Technical Manual

for Machinery Application of

# SORBTEX

Preformed Fabric Neoprene or Rubber
Shock Damping — Vibration Isolation Materials

**VOSS ENGINEERING, INC.**
Manufacturers of Vibration and Shock Controls —
Bridge and Structural Bearing Pads

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## The Nature of Vibration and Shock

Vibration and shock produce both force and motion causing stresses in the machine itself and in the machine's supporting structure. Machine produced disturbances are frequently transmitted to remote positions where they cause stresses either by direct deformation, or by sympathetic response to the disturbing frequency.

If the motion resulting from such disturbances is primarily air borne and within the audible range, it is recognized as noise. If the excitation is primarily "felt", it is identified as vibration when continuous, or as shock when sudden and short in duration. When such disturbances reach objectionable proportions -- either in the machine itself, or interfere with adjacent machines, or cause objectionable physical or psychological effect on plant employees, such disturbances should be controlled and minimized. For, not only can excessive vibration and shock cause mechanical and structural failures, but they can also greatly impair production efficiency and employee well being.

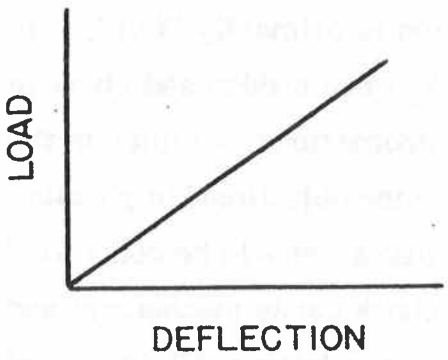
Whether the primary objective be the correction of vibration or shock for structural safety, employee comfort, or interference in production, the requirement is the same -- to reduce vibration. This may be done by reducing the unbalance or intensity of impact, or by the use of vibration and shock-isolation techniques.

This manual is designed to discuss isolation techniques and how they are efficiently applied with SORBTEX preformed, fabric-impregnated materials. The following discussion covers the areas of vibration-isolation and shock absorption to assist the engineer in solving conditions where vibration and shock are, or could be excessive.

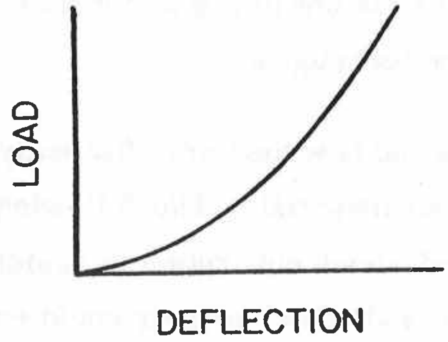
For the purpose of this presentation, vibration is considered as a continuing oscillation (steady-state) such as is caused by an unbalanced machine operating continuously. Shock is considered as the disturbance produced by a suddenly applied force or impact in which the ensuing oscillations die out due to the internal resistance of the system prior to the application of the next impulse.

It is not unusual for shock disturbances to be sufficiently close to each other to approach the steady-state vibration condition and must be handled as such.

All vibration and shock isolators require the use of resilient materials. Resilience is the ability of a material to deform (and store energy) when subjected to a load. Such materials are either linear or non-linear. A linear material is one in which the deflection of the material increases proportionately with the load, i.e., doubling the load also doubles the deflection. With a non-linear material, the deflection does not increase proportionately to the load. For example, doubling the load may produce one and one-half times the deflection. This is known as a "hardening" spring. It is possible for a material to deflect at a greater rate than the load (softening spring) but such materials are rarely used in vibration isolation and warrant no further discussion here. Typical load-deflection curves for a linear and non-linear material are shown in Figure 1.



LINEAR MATERIAL



NON LINEAR MATERIAL

FIGURE I

Vibration principles are generally presented with linear springs because the theory so developed lends itself to simple analysis.

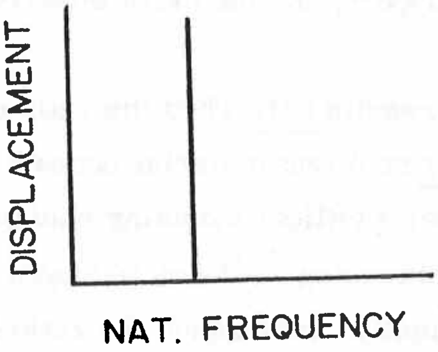
Practically all commercial isolators are non-linear. The application of vibration theory based on "linear" assumptions is satisfactory from a practical engineering viewpoint for small displacements. For large displacements, the non-linear characteristics become more significant and must be considered.

SORBTEX is a non-linear isolator of the "hardening" spring type. It is recommended and preferred over linear and other non-linear isolators because of its durability, high ultimate strength, ease of application and low cost. It is especially desirable for use under heavy applications where replacement and/or maintenance involve considerable lost production time and high cost.

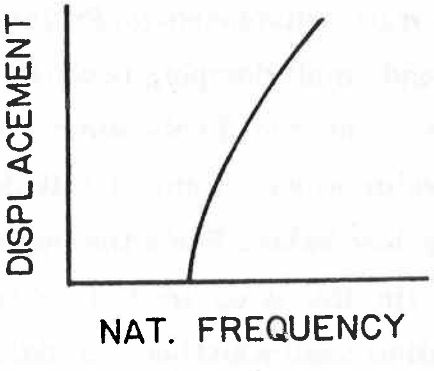
It is usual in any basic dissertation on vibration principles to consider only vertical motion. For purposes of clarity, this approach will also be used here. However, five other types of motion will be discussed later, and it will be shown that consideration of vertical motion alone is not sufficient in many cases.

The natural frequency of a system is the frequency at which the system vibrates naturally when displaced from its rest position. A linear isolator always vibrates freely at the same frequency regardless of how much it is displaced initially, as shown in the upper part of Figure 2. This natural frequency depends on the static deflection of the resilient material due to the dead weight of the object it supports. The natural frequency of SORBTEX increases, as the initial displacement increases. This is represented in the lower part of Figure 2.

When a periodic disturbing force, as is caused by the unbalance of a rotating machine, is imposed on a linear isolator, the force transmitted to the supporting structure depends on the ratio of the disturbing force frequency ($F_D$) to the natural frequency of the support ($F_N$). This results in the familiar transmissibility curve shown in Figure 3.

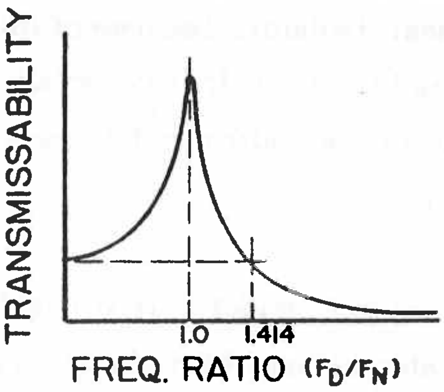


LINEAR MATERIAL



SORBTEX

FIGURE 2



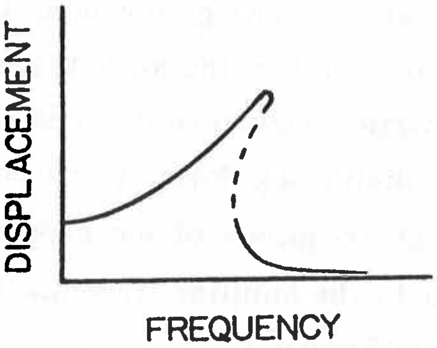
**LINEAR ISOLATOR**

FIGURE 3

This curve illustrates that if the ratio $F_D/F_N$ is very low, the full force of the unbalance is transmitted to the support. As the ratio increases, so does the transmitted force until at a ratio of 1.0 the supporting structure is subjected to many times the intensity of force produced by the machine. As the ratio increases further, the magnitude of the force is reduced until at a ratio of 1.414, the force transmitted is the same as though the frequency ratio approached zero (isolator is extremely stiff).

At greater ratios than 1.414 the isolator begins to perform the function for which it is provided -- to reduce the force transmitted to the support. The greater the ratio becomes, the less the force transmitted to the support, and the more effective the isolator.

It is important to emphasize that vibration isolation results only when the ratio of $F_D/F_N$ is greater than 1.414. It is not true that any resilient material beneath a vibrating machine will reduce vibration. An improper resilient mounting actually increases vibration. Proper use of a resilient mounting reduces the natural frequency of the machine on its mounting sufficiently to increase the ratio of $F_D/F_N$ as far as practicable above 1.414.



**NON LINEAR ISOLATOR**

FIGURE 4

With a non-linear isolator of the hardening spring type, the vibration displacement for large disturbing forces and small damping is shown in Figure 4. In this case, the displacement increases to some value when it immediately decreases to a very low value. Since the motion changes abruptly (in the area of the dashed curve) small vibration results and hence a sudden reduction in the transmitted force occurs beyond resonance rather than a gradual reduction as in the case of a linear material.

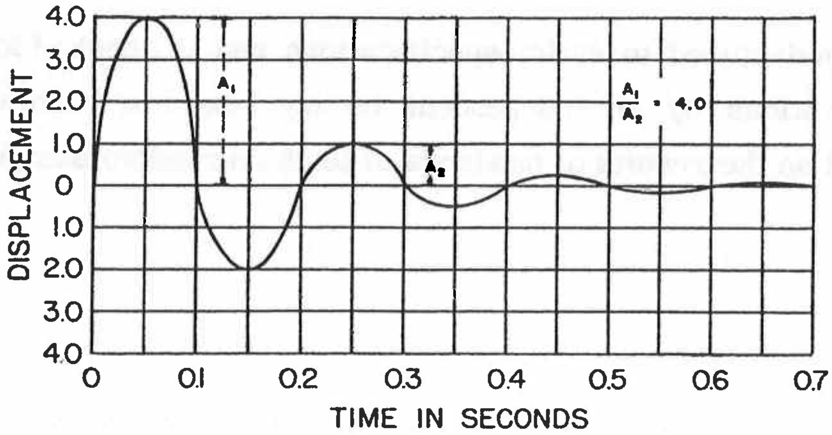
## Damping

The physical effect of damping in the resilient material is to cause the object or machine set in motion to come to rest more quickly than without it. All materials have an inherent amount of damping. The amount varies in different materials. In general, laminated materials such as SORBTEX have greater damping values than non-laminated materials.

When a machine on a mounting is suddenly displaced and "just" returns to its original position of equilibrium without oscillating, it is said to be critically damped. When the machine oscillates many times before coming to rest, the mounting is said to have low damping qualities. Damping is measured in terms of the Logarithmic Decrement, or as a proportion of critical damping. For the purpose of comparison, the following tabulation indicates the relative damping properties of some of the materials used in vibration isolation:

| Material | Logarithmic Decrement | Ratio of Critical Damping |
|---|---|---|
| SORBTEX | 1.40 | 0.22 |
| Rubber | 0.51 | 0.08 |
| Felt | 0.69 | 0.11 |
| Cork (ground and compressed) | 0.68 | 0.11 |
| Natural Cork | 0.88 | 0.14 |
| Steel | 0.03 | 0.005 |

A typical damped oscillation curve with SORBTEX is shown in Figure 5.



TYPICAL DAMPING CURVE FOR SORBTEX

FIGURE 5