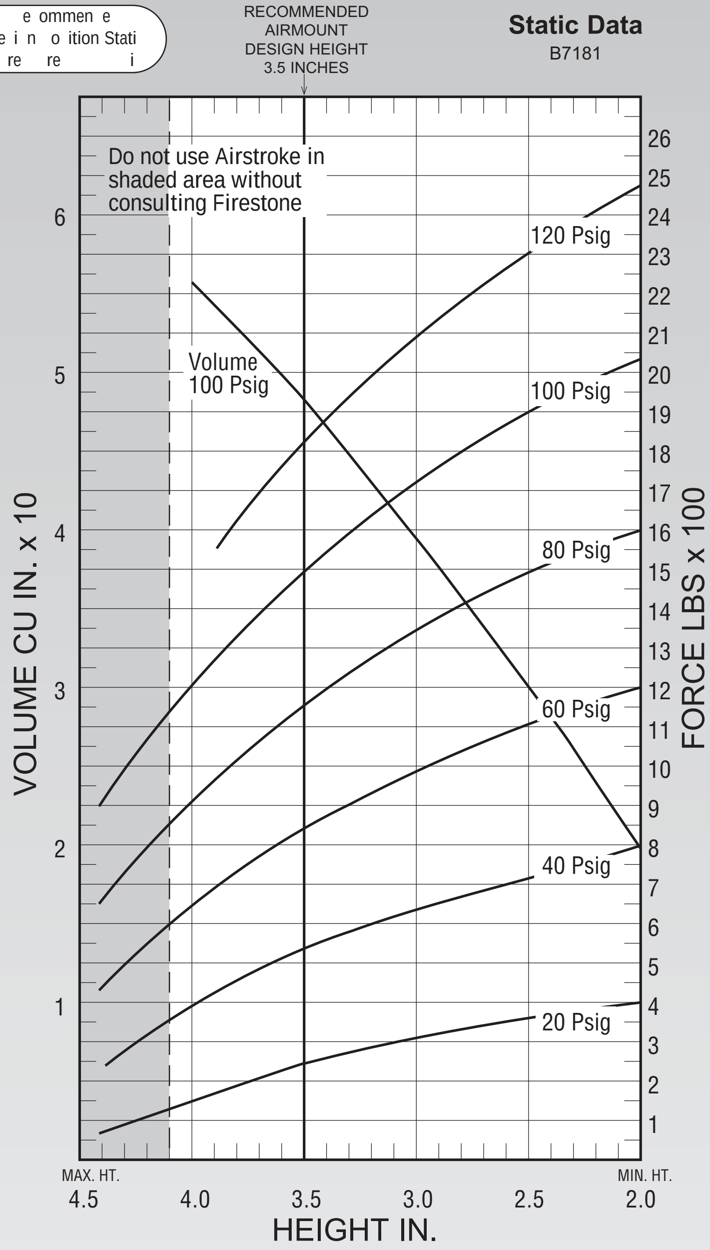

See page 12 for instructions on how to use chart.

Dynamic Characteristics at 3.5 in. Design Height (Required for Airmount isolator design only)				
Volume @ 100 PSIG = 53 in^3			Natural Frequency	
Gage Pressure (PSIG)	Load (lbs.)	Spring Rate (lbs./in.)	CPM	HZ
40	550	587	195	3.25
60	850	833	186	3.09
80	1,170	1,082	181	3.01
100	1,510	1,331	176	2.94

Force Table (Use for Airstroke™ actuator design)						
Assembly Height (in.)	Volume @ 100 PSIG (in^3)	Pounds Force				
		@20 PSIG	@40 PSIG	@60 PSIG	@80 PSIG	@100 PSIG
4.0	56	160	400	650	910	1,210
3.0	39	310	640	990	1,350	1,730
2.0	20	390	790	1,200	1,600	2,050