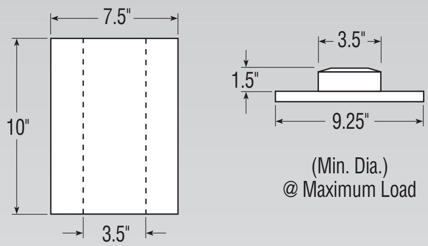
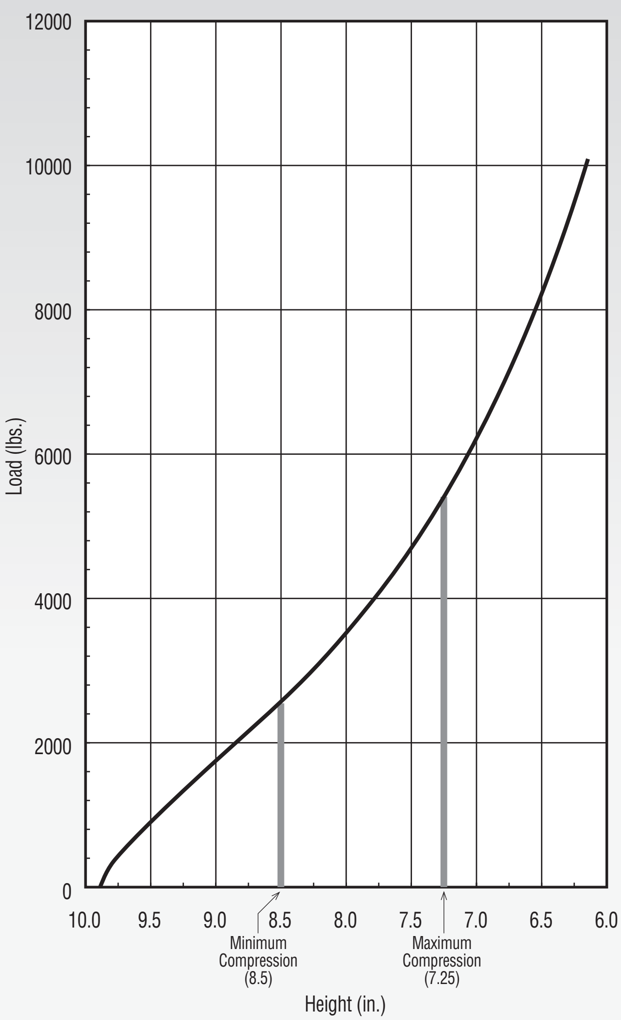
MARSH MELLOW™ SPRINGS — Firestone

0176

IMPERIAL

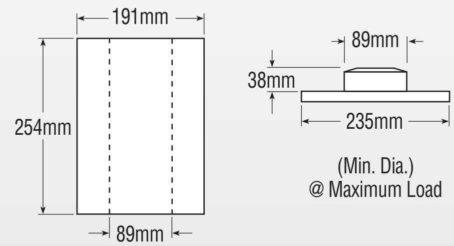
Compression (%)	15.0	20.0	22.5	25.0	27.5
Load (lbs.)	2300	3350	4000	4600	5300
Height (in.)	8.5	8.0	7.8	7.5	7.3
Rate (lbs./in.)	2000	2400	2500	2600	3100
Effective Deflection (in.)	1.15	1.40	1.60	1.77	1.71
Natural Freq. (CPM)	175	159	149	141	144
Maximum OD (in.)	7.9	8.1	8.3	8.4	8.6
Weight (lbs.)	12.58				

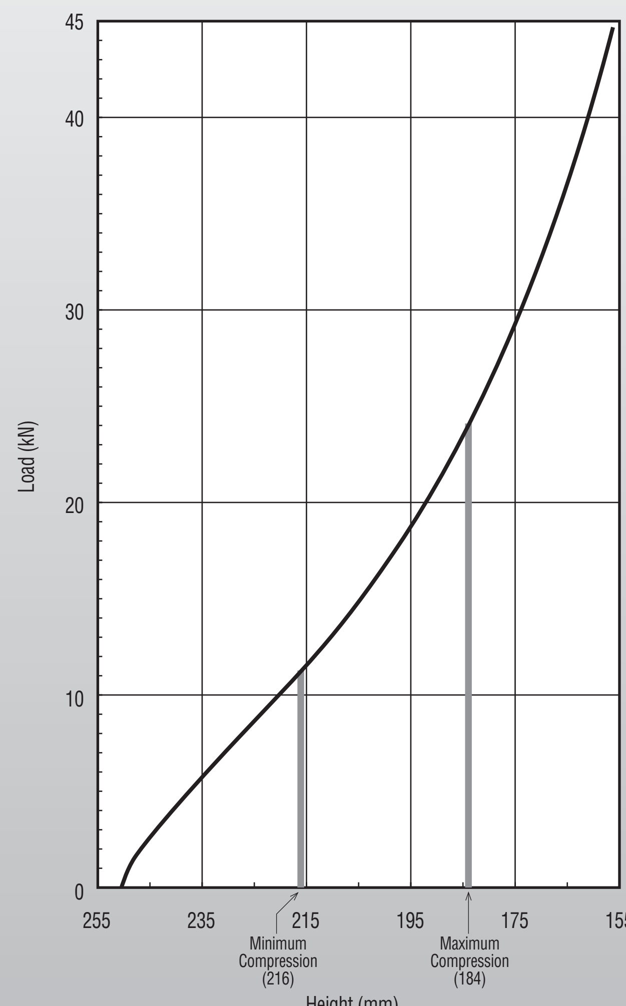




METRIC

Compression (%)	15.0	20.0	22.5	25.0	27.5
Load (kN)	10.22	14.89	17.78	20.44	23.56
Height (mm)	216	203	197	191	184
Rate (kN/m)	350	420	437	455	542
Effective Deflection (mm)	29	35	41	45	43
Natural Freq. (Hz)	2.92	2.65	2.48	2.36	2.40
Maximum OD (mm)	201	206	211	213	218
Weight (kg)	5.73				





Advantages of Firestone Marsh Mellow™ Springs

Constant Vibration Isolation with Changing Loads

The variable spring rate allows for a nearly constant natural frequency with changing loads. This results in consistent vibration isolation with variable loading.

High Load Carrying Capacity

Due to the Marsh Mellow spring's greater deflection capabilities and load carrying influences of the fabric reinforcement, it can carry a greater load when compared to an all rubber part of the same modulus and dimensions.

Excellent Vibration Isolation

Low natural frequencies provide excellent isolation of forced frequencies in the range of 800-1200 cycles per minute (13-20Hz).

Lateral Vibration Isolation

The lateral spring rate of a Marsh Mellow spring can be less than the vertical spring rate, resulting in a lower lateral natural frequency. Marsh Mellow springs provide better vibration isolation in all degrees of freedom.

Compact Overall Size

The ability to support greater loads and maintain a cylindrical shape results in a smaller overall size of the Marsh Mellow spring compared to an all rubber spring with identical load capacity. This is important when considering an application with a small design envelope.

Corrosion Resistant for a Durable, Long Life

Due to its rubber and fabric reinforced construction, the Marsh Mellow spring has been proven in the damp and corrosive environments of mines and mills where a standard coil spring will fail.

Does Not Bottom-Out

Due to the rubber construction, Marsh Mellow springs do not bottom-out like coil springs. Bottoming-out under overload or surge load sends a large amount of stress to all of the machine's components.

Eliminates Downtime and Potential Damage to Machinery

When a coil spring fails, it will often crack allowing fragments of the coil to damage equipment. This problem is eliminated with the rubber construction of Marsh Mellow springs. Additionally, Marsh Mellow springs exhibit exceptionally high overload characteristics and usually do not fail catastrophically, offering some support even during failure.

Increased Stability at Higher Percentages of Compression

Rubber is an incompressible fluid which will flow to the path of least resistance. In a Marsh Mellow, as the height compresses, the fabric reinforced rubber plies pantograph and the diameter grows. This supports the rubber core laterally even at 30-40% compression.

Effective Noise Reduction

Marsh Mellow springs reduce structurally transmitted noise caused by vibration. Marsh Mellow springs are quiet, unlike steel springs which often suffer coil chatter and readily transmit high frequency structural noise.

Low Cost

The Marsh Mellow spring's high load capability means fewer springs may be needed in an application, resulting in less overall cost.

Maintenance Free

Marsh Mellow springs have no moving parts. No maintenance or lubrication is required.

Precautions with Marsh Mellow™ Springs

Temperature
Our standard industrial Marsh Mellow™ springs have an operating range of -40°F to 135°F (-40°C to 57°C). The upper limit is defined by the actual rubber temperature during operation. High frequency inputs or large deflections will cause the rubber temperature to increase.

Design Envelope
Adequate clearance should be provided around the Marsh Mellow spring to prevent rubbing of the outer cover. The outside diameter of the spring at various heights is listed in the table of dynamic characteristics on each individual data page.

Contaminates
Shielding should be used to protect the rubber from exposure to hot metal, petroleum base fluids, acids, etc. Please consult Firestone Industrial Products if you wish to know how the spring will withstand a specific contaminate. (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.

Percent Compression
The general compression range of a Marsh Mellow spring is 15% to 27%, however this value may vary somewhat among springs and applications. Always follow the load ranges and their corresponding compression percentages as shown in the selection guide.

Allowable Stroke
When applying a Marsh Mellow spring, the stroke throughout the range of motion of the machine being isolated must be considered. Delta strain, defined as the ratio of the stroke to the free length, is restricted to less than 7.5%.

Note that a given stroke is typical of vibrating screen types of applications, where the stroke is designed into the system. In other isolation applications, this stroke may not be known. The stroke is typically not excessive in standard isolation applications, but should be considered. Consult Firestone for assistance.

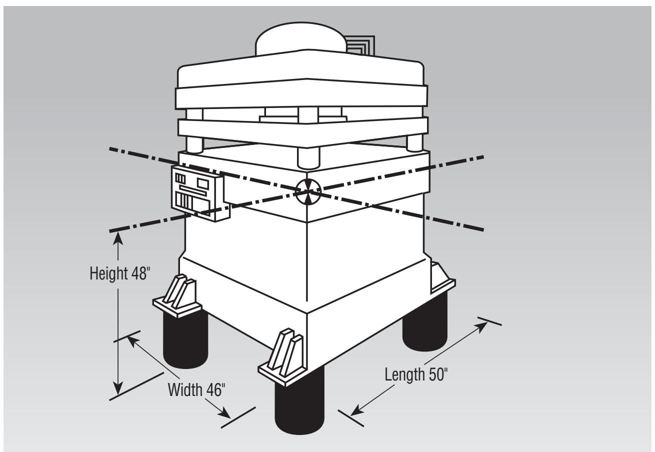
Disturbing Frequency Range
Marsh Mellow springs are suitable for disturbing frequencies in the 800-1200 CPM (13-20Hz) range or medium stroke applications. High frequency, high stroke applications may lead to overheating the Marsh Mellow spring. Low stroke applications, however, are capable of handling higher disturbing frequencies. Please consult Firestone Industrial Products for assistance.

Lateral Stability
The lateral spring rate to load ratio for a Marsh Mellow spring decreases as deflection increases. This is one reason it is important not to exceed the given load capabilities.

Precautions with Marsh Mellow™ Springs

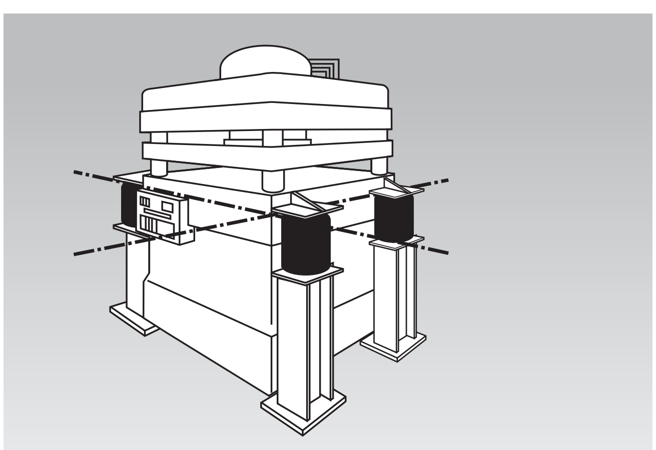
Center of Gravity

A Marsh Mellow™ spring isolation system is inherently soft (easily deflected); therefore, precautions must be taken to insure that the system is stable. First consider the location of the center of gravity (CG). Ideally, Marsh Mellow springs 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.



In the above example, the most narrow distance between two Marsh Mellow springs is 46 inches (117 cm). The height to the CG is 48 inches (122 cm); therefore, this system does not meet our guideline. Two possible solutions would be:

1. Increase the base dimensions to meet our guideline by increasing both the width and length to at least 48 x 2 or 96 inches (122 x 2 or 244 cm).
2. Locate the Marsh Mellow Spring at the CG as shown below.



Startup and Shutdown / Resonance and Amplification

Resonance is the condition where the forced frequency of the vibrating system is equal to the natural frequency of the suspension. When this happens, amplification of movement occurs. If the normal stroke of a vibrating screen, for example, is 5/16 of an inch (8 mm), during startup and shutdown (as the machine goes through resonance), the amplitude of movement will be multiplied. So while the machine is accelerating to normal operating speed and decelerating during shutdown, the stroke may be amplified in the range of ½ (12 mm) to 1½ (38 mm) inches. The longer the machine takes to go through resonance (to speed up to, or slow down from full operating speed), the larger the amplitude of movement. Note that in some applications, the addition of viscous or friction dampers may be required to reduce the amplitude of motion during startup and shutdown.

Isolating an Unbalanced Mass

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

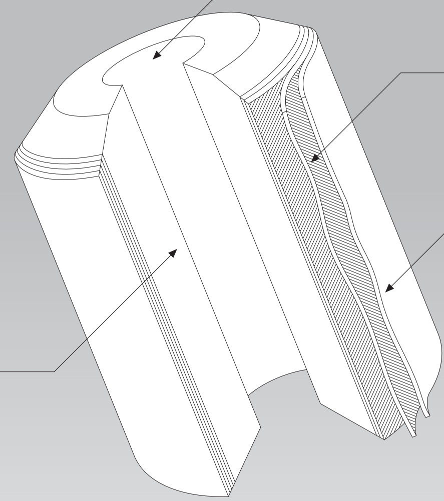
1. The ratio of the unbalanced moving mass to the total suspended mass.
2. The ratio of the speed of the unbalanced moving mass (forced frequency) to the natural frequency of the Marsh Mellow spring and supported mass system.

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 a static 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.

See page 10 for additional information.

Marsh Mellow™ Spring Construction



Unique construction elements are the key to the Marsh Mellow™ spring's design flexibility. The basic construction of the Marsh Mellow spring includes a solid rubber core with a hollow center, and several plies of fabric reinforced rubber as an outer cover. These elements may be modified to meet specific load and performance requirements.

Solid Rubber Core Material

The rubber material of the Marsh Mellow spring has a large effect on the performance of the spring as well as to what application it is suited. The rubber material used in vibration isolation applications is efficient and provides little damping. Higher damping compounds are available but better suit shock absorbing applications. The correct rubber core material is application dependent.

Hollow Center

The diameter of the hollow center is another variable in the load capacity of the Marsh Mellow spring. The hollow center directly affects the contact area over which force is applied. As expected, a smaller diameter center will support a greater load compared to an otherwise identical Marsh Mellow spring.

The hollow center also permits mounting the Marsh Mellow spring in a variety of applications. These mounting arrangements are discussed in greater detail within the "Installation and Mounting Arrangements" section of the *Marsh Mellow Spring Design Manual.*

Fabric Reinforcement

The fabric reinforced rubber has a large effect on the performance of the Marsh Mellow springs. In appearance, Marsh Mellow springs are cylindrical in shape with a hollow center the entire length of the part. What separates the Marsh Mellow spring from an all rubber part of the same dimensions is its bias plies of fabric reinforced rubber. The plies, which surround the rubber core material, provide stability and a consistent cylindrical shape. The angle which the plies are laid upon each other may be manipulated to meet application specific requirements.

The performance of the Marsh Mellow spring is influenced by several variables. If the models provided within this catalog do not meet your engineering requirements, please contact Firestone Industrial Products. By modifying the construction details, we may be able to meet your needs.

Cover Stock

The cover rubber aids in abrasion resistance and protects the inner layers of fabric reinforcement. This is not intended to take the place of an adequate design envelope. Please consult data pages for outside diameter dimensions, and allow for adequate space to avoid abrasion.

Marsh Mellow™ Spring Dynamic Characteristics

This section includes terminology associated with the dynamic characteristics of the Marsh Mellow™ spring. The terminology is defined both quantitatively and qualitatively. This information will help in determining which spring best suits an application, whether it is vibration isolation, isolating an unbalanced mass, or shock absorption.

Vibration Isolation

Vibration (disturbing frequency)

The periodic motion of a body, measured in cycles per minute.

Isolator

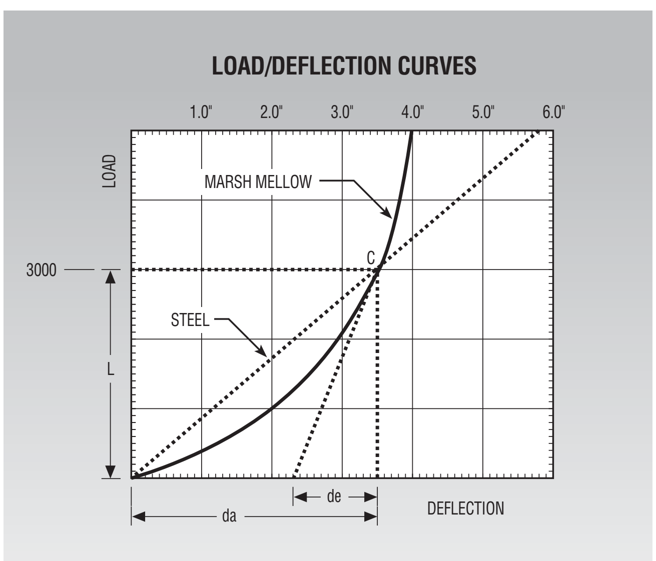
An isolator is a device which allows two objects to exist without influencing each other. For example, a Marsh Mellow spring prevents a vibrating object from affecting the surrounding environment while still allowing the object to vibrate.

Spring Rate

Spring rate is defined as the amount of force required to deflect a spring 1 inch. Graphically, spring rate is equal to the slope of the load/deflection curve at the corresponding load. A steel coil spring has a constant spring rate as shown by the straight line on the load/deflection chart below. The slope of a Marsh Mellow spring curve changes with height. This results in a changing spring rate. These characteristics are illustrated below:

$$\text{Spring Rate} = \frac{\textit{Force}}{\textit{Deflection}} = \text{Slope of the Load/Deflection Curve}$$

Load/Deflection Curves



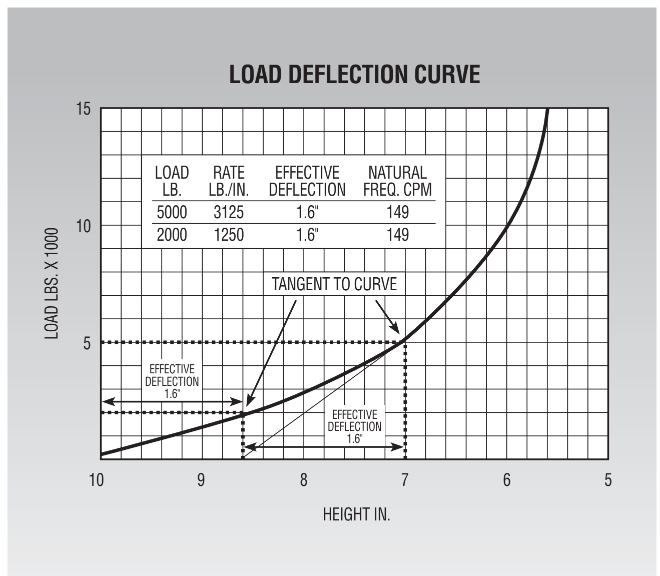
Effective Deflection

Because the slope of the Marsh Mellow spring load/deflection curve changes, the spring rate must be expressed in terms of effective deflection and load. Effective deflection is the difference between actual deflection and the x intercept of the tangent line to the load curve at the design load. Effective deflection is also equal to the given load divided by the slope of the load curve at that point.

$$\text{Effective Deflection (in)} = \frac{\textit{Load (lbs)}}{\textit{Spring Rate (lbs / in)}}$$

$$\text{Effective Deflection (m)} = \frac{\textit{Load (kN)}}{\textit{Spring Rate (kN / m)}}$$

Since the spring rate of a coil spring is constant, the effective deflection is equivalent to the actual deflection. A Marsh Mellow spring's spring rate increases as the load increases, therefore the effective deflection is almost constant. This results in a consistent isolator with changing loads.



Spring Type	Height	Load	Actual Deflection	Effective Deflection	Spring Rate
Coil Spring	7.3 in	1500lbs	1.2 in	1.2 in	1200 lb/in
Coil Spring	6.0 in	3000lbs	2.5 in	2.5 in	1200 lb/in
Marsh Mellow	6.0 in	1500lbs	2.5 in	1.8 in	810 lb/in
Marsh Mellow	4.8 in	3000lbs	3.7 in	1.8 in	1620 lb/in

Marsh Mellow™ Spring Dynamic Characteristics

Natural Frequency

A spring system's natural frequency determines the efficiency of an isolator. Effective isolators have a low natural frequency.

$$\text{Natural Frequency (CPM)} = 188 \times \sqrt{\frac{\text{Spring Rate (lbs / in)}}{\text{Load (lbs)}}}$$

$$= \frac{188}{\sqrt{\text{Effective Deflection (in)}}}$$

$$\text{Natural Frequency (Hz)} = 0.50 \times \sqrt{\frac{\text{Spring Rate (kN / m)}}{\text{Load (kN)}}}$$

$$= \frac{0.50}{\sqrt{\text{Effective Deflection (m)}}}$$

Disturbing Frequency

Disturbing frequency is the frequency of the motion which needs to be isolated. This is usually expressed in cycles per minute (CPM) or cycles per second (Hz). As an example, the disturbing frequency of a motor is the number of revolutions per minute. The lower the disturbing frequency is, the more difficult it is to isolate.

Transmissibility

Transmissibility is the amount of vibration energy which is transmitted from the vibrating source to the surrounding environment.

$$\text{\% Transmission} = \frac{100}{\left[\frac{\text{Disturbing Freq (CPM)}}{\text{Natural Freq (CPM)}}\right]^2 - 1}$$

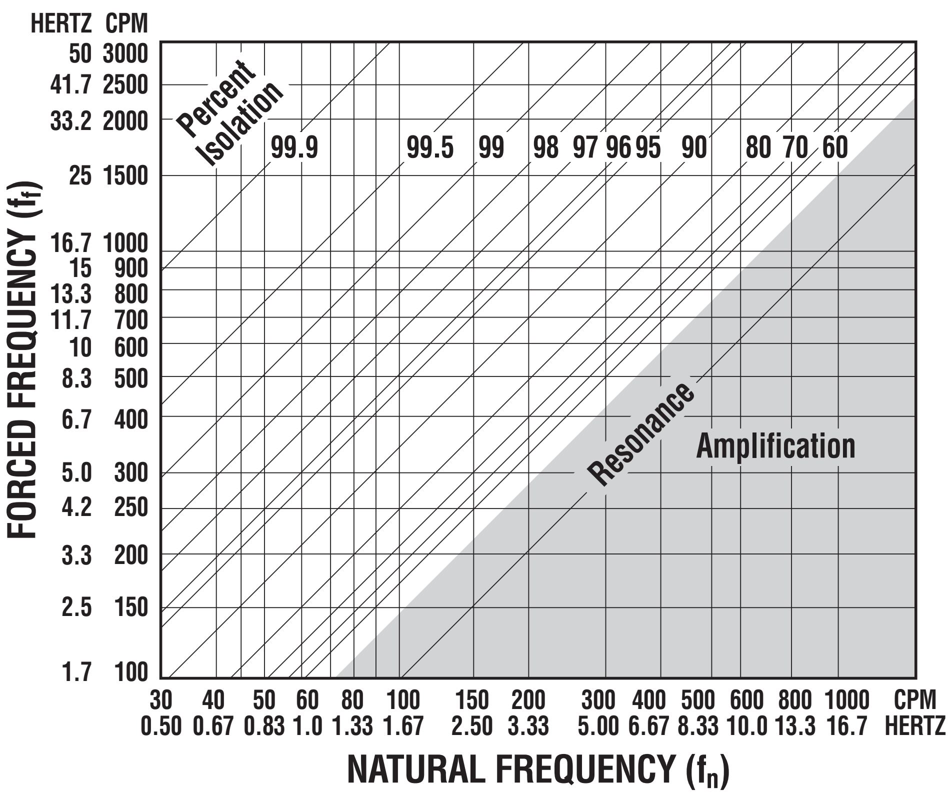
Isolation

Isolation is the amount of vibration energy prevented from being transmitted through the isolator.

% Isolation = 100% - Transmissibility

This equation is illustrated in the chart below.

ISOLATION CHART



Marsh Mellow™ Spring Dynamic Characteristics

Resonance

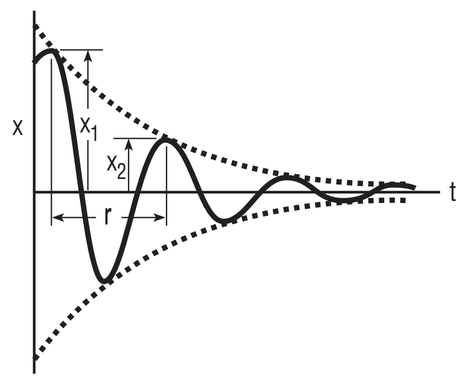
Resonance occurs when the disturbing frequency equals the natural frequency of the Marsh Mellow™ spring system. When this occurs the amplitude of vibration will increase without bound. The system is unstable at resonance.

Amplification

Amplification occurs when the disturbing frequency is less than 1.4 times the natural frequency. The vibrating motion is amplified in this range.

Amplitude

Amplitude is the amount of motion associated with the vibration. Quantitatively, the amplitude is half of the total peak to peak distance. On the figure below it is defined as X_1 and X_2.



Stroke

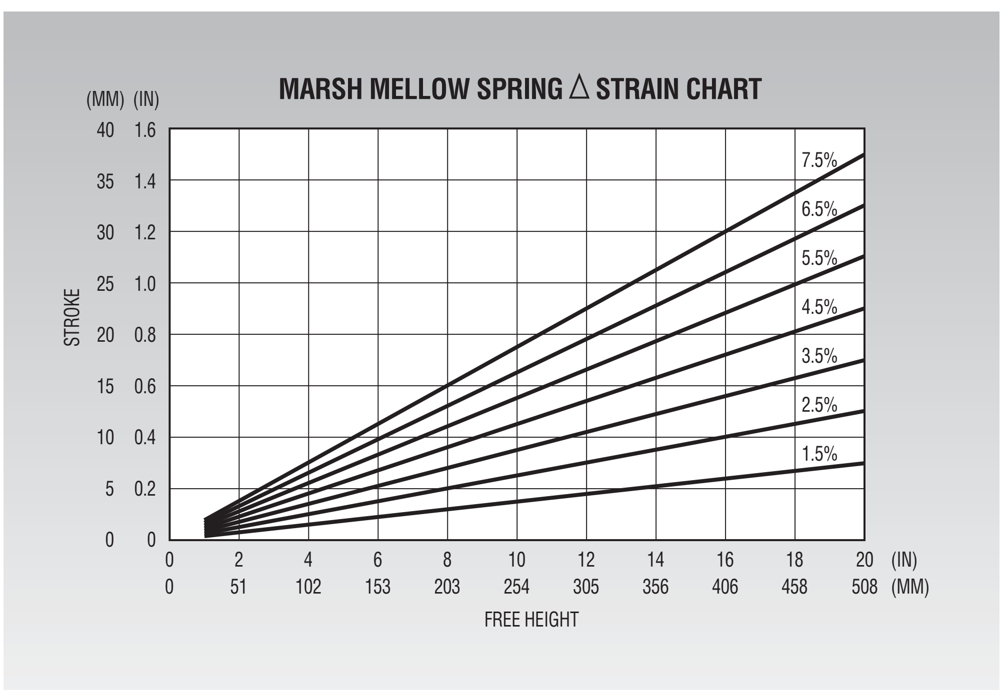
The stroke is the total peak to peak distance the machine moves during operation. It is equal to twice the amplitude.

Strain

Marsh Mellow springs will survive a defined amount of movement from vibrating equipment. The amount of movement, or stroke, allowed is measured in delta strain. Delta strain is dependent upon stroke and the free height of the Marsh Mellow spring.

$$\Delta\text{Strain} = \frac{\text{Stroke (in or mm)}}{\text{Free Height (in or mm)}} \times 100\%$$

The maximum delta strain allowed for the Marsh Mellow spring is 7.5%. The following delta chart shows the relationship of free height, stroke, and delta strain.



Marsh Mellow™ Spring Dynamic Characteristics

Isolating an Unbalanced Mass

Excursion

Excursion is the amount of movement caused by a moving mass. An isolator will not decrease this movement. Excursion, however, can be controlled through dampers or by increasing the static mass. Excursion is directly proportional to the ratio of moving mass to static mass. The smaller the ratio is, the smaller the amount of excursion. A good "rule of thumb" is a static mass no smaller than 10 times the moving mass.

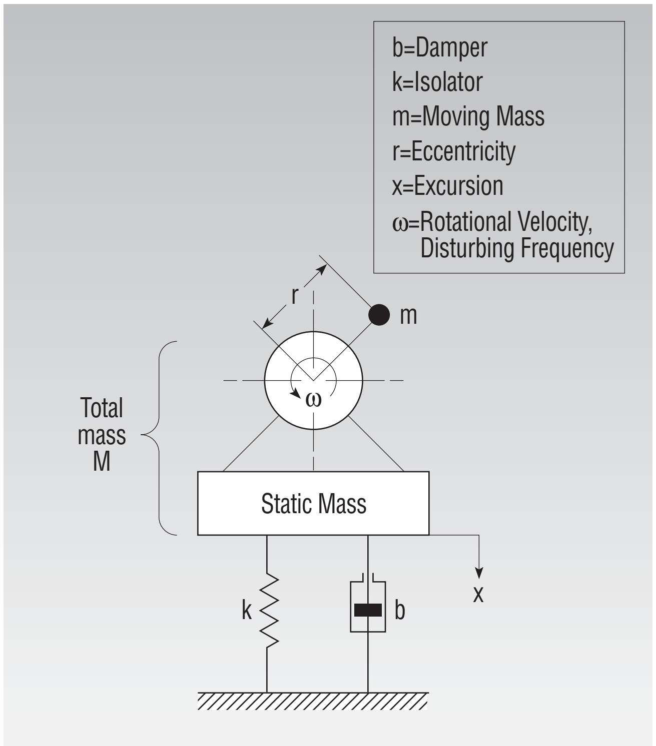
$$\text{Excursion(in or mm)} \sim \frac{\text{MovingMass(lbs or kN}}{\text{StaticMass(lbs or kN)}}$$

Static, or Inertia, Mass

Static, or inertia, mass is a heavy base used to decrease the amount of movement caused by a smaller moving mass.

Eccentricity

Eccentricity is the radius a moving mass rotates, thereby causing excursion. The larger the eccentricity, the greater the amount of excursion.



Marsh Mellow™ Spring Dynamic Characteristics

Shock Impact

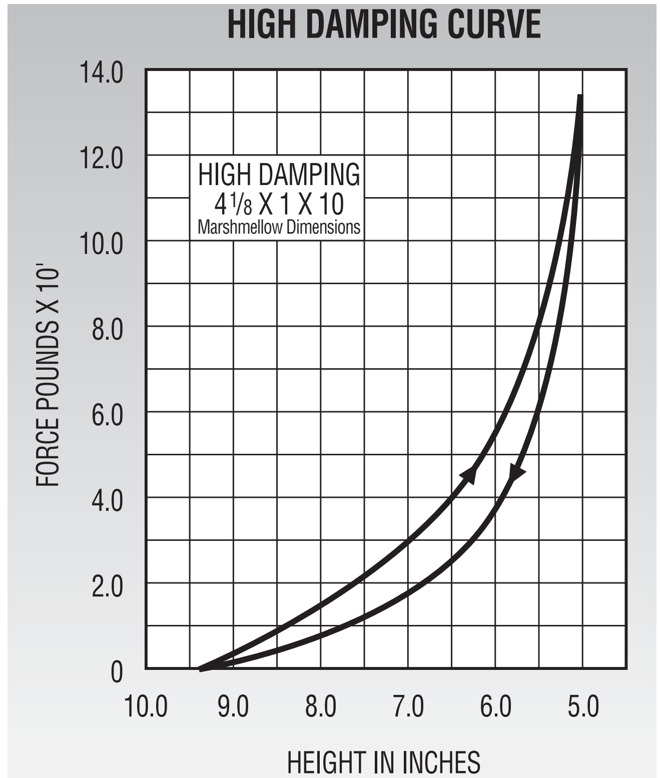
The Marsh Mellow™ spring is also used in shock impact applications. In these applications, energy must be dissipated from a system. It is important to know both the energy which must be absorbed, as well as the damping capability of the Marsh Mellow spring. The amount of energy in a system can be calculated by knowing the parameter of application (mass of object, velocity, height of free fall, etc.). The energy which can be dissipated into the spring is equal to the amount of hysteresis in the Marsh Mellow spring load/deflection curve. These two variables are required in order to select the correct spring in a shock impact application.

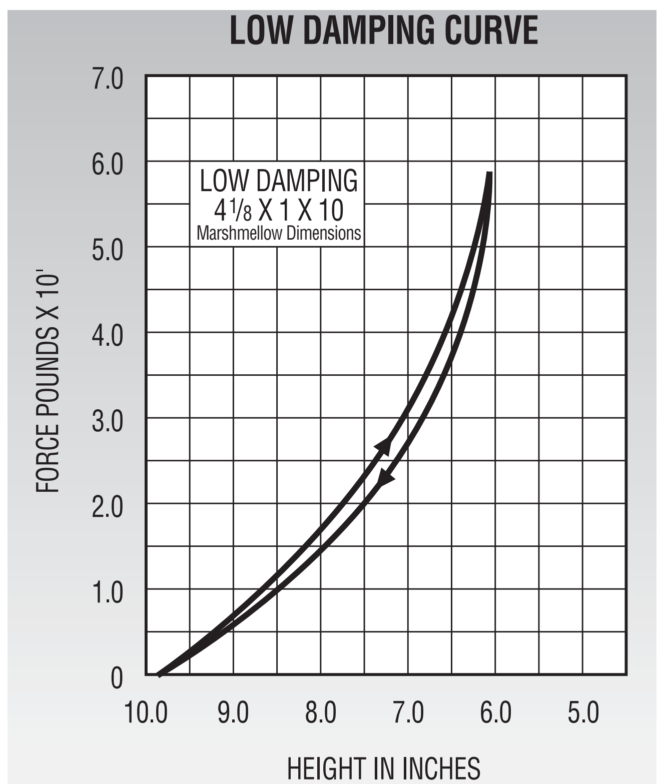
Damping

Damping occurs when energy is dissipated from a system. In order to absorb energy in a system, a damping device is used. Damping is greatest in springs with a large degree of hysteresis. The greater the amount of hysteresis in a Marsh Mellow spring curve, the greater the amount of energy absorbed by the spring and dissipated from the system. Marsh Mellow springs used for vibration isolation are typically low damping.

Hysteresis

Hysteresis can be viewed as the change in load as the spring is compressed and returns to its starting height. A Marsh Mellow spring will produce a greater amount of force as it is compressed compared to the extension. When a solid is deflected, some of the energy necessary to deflect it turns into heat. This is not returned in the form of return force, but as dissipated heat.





Individual Data Sheet

On each individual data sheet detailed information is provided on a specific Marsh Mellow™ spring. Each sheet contains four main components.

- Part Number
- Table of Dynamic Characteristics
- Drawing showing Marsh Mellow spring Dimensions and Mounting Pin Dimensions
- Load/Deflection Curve

Part Number

The part number of the Marsh Mellow spring is shown at the top of the data sheet. The part number will start with W22-358-_ _ _ _. The last four digits are specific for each Marsh Mellow spring.

Table of Dynamic Characteristics

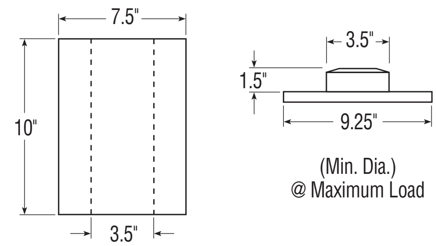
The Table of Dynamic Characteristics contains critical information needed to select the correct Marsh Mellow spring. The range of allowable percentages of compression are given at the top of the table. The corresponding heights and loads, as well as the spring rate and effective deflection, are listed below the percentages of compression. It is necessary to know the natural frequency of the Marsh Mellow spring to determine the percentage of isolation. The outside diameter of the Marsh Mellow spring throughout the allowable compression is listed in order to check the design envelope.

(W22-358-0176)

IMPERIAL					
Compression (%)	15.0	20.0	22.5	25.0	27.5
Load (lbs.)	2300	3350	4000	4600	5300
Height (in.)	8.5	8.0	7.8	7.5	7.3
Rate (lbs./in.)	2000	2400	2500	2600	3100
Effective Deflection (in.)	1.15	1.40	1.60	1.77	1.71
Natural Freq. (CPM)	175	159	149	141	144
Maximum OD (in.)	7.9	8.1	8.3	8.4	8.6

Marsh Mellow Spring and Mounting Pin Dimensions

A Marsh Mellow spring has three important dimensions: outside diameter, inside diameter, and free height. The three dimensions illustrated on the data sheet are at an unloaded state. The heights and outside diameters of the Marsh Mellow spring under loaded conditions are listed in the table of dynamic characteristics.



The mounting pin dimensions for the specific spring are needed for installation. These given dimensions are for typically mounting the Marsh Mellow spring in vibration isolation applications. The height of the mounting pin, and mounting plate diameter, are the minimum values allowed at maximum loading. The pin diameter should be equal to the inside diameter of the spring.

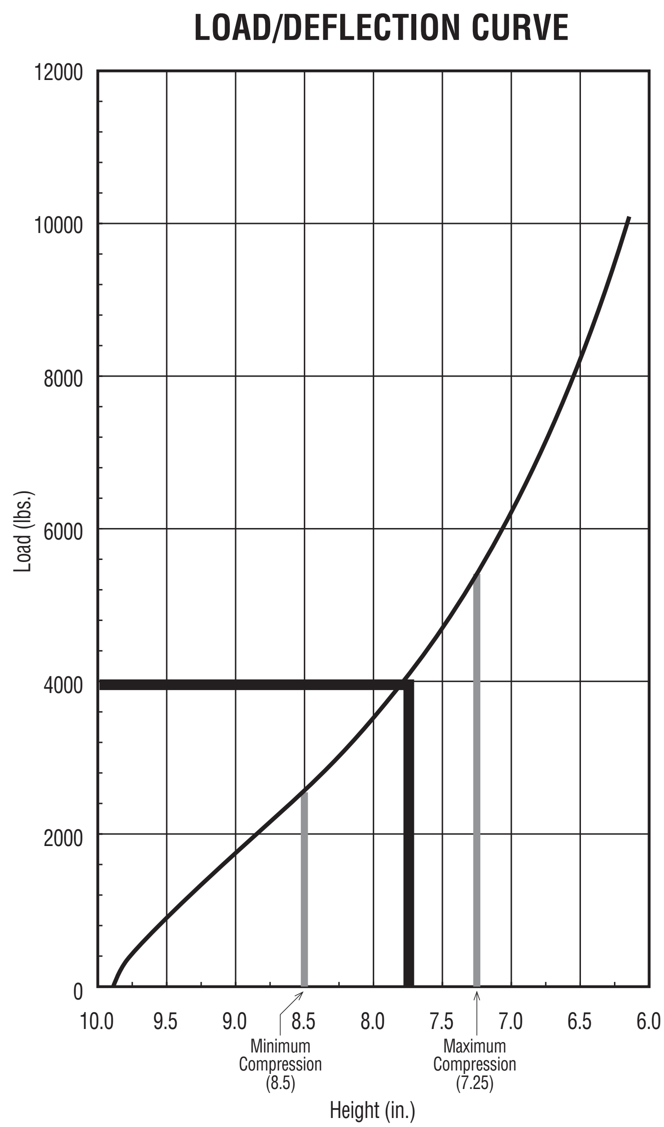
Individual Data Sheet

Load/Deflection Curve

The load/deflection curve shows the load vs. height of the Marsh Mellow™ spring.

In order to determine the height of the Marsh Mellow spring at a given load, use the load/deflection curve. Move horizontally on the chart from the given load on the vertical axis. Stop and make a fixed point at the compression curve. The height directly below this point on the x axis is the height of the Marsh Mellow spring at the given load. This procedure is shown on the chart below with a given load of 4000 lbs.

1. Proceed right horizontally from a load of 4000 lbs.
2. Stop and make a fixed point directly on the compression curve.
3. Proceed straight down to the horizontal axis.
4. The intersection at the horizontal axis is the height at the given load, 7.8 inches.



Selection Procedure *(Imperial)*

Vibration Isolation Selection

1. For specific design parameters needed to determine the correct Marsh Mellow™ spring for an application, consult the “Design Parameter Sheet” on page 61.
2. If possible, determine the load at each mounting point. If this is not possible, estimate the load on the Marsh Mellow spring by adding the weight of the machine plus the weight of the materials on the machine while operating, then divide the total weight by the number of Marsh Mellow springs to be used. This estimate will only be accurate if the load’s center of gravity is equidistant from each mounting point. If the weight of the machine is unknown, contact the equipment manufacturer, your distributor or Firestone Industrial Products for assistance. Firestone Industrial Products’ or your distributor’s machine weight estimates are based on the manufacturer’s published weights of current models of the same size and type. Weight consideration must be given to a special machine, modified machines, or older machines that will add weight to the unit.
3. Select a spring that falls in the mid-range of the minimum and maximum load capacities shown in the “Selection Guide”. For maximum life and stability, it is suggested that Marsh Mellow springs be used at or less than 25% (of free height) actual static deflection. Although the maximum loading figures in the above selection guide are given at 27.5% deflection (and these Marsh Mellow springs all pass our lateral stability test at up to 30% deflection), the lateral rate to load ratio decreases as deflection increases. The extra 2.5% deflection, then, is a safety factor for possible weight miscalculations. Additionally, the delta strain (Stroke/Free Length x 100) should not exceed 7.5%.
4. If more than one spring meets the load criteria in number 2, then select the spring with the lowest natural frequency (isolation percentage will be increased).
5. Determine the stroke required.
6. Refer to the second selection guide table. Check to make sure that for a given stroke and part, the height and load are within the allowable limits given.
7. If it does not fall within the proper range, then select a different spring or go to more than one Marsh Mellow spring per corner.
8. Consult the individual data page for the specific load and vibration capabilities, as well as mounting and Marsh Mellow spring dimensions.
9. Determine if the natural frequency of the Marsh Mellow spring will sufficiently isolate the disturbing vibration.
10. Tag lines are usually required for inclined screens or screens with off-mounted pivoted motors. (Consider using our tension band W22-358-0215 or W22-358-0275).
11. Please review the “Installation” section of the *Marsh Mellow Spring Design Manual* for additional information.

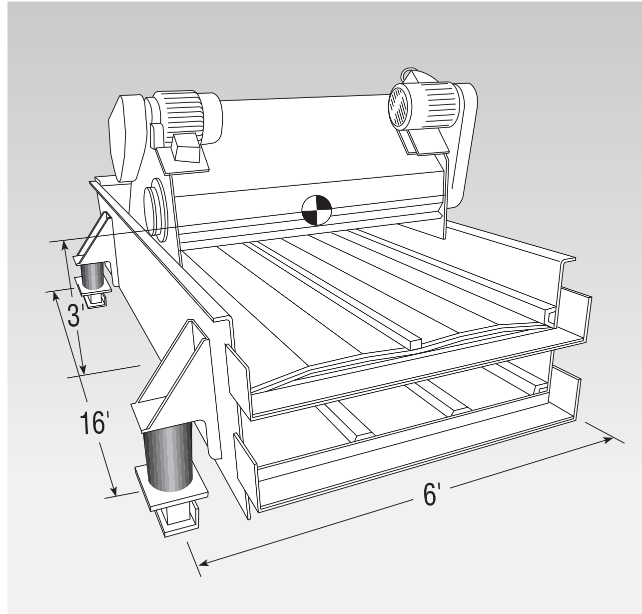
Selection Procedure *(Imperial)*

Vibration Isolation Selection Example

The following example follows the correct procedure in determining which Marsh Mellow™ spring best suits a given set of requirements.

The vibrating screen illustrated to the right has the following description and design requirements:

Description of Equipment	= Vibrating screen
Total Weight of Machine	= 12000 lbs.
Total Material Load	= 4000 lbs.
Number of Mounting Points	= 4
Space Available	=10 inch diameter footprint
Stroke	= 1/2 inch
Disturbing Frequency	= 1000CPM
Percent Isolation Desired	= 90%



1. Determine Individual Spring Load

The exact load at each mounting point is not available, so the individual loads must be estimated. The minimum load each spring will support is assumed to be equal to the machine weight divided by the number of mounting points.

$$\text{Minimum Load} = \frac{\text{Machine Load(lbs)}}{\text{\# of Mounting Points}} = \frac{12000\text{lbs}}{4} = 3000\text{lbs per spring}$$

The maximum load is equal to the machine load plus the weight of the material.

$$\text{Maximum Load} = \frac{\text{(Machine + Material Load)lbs}}{\text{\# of Mounting Points}} = \frac{(12000 + 4000)\text{lbs}}{4} = 4000\text{lbs per spring}$$

2. Examine Marsh Mellow Spring Load Capabilities

From the “Selection Guide - Load Capabilities”, seven different Marsh Mellow springs will support load range from 3000lbs. to 4000lbs. The W22-358-0200, 0176, 0042, 0190, 0179, 0122, and 0228. As discussed in the “Dynamic Characteristics” section, a lower natural frequency Marsh Mellow spring will provide better isolation. Since the W22-358-0176 has a low natural frequency at both minimum and maximum loading, we will select this part for the example.

3. Determine Stroke Requirement

The required stroke for this screen is 0.5 inches with a maximum load of 4000lbs. On the “Selection Table - Stroke Requirements”, the 0176 has a maximum stroke capability of 0.5 inches with a load range of 1940 to 4540lbs. The 0176 meets this requirement.

Selection Procedure *(Imperial)*

4. Determine Exact % Isolation

The percentage of isolation can either be calculated or the % Isolation chart may be used. The first step is to refer to the individual data page for necessary information. The Dynamic Characteristics table will provide this data.

IMPERIAL					
Compression (%)	15.0	20.0	22.5	25.0	27.5
Load (lbs.)	2300	3350	4000	4600	5300
Height (in.)	8.5	8.0	7.8	7.5	7.3
Rate (lbs./in.)	2000	2400	2500	2600	3100
Effective Deflection (in.)	1.15	1.40	1.60	1.77	1.71
Natural Freq. (CPM)	175	159	149	141	144
Maximum OD (in.)	7.9	8.1	8.3	8.4	8.6

At the minimum load of 3000lbs, the 0176 is between 15% and 20% compression. We can interpolate this data and estimate the natural frequency at minimum load.

$$\frac{\text{MinimumLoad - Load@15\%}}{\text{Load@20\% - Load@15\%}} = \frac{\text{NaturalFreq - NaturalFreq@15\%}}{\text{NaturalFreq@20\% - NaturalFreq@15\%}}$$

$$\text{NaturalFreq} = \text{NatFreq@15\%} + \frac{[(\text{MinimumLoad - Load@15\%}) \times (\text{NatFreq@20\% - NatFreq@15\%})]}{\text{Load@20\% - Load@15\%}}$$

$$\text{NaturalFreq} = 175\text{CPM} + \frac{[(3000 - 2300)\text{lbs} \times (159 - 175)\text{CPM})]}{(3350 - 2300)\text{lbs}}$$

NaturalFreq@3000lbs = 164CPM

We can interpolate the natural frequency at the maximum load of 4000lbs in a similar way. However, in this case we know the natural frequency at 4000lbs directly from the data table.

NaturalFreq@4000lbs = 149CPM

Knowing these natural frequencies, as well as the disturbing frequency, allows us to determine the exact % isolation with the following equations:

$$\%\text{Isolation} = 100 - \left[\frac{100}{\left(\frac{\text{DisturbingFreq}}{\text{NaturalFreq}}\right)^2 - 1}\right]$$

$$\%\text{Isolation@3000lbs} = 100 - \left[\frac{100}{\left(\frac{1000\text{CPM}}{164\text{CPM}}\right)^2 - 1}\right]$$

%Isolation@3000lbs. = 97.2%

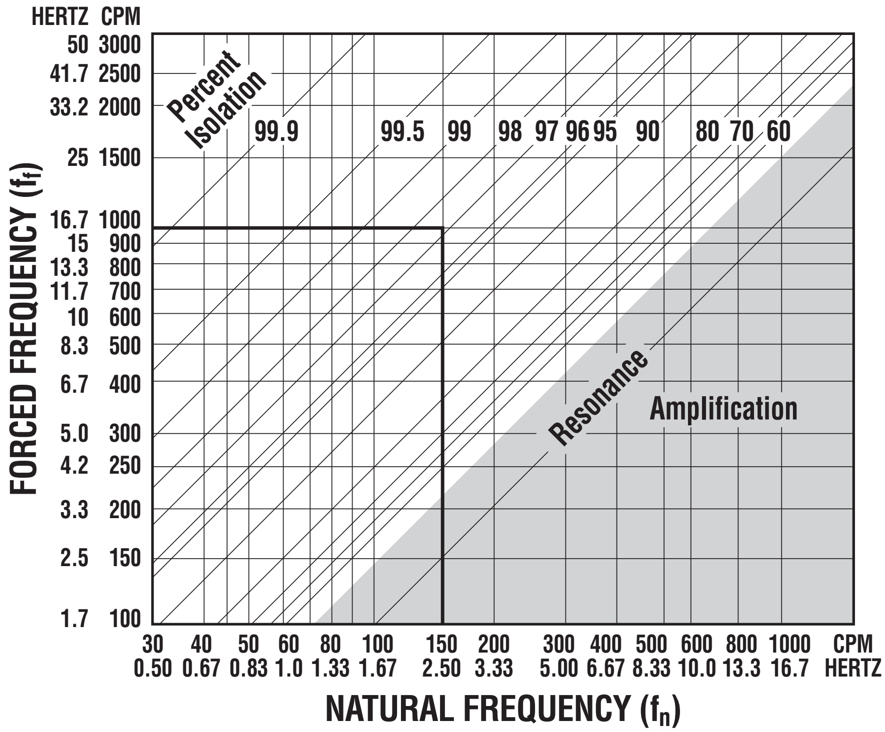
$$\%\text{Isolation@4000lbs} = 100 - \left[\frac{100}{\left(\frac{1000\text{CPM}}{149\text{CPM}}\right)^2 - 1}\right]$$

%Isolation@4000/lbs = 97.7%

(Note: The percentage of isolation is relatively constant with changing loads.)

Selection Procedure *(Imperial)*

PERCENT ISOLATION CHART



The percentage of isolation can also be determined using the % isolation chart shown above.

The diagonal lines across the chart represent specific isolation percentages. The intersection point, where the forced frequency and natural frequency meet, will lie on or between these diagonal lines. As shown above, the forced frequency of 1000 CPM and the natural frequencies of 149 and 164 CPM result in 97-98% isolation.

The percent isolation of 97% exceeds the required isolation of 90%.

5. Determine Exact Strain

The maximum allowable delta strain a Marsh Mellow™ spring can withstand is 7.5%. In order to calculate this we need to know the free height of the Marsh Mellow spring. Strain is equal to the stroke, 0.5 inches, divided by the free height.

$$\Delta\text{Strain} = \frac{\text{Stoke (in)}}{\text{FreeHeight (in)}} \times 100\%$$

$$\Delta\text{Strain} = \frac{\text{0.5 inches}}{\text{10 inches}} \times 100\% = 5\%$$

The required stroke is within the 0176's limitations.

6. Design Envelope Requirements

The Dynamic Characteristics Table shows that the outside diameter meets the space requirements of a minimum 10 inch diameter footprint. The OD is given at various heights between 15% and 27.5% compression. The OD of the Marsh Mellow spring at 26% compression is approximately 8.5 inches. The height of the Marsh Mellow spring can easily be read from the load deflection curve. From the previous section "Individual Data Sheet, Load Deflection Curve" we determined the height of the 0176 with a load of 4000 lbs is 7.8 inches.

7. Lateral Stability

As shown on the sketch of the equipment, the Marsh Mellow springs are mounted within the recommended distance of the center of gravity. The 0176 is also being used between 15% and 27.5% compression for maximum lateral stability. For additional stability with inclined screens or screen with off-mounted pivot motors, Firestone tension bands are often used as tag lines. The W22-358-0215 and 0275 tension bands are widely used in this application.

Selection Procedure *(Imperial)*

Shock Impact Selection

Marsh Mellow™ springs are commonly found on overhead cranes and other bumper applications. The following are the basic guidelines in determining the correct Marsh Mellow spring under shock impact conditions.

Calculating the Required Energy Dissipation

To size the proper Marsh Mellow spring, the amount of energy generated by the moving object must be known.

There are several ways to calculate this.

*For a free falling mass **without** an initial velocity:*

The following will calculate the amount of energy that needs to be absorbed for a free falling mass which starts at rest.

Potential Energy = mass x gravity x height (lb_{force}•inches)

mass x gravity = the weight of the object (lb_{force})

height = the height the object begins its descent (inches)

*For a free falling mass **with** an initial velocity:*

This calculation models a falling mass which has an initial velocity. The energy generated during free fall must be added to the kinetic energy associated with its initial velocity.

Kinetic Energy = 1/2 x mass x velocity^2 (lb_{force}•inches)

Potential Energy = see calculation for free falling mass without initial velocity

mass $= \frac{\text{weight } (lb_{force})}{386}$

velocity = initial velocity before free fall $\left(\frac{\text{inches}}{\text{seconds}}\right)$

For a horizontal impact or if the velocity immediately before impact is known:

Under these conditions the kinetic energy generated by velocity must be calculated.

Kinetic Energy = 1/2 x mass x velocity^2 (lb_{force}•inches)

mass $= \frac{\text{weight } (lb_{force})}{386}$

velocity = velocity object $\left(\frac{\text{inches}}{\text{second}}\right)$

Marsh Mellow Spring Selection

After the amount of energy needed to be absorbed is calculated, the proper Marsh Mellow spring for the application may be determined. Please contact Firestone Industrial Products to select the correct Marsh Mellow spring which has at least the same amount of absorbed energy capability as required for the application.

Note: While the Marsh Mellow spring will absorb the impact energy on the compression stroke and dissipate some amount of this energy, it will still return some of the energy in the form of a rebound stroke. In some applications, viscous or friction dampers may be required to control the speed of the rebound stroke.

Selection Procedure *(Metric)*

Vibration Isolation Selection

1. For specific design parameters needed to determine the correct Marsh Mellow™ spring for an application, consult the “Design Parameter Sheet” on page 61.

2. If possible, determine the load at each mounting point. If this is not possible, estimate the load on the Marsh Mellow spring by adding the weight of the machine plus the weight of the materials on the machine while operating, then divide the total weight by the number of Marsh Mellow springs to be used. This estimate will only be accurate if the load’s center of gravity is equidistant from each mounting point. If the weight of the machine is unknown, contact the equipment manufacturer, your distributor or Firestone for assistance. Firestone’s or your distributor’s machine weight estimates are based on the manufacturer’s published weights of current models of the same size and type. Weight consideration must be given to a special machine, modified machines, or older machines that will add weight to the unit.

3. Select a spring that falls in the mid-range of the minimum and maximum load capacities shown in the “Selection Guide”. For maximum life and stability, it is suggested that Marsh Mellow springs be used at or less than 25% (of free height) actual static deflection. Although the maximum loading figures in the above selection guide are given at 27.5% deflection (and these Marsh Mellow springs all pass our lateral stability test at up to 30% deflection), the lateral rate to load ratio decreases as deflection increases. The extra 2.5% deflection, then, is a safety factor for possible weight miscalculations. Additionally, the delta strain (Stroke/Free Length x 100) should not exceed 7.5%.

4. If more than one spring meets the load criteria in number 2, then select the spring with the lowest natural frequency (isolation percentage will be increased).

5. Determine the stroke required.

6. Refer to the second selection guide table. Check to make sure that for a given stroke and part, the height and load are within the allowable limits given.

7. If it does not fall within the proper range, then select a different spring or go to more than one Marsh Mellow spring per corner.

8. Consult the individual data page for the specific load and vibration capabilities, as well as mounting and Marsh Mellow spring dimensions.

9. Determine if the natural frequency of the Marsh Mellow spring will sufficiently isolate the disturbing vibration.

10. Tag lines are usually required for inclined screens or screens with off-mounted pivoted motors. (Consider using our tension band W22-358-0215 or W22-358-0275).

11. Please review the “Installation” section of the *Marsh Mellow Spring Design Manual* for additional information.

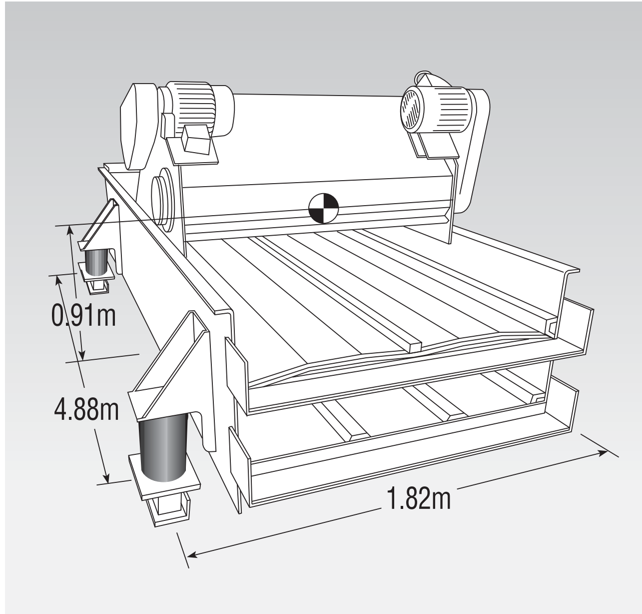
Selection Procedure *(Metric)*

Vibration Isolation Selection Example

The following example follows the correct procedure in determining which Marsh Mellow™ spring best suits a given set of requirements.

The vibrating screen illustrated to the right has the following description and design requirements:

Description of Equipment	= Vibrating screen
Total Weight of Machine	= 53.3kN
Total Material Load	= 17.8kN
Number of Mounting Points	= 4
Space Available	=254mm diameter footprint
Stroke	= 12mm
Disturbing Frequency	= 16.7Hz
Percent Isolation Desired	= 90%



1. Determine Individual Spring Load

The exact load at each mounting point is not available, so the individual loads must be estimated. The minimum load each spring will support is assumed to be equal to the machine weight divided by the number of mounting points.

$$\text{Minimum Load} = \frac{\text{Machine Load(kN)}}{\text{\# of Mounting Points}} = \frac{53.3\text{kN}}{4} = 13.3\text{kN per spring}$$

The maximum load is equal to the machine load plus the weight of the material.

$$\text{Maximum Load} = \frac{\text{(Machine + Material Load)kN}}{\text{\# of Mounting Points}} = \frac{(53.3 + 17.8)\text{kN}}{4} = 17.8\text{kN per spring}$$

2. Examine Marsh Mellow Spring Load Capabilities

From the "Selection Guide - Load Capabilities", seven different Marsh Mellow springs will support load range from 13.3kN to 17.8kN. The W22-358-0200, 0176, 0042, 0190, 0179, 0122, and 0228. As discussed in the "Dynamic Characteristics" section, a lower natural frequency Marsh Mellow spring will provide better isolation. Since the W22-358-0176 has a low natural frequency at both minimum and maximum loading, we will select this part for the example.

3. Determine Stroke Requirement

The required stroke for this screen is 12mm with a maximum load of 17.8kN. On the "Selection Table - Stroke Requirements", the 0176 has a maximum stroke capability of 12mm with a load range of 8.62 to 20.18kN. The 0176 meets this requirement.

Selection Procedure *(Metric)*

4. Determine Exact % Isolation

The percentage of isolation can either be calculated or the % Isolation chart may be used. The first step is to refer to the individual data page for necessary information. The Dynamic Characteristics table will provide this data.

METRIC					
Compression (%)	15.0	20.0	22.5	25.0	27.5
Load (kN)	10.22	14.89	17.78	20.44	23.56
Height (mm)	216	203	197	191	184
Rate (kN/m)	350	420	437	455	542
Effective Deflection (mm)	29	35	41	45	43
Natural Freq. (Hz)	2.92	2.65	2.48	2.36	2.40
Maximum OD (mm)	201	206	211	213	218

At the minimum load of 13.3kN, the 0176 is between 15% and 20% compression. We can interpolate this data and estimate the natural frequency at minimum load.

$$\frac{\text{MinimumLoad - Load@15\%}}{\text{Load@20\% - Load@15\%}} = \frac{\text{NaturalFreq - NaturalFreq@15\%}}{\text{NaturalFreq@20\% - NaturalFreq@15\%}}$$

$$\text{NaturalFreq} = \text{NatFreq@15\%} + \frac{[(\text{MinimumLoad - Load@15\%}) \times (\text{NatFreq@20\% - NatFreq@15\%})]}{\text{Load@20\% - Load@15\%}}$$

$$\text{NaturalFreq} = 2.92\text{Hz} + \frac{[(13.3 - 10.22)\text{kN} \times (2.65 - 2.92)\text{Hz})]}{(14.89 - 10.22)\text{Hz}}$$

NaturalFreq@13.3kN = 2.73Hz

We can interpolate the natural frequency at the maximum load of 17.8kN in a similar way. However, in this case we know the natural frequency at 17.8kN directly from the data table.

NaturalFreq@17.8kN = 2.48Hz

Knowing these natural frequencies, as well as the disturbing frequency, allows us to determine the exact % isolation with the following equations:

$$\%\text{Isolation} = 100 - \left[\frac{100}{\left(\frac{\text{DisturbingFreq}}{\text{NaturalFreq}}^2\right) - 1}\right]$$

$$\%\text{Isolation@13.3kN} = 100 - \left[\frac{100}{\left(\frac{16.7\text{Hz}}{2.73\text{Hz}}^2\right) - 1}\right]$$

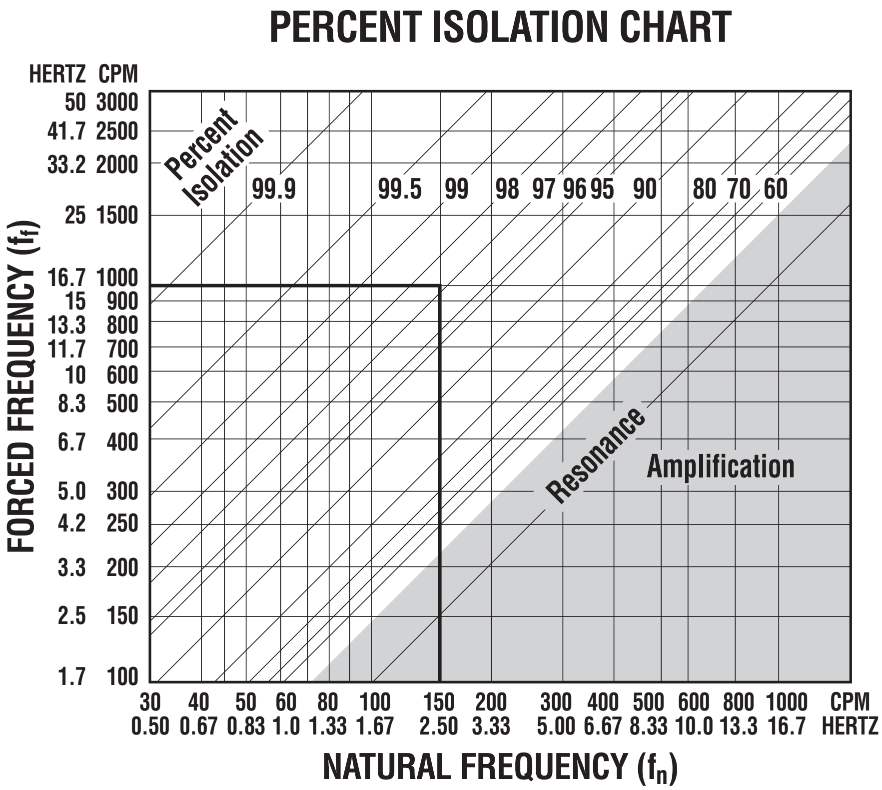
%Isolation@13.3kN = 97.2%

$$\%\text{Isolation@17.8kN} = 100 - \left[\frac{100}{\left(\frac{16.7\text{Hz}}{2.48\text{Hz}}^2\right) - 1}\right]$$

%Isolation@17.8kN = 97.7%

(Note: The percentage of isolation is relatively constant with changing loads.)

Selection Procedure *(Metric)*



The percentage of isolation can also be determined using the % isolation chart shown above.

The diagonal lines across the chart represent specific isolation percentages. The intersection point, where the forced frequency and natural frequency meet, will lie on or between these diagonal lines. As shown above the forced frequency of 16.7Hz and the natural frequencies of 2.48 and 2.73Hz result in 97-98% isolation.

The percent isolation of 97% exceeds the required isolation of 90%.

5. Determine Exact Strain

The maximum allowable delta strain a Marsh Mellow™ spring can withstand is 7.5%. In order to calculate this we need to know the free height of the Marsh Mellow spring. Strain is equal to the stroke, 12mm, divided by the free height.

$$\Delta\text{Strain} = \frac{\text{Stoke (mm)}}{\text{FreeHeight (mm)}} \times 100\%$$

$$\Delta\text{Strain} = \frac{12\text{mm}}{254\text{mm}} \times 100\% = 5\%$$

The required stroke is within the 0176's limitations.

6. Design Envelope Requirements

The Dynamic Characteristics table shows that the outside diameter meets the space requirements of a minimum 254mm diameter footprint. The OD is given at various heights between 15% and 27.5% compression. The OD of the Marsh Mellow spring at 26% compression is approximately 216mm. The height of the Marsh Mellow spring can easily be read from the load deflection curve. From the previous section "Individual Data Sheet, Load Deflection Curve", we determined the height of the 0176 with a load of 17.8kN is 198mm.

7. Lateral Stability

As shown on the sketch of the equipment, the Marsh Mellow springs are mounted within the recommended distance of the center of gravity. The 0176 is also being used between 15% and 27.5% compression for maximum lateral stability. For additional stability with inclined screens or screen with off-mounted pivot motors, Firestone tension bands are often used as tag lines. The W22-358-0215 and 0275 tension bands are widely used in this application.

Selection Procedure *(Metric)*

Shock Impact Selection

Marsh Mellow™ springs are commonly found on overhead cranes and other bumper applications. The following are the basic guidelines in determining the correct Marsh Mellow spring under shock impact conditions.

Calculating the Required Energy Dissipation

To size the proper Marsh Mellow spring, the amount of energy generated by the moving object must be known.

There are several ways to calculate this.

*For a free falling mass **without** an initial velocity:*

The following will calculate the amount of energy that needs to be absorbed for a free falling mass which starts at rest.

Potential Energy = mass x gravity x height (N•m)

mass x gravity = the weight of the object (N)

height = the height the object begins its descent (m)

*For a free falling mass **with** an initial velocity:*

This calculation models a falling mass which has an initial velocity. The energy generated during free fall must be added to the kinetic energy associated with its initial velocity.

Kinetic Energy = 1/2 x mass x velocity^2 (N•m)

Potential Energy = see calculation for free falling mass without initial velocity

mass $= \frac{\text{weight (N)}}{9.81}$

velocity = initial velocity before free fall $\left(\frac{\text{meters}}{\text{second}}\right)$

For a horizontal impact or if the velocity immediately before impact is known:

Under these conditions the kinetic energy generated by velocity must be calculated.

Kinetic Energy = 1/2 x mass x velocity^2 (N•m)

mass $= \frac{\text{weight}}{9.81}$ (N)

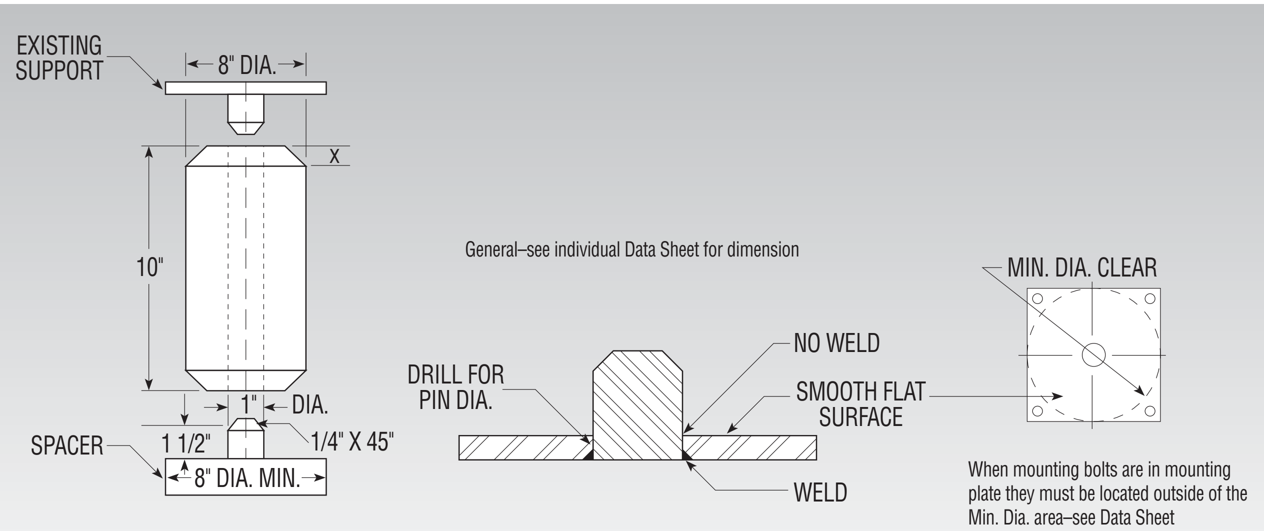
velocity = velocity object $\left(\frac{\text{meters}}{\text{second}}\right)$

Marsh Mellow Spring Selection

After the amount of energy needed to be absorbed is calculated, the proper Marsh Mellow spring for the application may be determined. Please contact Firestone Industrial Products to select the correct Marsh Mellow spring which has at least the same amount of absorbed energy capability as required for the application.

Note: While the Marsh Mellow springs will absorb the impact energy on the compression stroke and dissipate some amount of this energy, it will still return some of the energy in the form of a rebound stroke. In some applications, viscous or friction dampers may be required to control the speed of the rebound stroke.

Installation



Note: Pin diameter equals spring inside diameter.

Vibration Isolation New Installation

1. Select the correct Marsh Mellow™ spring for the specific application following the guide lines in "Selection Procedure" of the *Marsh Mellow Spring Design Manual.*

2. Fabricate mounting plates with locating pins for the Marsh Mellow spring according to the dimensions on the individual data sheet.

3. Raise the machine to a height greater than the height of the mounting plates and Marsh Mellow spring free height. Prepare the mounting surface,* and insert the Marsh Mellow spring assembly with upper and lower mounting plates in place.

4. Carefully lower the machine on mounting plates, making sure the upper and lower mounting plates are in line vertically at all support points.

5. **Caution**–check the loaded Marsh Mellow spring height. It ***must*** be within the height range shown on the data sheet. If the height is not within the height range, the estimated loads are not correct. If the height is greater than the limit, the machine may shift while going through resonance. If the height is less than allowable, the spring is overloaded and may be damaged while running. In either case, contact your distributor or Firestone Industrial Products. Record the actual height to determine the actual load from the data sheet. This will assist your distributor or Firestone in recommending another size Marsh Mellow spring.

6. If the height of the loaded Marsh Mellow spring is within the range but the machine is not level, raise the lower end by using shims.

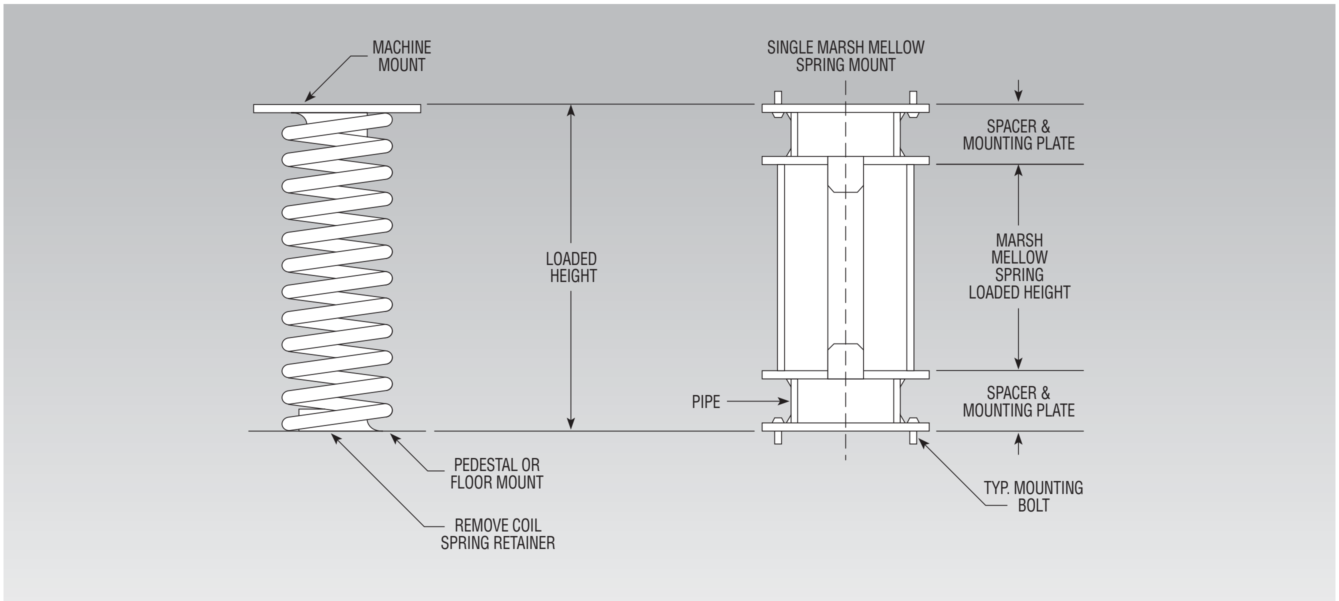
7 If the height is correct, drill holes in the mounting plates and mating machine mount and floor mount. Bolt securely.

8. Run the machine through startup and shutdown 2 or 3 times to observe any erratic motion. If gallop through resonance is excessive, something may be wrong. If there is any question, contact your distributor or Firestone Industrial Products.

9. Operate the machine as you would normally–check the temperature of the Marsh Mellow spring after about 1 hour and 4 hours of operation by placing your hand on the surface of the Marsh Mellow spring. The Marsh Mellow spring will be warm. If the Marsh Mellow spring is so hot that you can't leave your hand on it, something is wrong. Check your spring height. If it is not within the height range as shown on the Marsh Mellow spring data sheet, your load is not correct and a different size spring is needed. Contact your distributor or Firestone and ***do not*** continue to run the machine under this condition.

*Note: Use water or silicone spray lube to assist in pressing the Marsh Mellow spring on the pin. Avoid damaging the ID.

Installation



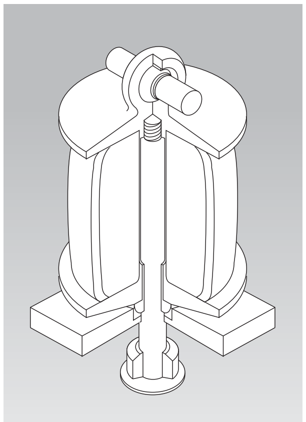
Coil Spring Replacement

1. Select the correct Marsh Mellow™ spring for the specific application following the guide lines in “Selection Procedure” of the *Marsh Mellow Spring Design Manual.*
2. Measure present spring loaded height while the machine is shut down.
3. From the Individual Marsh Mellow Spring Data Sheet, find the loaded Marsh Mellow spring height.
4. Determine the total spacer/mounting plate height required by subtracting the loaded Marsh Mellow spring height from present loaded spring height.
5. Fabricate mounting plates for the Marsh Mellow spring. Follow the same scheme shown above.
6. Raise the machine. Remove the existing spring. Prepare the mounting surface, and insert the Marsh Mellow spring assembly with upper and lower mounting plates in place.
7. Carefully lower the machine on mounting plates, making sure the upper and lower mounting plates are in line vertically at all support points.
8. Follow steps 5-9 of “Vibration Isolation New Installation” for final installation.

Installation

Miscellaneous Mounting Arrangements

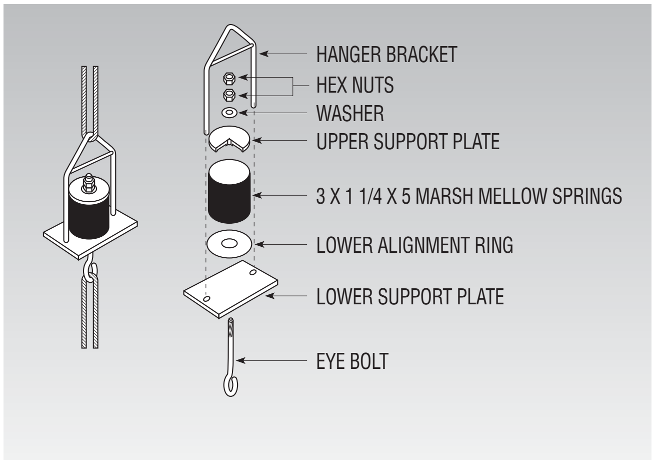
The following mounting arrangements shown below are for various applications. If your application requires such an arrangement and additional information is required, please call Firestone Industrial Products.



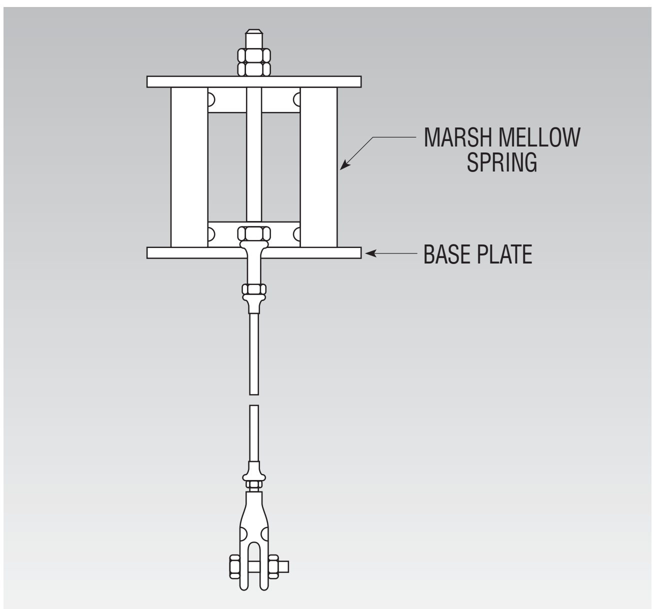
Shock Impact

The center rod arrangement provides an ideal system to utilize the Marsh Mellow™ spring in shock impact applications. This design provides lateral stability in a high damping application.

Tension Retainer

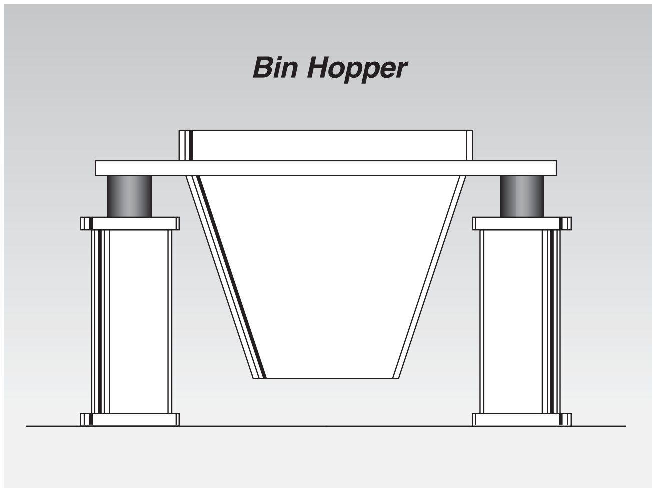


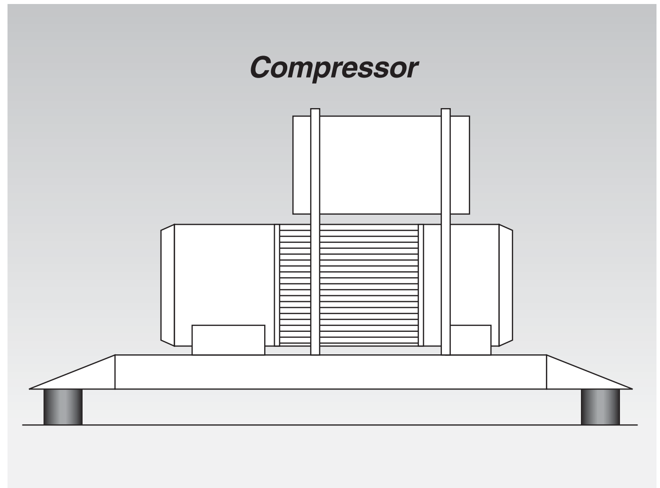
Hanging Vibrator Screen Mount

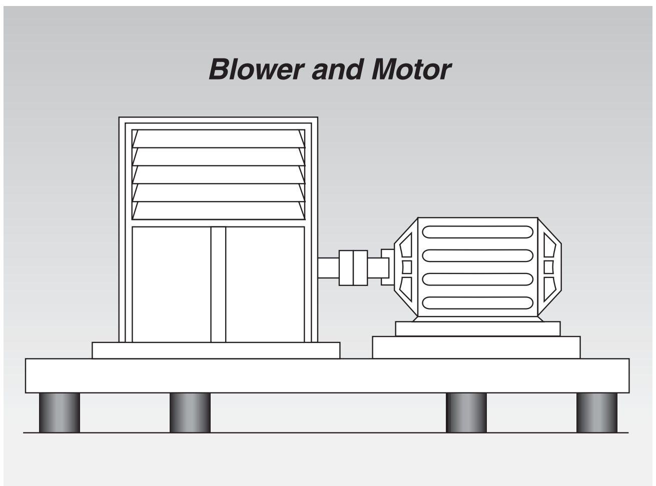


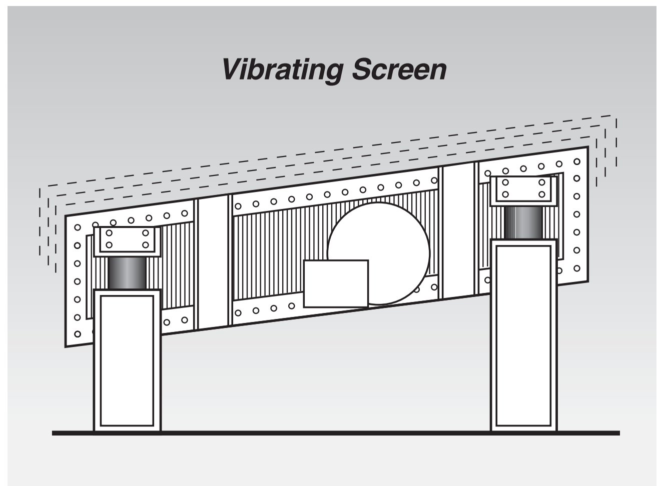
Applications

Vibration Isolation



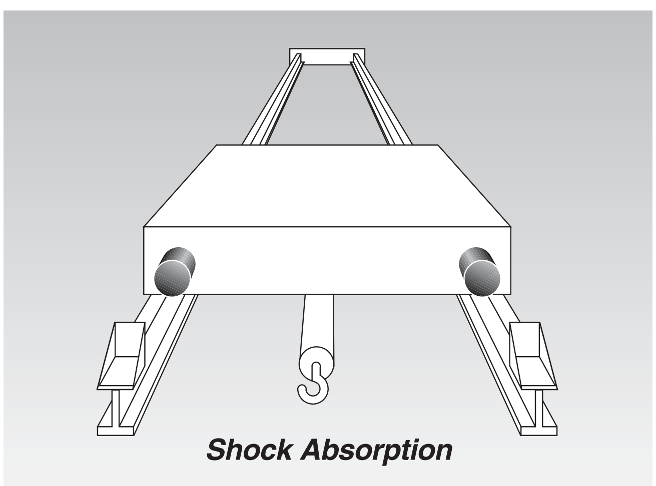






Shock Impact

Shock absorption is a natural application for Marsh Mellow™ springs. Suitable for cranes, hammers, bumpers, and similar applications.



Tag Line

Tag lines are usually required for inclined screens or screens with off-mounted pivot motors. Consider using Marsh Mellow spring tension bands. Marsh Mellow spring tension bands are constructed with just the fabric reinforced plies and serve as an industrial strength band.