



### 3 Introduction

The purpose of isolation is to control unwanted vibration so that its adverse effects are kept within acceptable limits.

### 4 Background

When is a foundation (inertia block, reaction mass) required? In certain applications, it is not desirable or feasible to mount a machine directly on vibration isolators. An integral part of many machine tool and equipment installations is a properly designed and isolated foundation.

### 7 Design Services

Our Engineering group will assist you with design solutions for your machinery or equipment foundation including; structural design and dynamic analysis, finite element modeling and modal analysis, if required.

### 11 Vibration Isolators

A brief discussion regarding isolator natural frequency, static and dynamic spring rate, damping and transmissibility, including types of isolators and isolator performance.

### 14 FABSORB™

Fabsorb™ isolation material is an economical approach to foundation isolation where high frequency vibration control is required.

### 18 Regufoam® and Regupol®

These vibration isolation materials provide low frequency isolation, ease of installation and design flexibility to meet a wide range of applications.

### 20 INFAB™

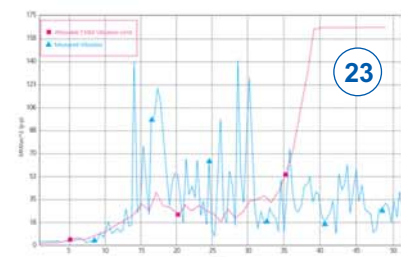
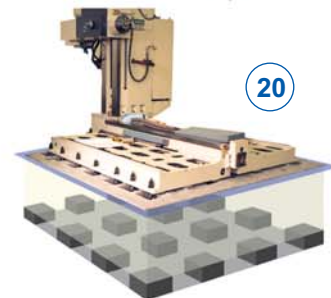
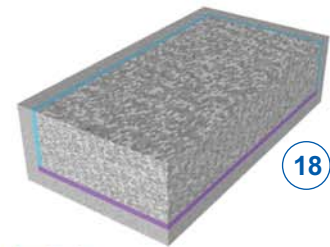
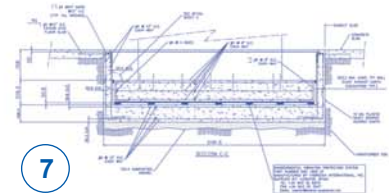
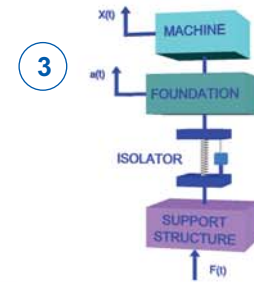
Vibration isolators of molded elastomer that offer low frequency isolation and high load capacity.

### 22 Pneumatic Isolators and Air Bags

Pneumatic isolators provide exceptional low frequency and shock isolation for sensitive machines and equipment. Air bag isolators allow for large displacements (stroke) where solutions require the same.

### 23 Vibration Measurement & Analysis

Fabreeka provides Vibration Measurement & Analysis services prior to and after installation to determine and/or verify the resultant amplitude and frequency of vibration at your facility.



# Introduction

**Vibrating, rotating, reciprocating and impacting equipment create machine-induced vibration and/or shock, which is transmitted into their support systems. Rotating machines and equipment that are not properly balanced produce centrifugal forces creating steady state and random vibration. Machines generating pulses or impacts, such as forging presses, injection molding, impact testers, hammers, centrifugal pumps and compressors are the most predominate sources of vibration and shock.**

If the equipment requiring isolation is the source of unwanted vibration (Figure 1), the purpose of isolation is to reduce the vibration transmitted from the source to its support structure. This vibration producing equipment consists mainly of machines that apply severe dynamic forces in their supporting structures.

Conversely, if the equipment requiring isolation is the recipient of unwanted vibration (Figure 2), the purpose of isolation is to reduce the vibration transmitted from the support structure to the recipient to maintain performance. This includes equipment such as precision machine tools and measuring machines where vibrations must be kept within acceptable limits to achieve the desired surface finish, tolerances or accuracies.

Depending on the circumstances, it should be noted that a machine could be both a source *and* recipient of unwanted vibration. For example, a surface grinder is generally a vibration-sensitive piece of equipment that needs to be protected from floor vibrations. However, as the surface grinder reverses its heavy table during operation, it produces a large dynamic force, which may disturb other nearby precision equipment.

Some machine tools of ordinary precision are neither sensitive to vibration nor produce large dynamic forces, and therefore may or may not require isolation.

Operating frequencies of rotating/reciprocating machines often are very close to the natural frequency of their support structure (floor slab and soil). Compressors, for example, can generate vibration of substantial magnitudes at low frequencies that coincide with the natural frequency of the floor slab, thus creating a resonance (amplification of vibration) in the floor.

In order to achieve acceptable amplitudes of vibration at the source or recipient, it becomes necessary to make the support structure independent (isolated) from the rest of the environment. This separation prevents vibration from being transmitted directly through the support structure.

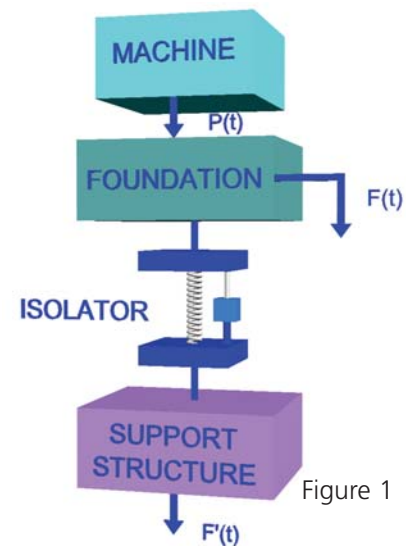


Figure 1

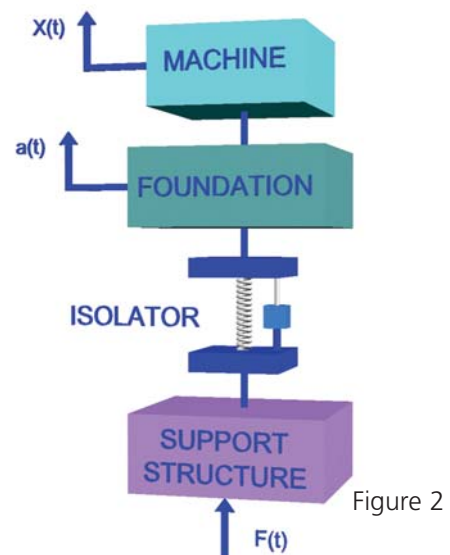


Figure 2



## Background

The separation method of cutting the existing floor slab or even creating trenches around machines to reduce the vibration being transmitted by the soil beneath the floor slab is experimental at best and often not a practical solution. A thorough understanding of the machine, the support structure (floor) and the soil is required. The effectiveness of this approach relies heavily on the soil mechanics, magnitude and frequency of the vibration amplitudes to be reduced. To be an effective solution, trenches and slab cuts can be up to 6 feet deep and 10 inches wide, which requires the soil to be extremely stable and can also cause safety issues.

### Soil Mechanics

When installing machinery or equipment on a support foundation that rests directly on soil as the means of providing isolation, the soil conditions must be taken into account. Poorly designed and installed foundations may amplify vibration or worse, may settle unevenly and sink. Interaction between the soil and the foundation is equally as important as the interaction between the machine and the foundation.

Any static and dynamic forces exerted on the foundation also are exerted on the soil, and the load-bearing capacity of the soil is a key factor in determining the size of the foundation.

If soil alone is to be used as the means of isolation, it is necessary to know the characteristics of the energy dissipative properties of the soil. Establishing these properties depends not only on the type of soil, but also on the physical design of the foundation; in particular, the depth, the ratio between length and width and the material and density of the backfill.

It is difficult to take into account the influence of all these factors on the value of the energy dissipative properties of the soil. Therefore, the natural frequency and damping properties of the soil cannot be clearly defined based on the soil type alone. (Estimated values for soil natural frequency are listed in Table 1.)

Additionally, the natural frequency of soil can increase if the input vibration amplitudes are small and can decrease when the input vibration amplitudes are larger.

The damping property of most soils decreases as the pressure beneath the foundation increases and also when amplitudes of vibration are small. The larger the vibration input and the contact area of the foundation, the larger the damping value of the soil, and as a result, the lower the amplification of vibration at the soil's natural frequency.

Natural Frequencies of Soils*	
Ground or Structure	Frequency (Hz)
Peat	7
Suspended concrete floor	10 - 15
Ground floor	12 - 34
Soft clay	12
Medium clay	15
Stiff clay	19
Loose fill	19
Dense medium grain sand	24
Very dense mixed grain sand	24
Uniform coarse sand	26
Pea gravel	28
Limestone	30
Hard sandstone	34

**Table 1**

\*Assumes soil is homogeneous. Values do not account for amplitude of vibration input or foundation geometry.

The determination of a soil's dynamic properties (spring rate, damping) can be highly indeterminate. In many cases, the calculations are complex and many assumptions are made. Energy dissipation does occur in soil; however, the rate of damping and the natural frequency are a function of the magnitude of the vibration input and foundation geometry.

In many cases, manufacturing and quality control must co-exist in workcells or in close proximity to one another. For certain machines, the permissible amplitudes of machine foundation vibrations in a manufacturing environment are very low. It often is very difficult to decrease or isolate vibration amplitudes by properly selecting the contact area where the foundation meets the soil. It also may not be possible to increase the stiffness (rigidity) of the machine support structure (floor) itself to avoid resonance or amplification of vibration. In these cases, unacceptable vibration amplitudes can be significantly reduced by using vibration isolators.

### Foundations Requiring Vibration Isolators

In certain applications, it is not desirable or feasible to mount a machine directly on vibration isolators.

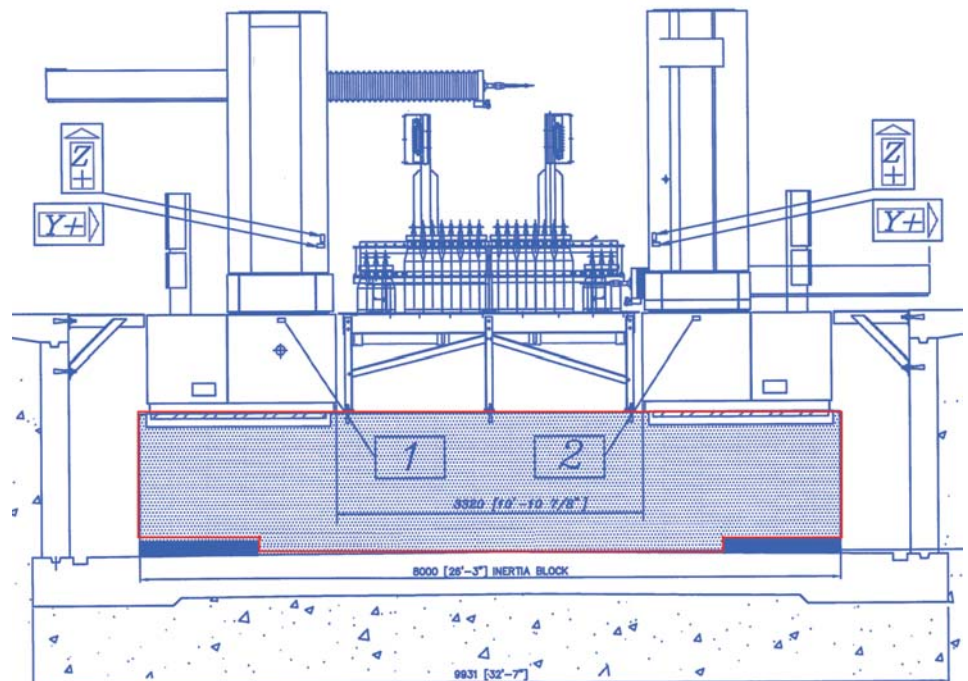
Direct installation of vibration isolators on a machine whose frame/bed stiffness is marginal or inadequate and requires a stiff connection can cause bending, relative displacement and other problems, even when the floor is sufficiently rigid. For smaller machines, this can be remedied by securing the frame/bed to a rigid plate, thereby creating a rigid support structure, and then installing the isolators between the plate and the floor. For larger machines, the frame/bed is attached to a properly designed concrete foundation, which is then supported on the appropriate isolators for the application.



A concrete support structure (foundation, inertia block, reaction mass) is used to satisfy one or more of the following conditions:

1) Provide/improve structural stiffness for the machine/equipment being isolated.

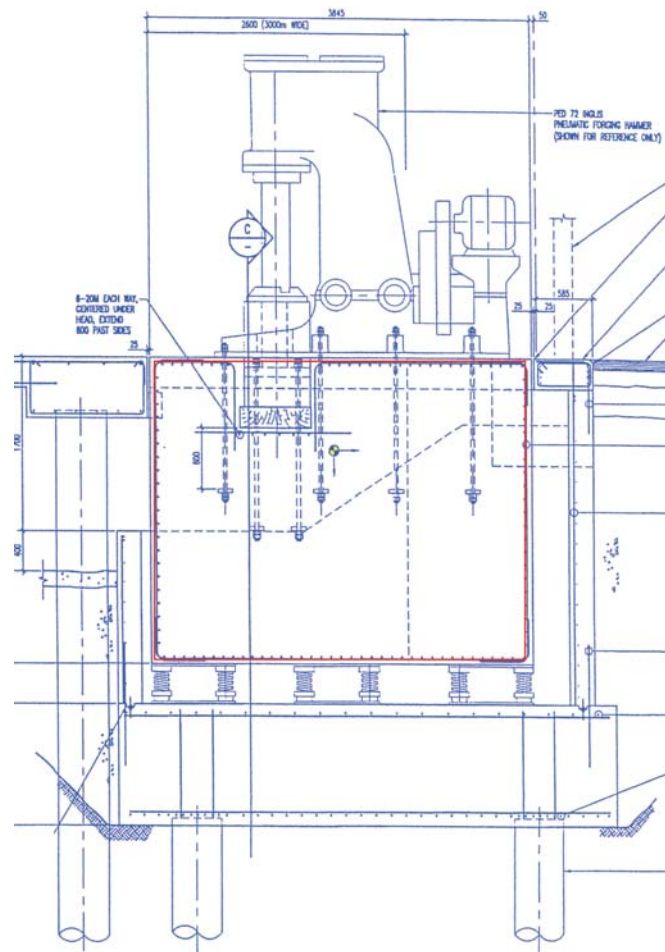
Some types of equipment do not operate properly unless supported by a rigid structure. This applies to certain types of machine tools that are not inherently rigid and therefore need a rigid support to maintain the prescribed accuracy. In other types of machinery (such as printing presses) consisting of articulated components, a rigid support may be needed to maintain the proper alignment of working parts.



Dual horizontal arm coordinate measuring machine with separate workpiece table. The foundation makes a rigid connection between the measuring arms and the workpiece. Pneumatic isolators (installed in the pockets at the base) support and isolate the foundation.

2) Increase stability on the vibration isolators by limiting dynamic deflection.

If a machine (such as a diesel engine, forging hammer or electro-dynamic shaker) generates relatively large forces during its operation, the overall movement of the machine on its isolation system tends to become excessive unless its effective mass is substantially increased. This increase in effective mass can be achieved by attaching the machine rigidly to an inertia block and mounting the inertia block (reaction mass) on isolators.



Inglis forging hammer installed on concrete reaction mass supported by coil spring isolators.

3) Isolate the equipment/machine from the environment when installing isolators directly beneath the unit would compromise the conditions above.

In applications in which the frequency of excitation is low, the natural frequency of the isolation system must be very low to provide low transmissibility and therefore good vibration isolation. A problem often arises with a machine intended to be mounted only at its base, because a low-stiffness base-mounted system tends to be unstable and will allow excessive motion to take over.

Effective isolation may therefore be difficult to achieve. A mounting arrangement where the isolators are relocated may be used to move the isolation system's elastic center closer to the center of gravity of the machine. This will reduce the effect of "rocking," improve the vibration isolation and reduce motion on the isolators. In most applications, it is more feasible to attach the machine rigidly to a foundation (to lower the center of gravity of the machine and foundation together) and to suspend the foundation on isolators located in the same horizontal plane as the center of gravity.

A foundation or mass designed to meet the requirements outlined previously may be installed either above floor level or in a pit below floor level. Isolators used to support the foundation may be made of rubber, mat material, steel springs, air springs or other suitable, resilient material. The required size of the foundation depends on the reason for its use, the type and size of equipment and the type of isolation required.

The desired natural frequency (stiffness) and damping for the isolation system is usually established by the operating characteristics of the mounted equipment (source) and/or the isolation required (recipient). The design basis for the support foundation natural frequency assumes that the foundation is a rigid body with a stiffness much greater than the isolators. Similarly, the pit base also should be stiffer than the soil supporting it.



# Design Services

## Foundation Design

The function of a foundation is not only to support the weight of the machine/equipment, but also to keep the vibration levels and dynamic displacement of the isolation system within acceptable limits.

Designing foundations supporting machines that can produce static and dynamic loads requires sound engineering procedures for a reliable result. An incorrectly designed foundation is extremely difficult to correct once installed.

Engineering disciplines involved in the proper design procedures for isolated support foundations include theory of vibrations, geotechnical engineering (soil characteristics), structural analysis, and in some applications, dynamic analysis.

The design conditions and requirements can be classified into three groups: machine properties, including unbalanced forces, operating speeds; weight, center of gravity and allowable deflection; soil parameters, including load bearing capacity, and environmental requirements - *What degree of isolation is required and at what frequencies?*

## Soil

The machine/equipment, foundation, isolators and pit ultimately all are supported by the soil beneath them. Geotechnical recommendations and evaluation of the soil (soils analysis) should be made and must be part of the design. This analysis includes soil characteristics, including load-bearing capacity, shear modulus, density, soil type and the composition of the soil at various depths. In the structural design of the support foundation, piles may be required depending on the load bearing capacity of the soil, high water table or generally poor soil conditions that indicate unacceptable permanent settling of the foundation will occur.

Settling, if any, should be uniform and kept to a minimum, especially when designing support foundations for equipment providing large dynamic loads/forces. If the foundation supported by isolators is used to enhance the machine frame/bed stiffness or is used as an integral part of the structural sup-

port of the machine (i.e. gantry CMM, turbine, roll grinder), then the dimensions of the foundation are defined by the machine geometry. The weight and type of machine along with a preliminary foundation size will give an indication of the soil's support requirements.

The traditional rules observed in the past of making the foundation 3 to 5 or even 10 to 12 times the weight of the equipment/machine it supports are applicable only when the foundation will be isolated by the soil and where the soil dynamic properties are known.

## Structural Design and Stiffness

To be acceptable, the proposed design of a foundation or any support structure must provide a reliable structural configuration that also meets the static and dynamic criteria for the structure. Deflections in the foundation caused by static loads or by dynamic forces/inputs should be within acceptable limits. This design approach sometimes requires modeling of the foundation, so that the real structure behavior is predetermined and errors are minimized.

The calculations for the stiffness of a foundation yield the static and dynamic behavior and stress concentration points that occur. Stresses are related to the geometry of the foundation and the distribution of loads and forces acting upon it. A stress analysis will indicate the magnitude of stress imposed by static and dynamic loading (Figure 3).

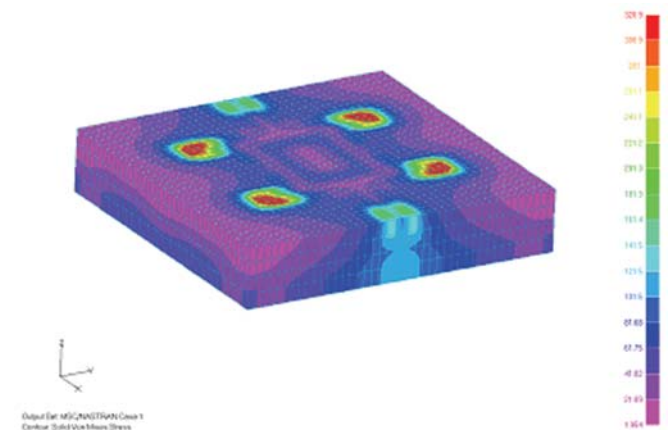


Figure 3 - Foundation stress analysis.

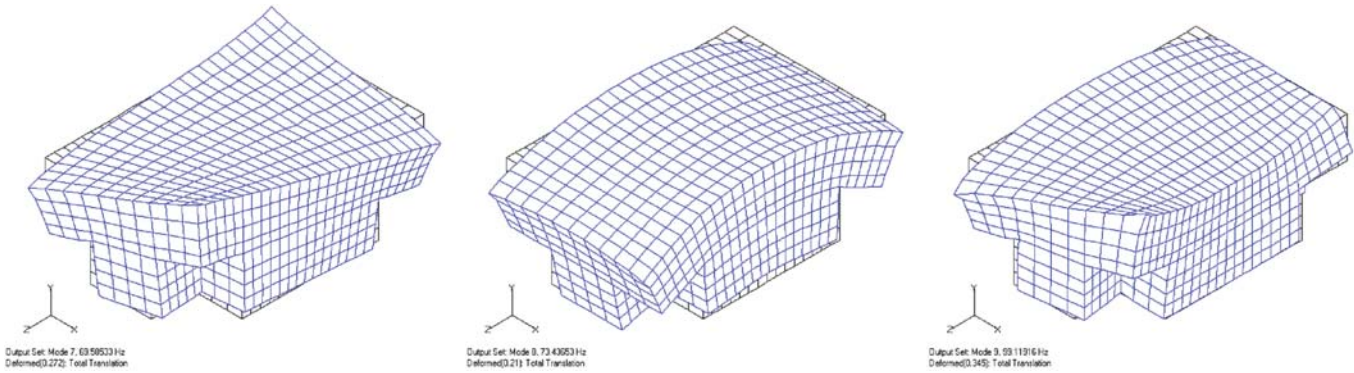


Figure 4 - Mode shapes of a support foundation.

Data on forces, such as axial, shear, torques and moments for maximum loading at each support or attachment location of the machine are necessary to predict the load conditions on the foundation. These loads are used to determine the longitudinal and/or transverse (width) reinforcement and concrete strength required, which relates directly to any deflection.

The modulus of elasticity is a key design factor in the strength of concrete. (See Figure 6.) Limits on the differential deflection allowed from one point to another on a foundation are set to avoid possible damage or misalignment of conduit and other connections. The depth of a foundation is determined by the bearing strength of the soil, the machine support requirements (structural stiffness) and in critical designs, the dynamic stiffness, which includes the foundation's natural frequency and bending modes.

Geometry and mass are important considerations in the dynamic design of foundations. However, the foundation-to-equipment mass ratios that are sometimes recommended, do little in preventing foundation vibration unless the dynamic response of the foundation is known.

A finite element analysis will define and model the mode shapes and response frequencies of the foundation, as well as the response of the isolation system and foundation to machine induced inputs and/or environmental inputs (Figure 5).

Mode shapes (stiffness of a structure in each axis) identify the physical direction of each frequency mode and any deformations, such as bending or twisting. In general, a structure's modes indicate the relative degree of structural stiffness among various points on that structure (Figure 4).

Examining mode shapes in a vibrating structure is a valuable step in adjusting vibration amplitudes at critical points by varying the stiffness, mass and damping in a structure.

Forces imposed by the supported machine can induce a high enough vibration amplitude at the natural frequency (or one of the response modes) of the foundation to cause resonance or amplification of the vibration. The single most important factor in any successful design where machine induced vibration is involved (source) is to avoid resonance between the machine and the foundation.

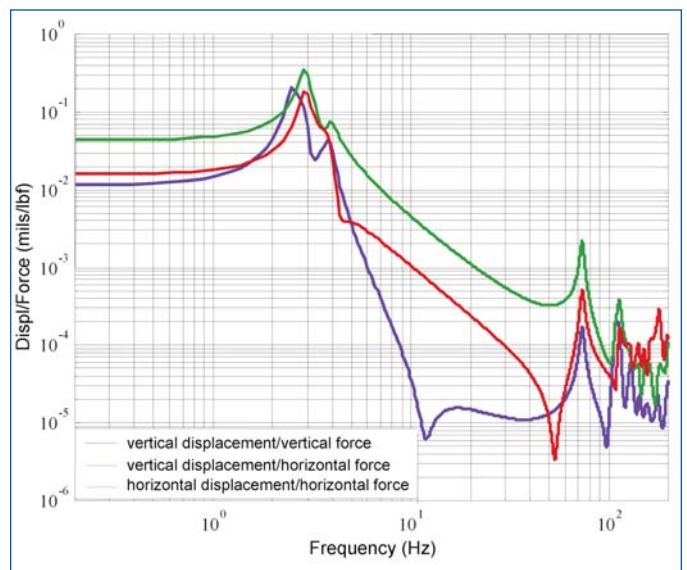


Figure 5



Amplification at the point of resonance should be addressed for environmentally induced, random or steady state vibration, although the vibration isolators supporting the foundation should provide sufficient isolation at the foundation's natural frequency to avoid amplification.

During startup or shutdown of a machine, a temporary resonance condition may be tolerated, where the support structure or even the vibration isolators are in resonance with the machine's operating frequency, especially if significant damping is available.

Data on the operating speed and forces generated by a machine, or the measured vibration amplitudes and frequencies at which they occur for a machine sensitive to vibration, are therefore required in a dynamic analysis in order to check for possible resonances.

### Concrete

An important part of a foundation's structure and stiffness is the specified concrete strength used in the design.

A specified concrete strength is easy to obtain and is often used as the only criteria. However, shrinkage control can be one of the most important factors in providing a successful project. The following are major factors controlling shrinkage:

- 1) Water/cement ratio (slump) of delivered concrete
- 2) Aggregate proportioning and size
- 3) Water reducing additives
- 4) Site conditions, such as hot, dry climate
- 5) Curing
- 6) Control joints and reinforcing

Each of these six factors needs consideration. Slump is controlled by controlling the total water per cubic yard of concrete, while strength is governed by the thickness or consistency. This thickness is determined by the ratio of the weight of water to the weight of cement.

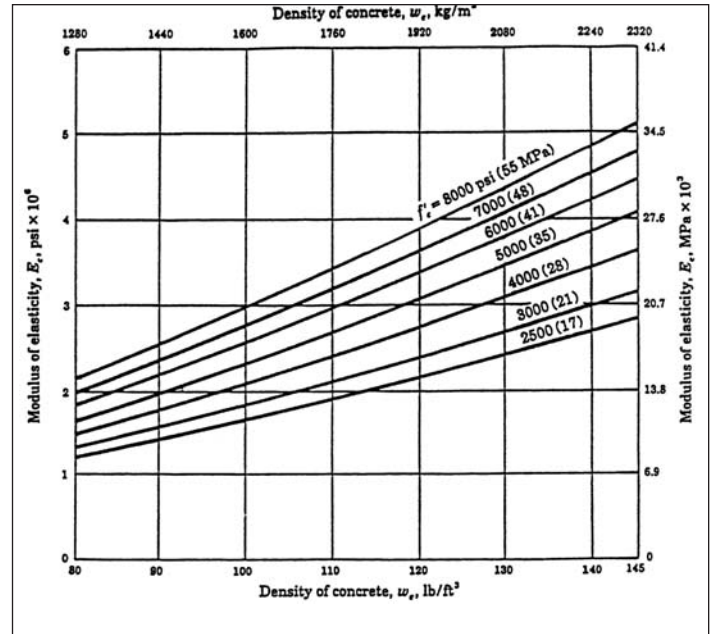


Figure 6

Shrinkage is simply the reduction in volume that takes place when the concrete dries from its original wet condition down to a point where its moisture condition reaches equilibrium with the humidity in the air. Unrestrained shrinkage does not develop cracks.



Concrete sample and slump measurement of concrete mix before pouring foundation.

When designed and cured properly, large foundations result in very low concrete shrinkage while in a controlled environment. Most of the shrinkage occurs in the first two months and it is nil in the following months if the ambient environment does not change. Concrete surface sealants, if required, should be applied after most of the shrinkage has occurred.

For critical designs or for precision equipment, concrete samples should be taken at least one for each 25 cubic yards of concrete placed to check the slump. Test samples should also be taken at 7 and 28 days (assuming a 28-day cure) to verify the strength.

**Design factors in the dynamic analysis of an isolated support foundation include:**

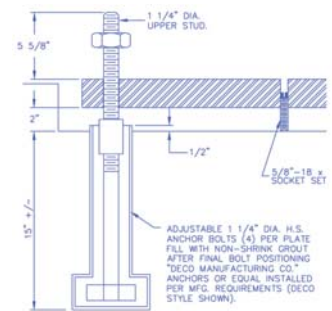
- ◆ Unbalanced forces applied by supported equipment/machine
- ◆ Center of gravity of machine/equipment
- ◆ Natural frequency (resonance) and response modes of foundation
- ◆ Transmissibility
- ◆ Displacement on vibration isolators

**Summary**

A good foundation design requires realistic analysis and supervision during construction. Stiffness in design is important both structurally and dynamically. Dynamic coupling or amplification at resonance due to the interaction of all components in the isolated foundation design can be avoided if the natural frequencies of the soil, pit, isolators and support foundation are verified.

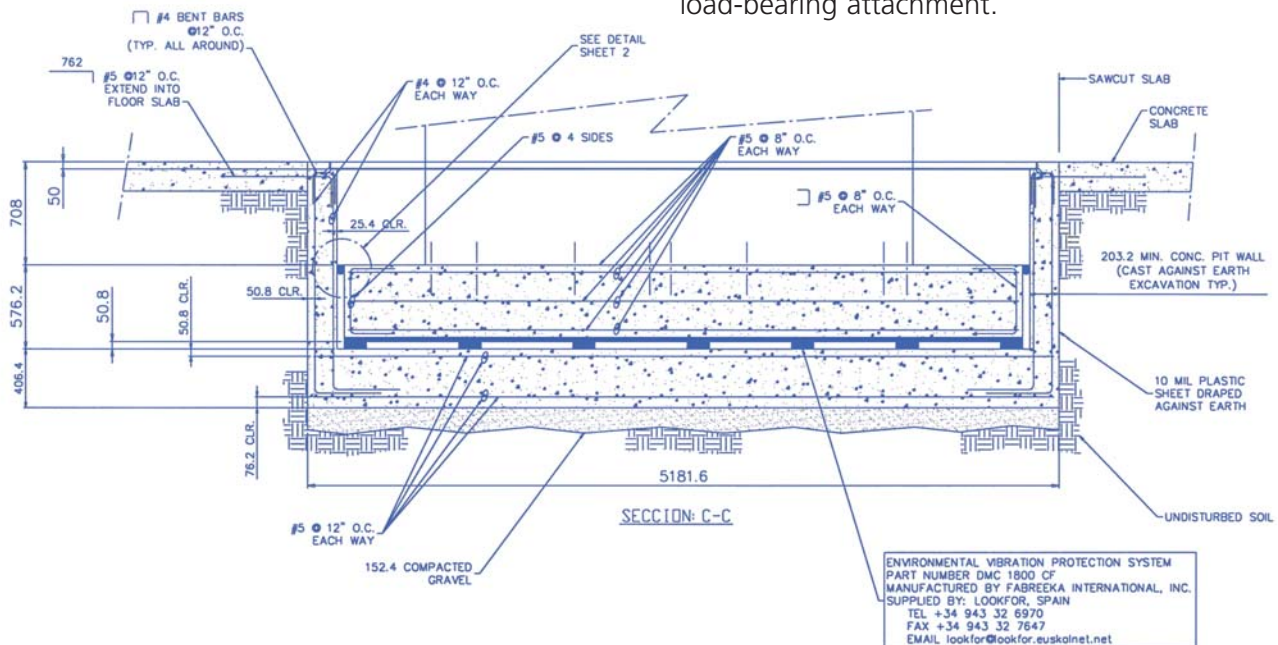
Direct vibration measurements can be made that will render the actual frequency response of the soil and the best possible values for analysis. This is particularly important for foundations that are isolated using mat materials directly on compacted soil without using a rigid concrete pit or sidewalls.

Once the approved foundation has been constructed, the machine/equipment should be attached to the foundation to make a structurally sound connection. To achieve this, the connection should meet the rigidity and support requirements of the machine. Typical connections, which also offer leveling adjustment are anchor bolts with shims and leveling wedges.



MACHINE SUPPORT PLATE  
SCALE = 1:4

Grouting also may be required to provide a solid, load-bearing attachment.



# Vibration Isolators

The purpose of an isolator is to decrease the amplitudes of forced, random and steady state vibrations being transmitted into a machine or equipment support foundation. Isolators exist in many forms, including rubber, mat materials, metal coils, air bags and pneumatic isolators. The type of isolator (performance) used as the solution for an application depends on the type of machine to be isolated, static load, dynamic deflection and damping properties of the isolator.

All vibration isolators are essentially springs with an additional element of damping. In some cases, the "spring" and "damper" are separated, as in the case of a coil spring isolator used in conjunction with a viscous damper. The majority of isolator designs however, incorporate the spring and damper into one integral unit.

Important characteristics of any isolator are its load-deflection and load-natural frequency properties. The dynamic spring rate and damping of an isolator mostly are determined by the type of material used, while the stiffness (static and dynamic) is a function of the isolator design (material, shape). Static spring rate, dynamic spring rate, creep, natural frequency, damping and load deflection values vary widely from material to material and design to design. Therefore, materials or elements used for vibration isolation are chosen based on the significant differences in their performance when used to isolate specific frequencies and amplitudes.

## Transmissibility

The ratio of the vibration transmitted after isolation to the disturbing vibration is described as *transmissibility* and is expressed in its basic form in Equation (1).

$$(1) \quad T = \frac{1}{1 - [F_d^2/F_n^2]} \quad \text{\textit{Theoretical, undamped transmissibility}}$$

Where  $F_d$  is the disturbing frequency and  $F_n$  is the natural frequency of the isolator. When considering the property of *damping*, the equation is rewritten as Equation (2).

$$(2) \quad T = \frac{1 + (2\zeta F_d/F_n)^2}{\sqrt{(1 - [F_d^2/F_n^2])^2 + (2\zeta [F_d/F_n])^2}}$$

Where  $\zeta$  represents the damping ratio of the isolator.

Natural frequency and damping are the basic properties of an isolator that determine the transmissibility of a system designed to provide vibration and/or shock isolation. Additionally, other important factors must be considered in the selection of an isolator/isolation material. Two such factors are:

- ♦ The source and type of the dynamic disturbance causing the vibration / shock.
- ♦ The response of the isolator to the dynamic disturbance.

With an understanding of its properties, the type of isolator is chosen primarily for the load it will support and the dynamic conditions under which it will operate.

## Natural Frequency, Spring Rate

Not all isolators whose isolation characteristics are based on mechanical deflection have a linear relationship between load and deflection. A common mistake is that the following equation [Equation (3)] can be used to calculate the natural frequency for all isolators if the spring rate ( $k$ ) and weight ( $w$ ) to support are known.

$$(3) \quad F_n = \frac{1}{2\pi} \sqrt{\frac{k}{m}} \quad \text{where mass (m) = } \frac{w}{g}$$



If the stiffness or spring rate (k) is not known, the equation can be rewritten [Equation (4)], so that the static natural frequency of the isolator is a function of its static deflection ( $\delta_s$ ). This results in a determination of the isolator's static natural frequency where (g) represents the gravitational constant.

$$(4) \quad f_n = \frac{1}{2\pi} \sqrt{\frac{g}{\delta_s}} \quad \text{\textit{Theoretical, undamped static natural frequency}}$$

However, using the static, linear principle in Equation (4), the following is true:

- 1) Large deflections are required for low frequency isolation.
- 2) Damping properties are neglected.
- 3) Only the *static* natural frequency is obtained.
- 4) The isolator is assumed to have a linear spring rate.

The static deflection principle can be used only when the isolator under consideration is both linear and elastic. For example, rubber, felt, fiberglass and composite pads tend to be non-linear and exhibit a *dynamic* spring rate, which differs from the static spring rate.

The natural frequency calculated using the static deflection ( $\delta_s$ ) determined from a static load - deflection test of an isolator invariably will give a value lower than that experienced during vibration (*dynamically*).

Any isolator with a calculated natural frequency based on static deflections may not behave in the predicted way because the dynamic spring rate differs from the static spring rate.

It is the dynamic natural frequency which has to be used in calculations rather than the static.

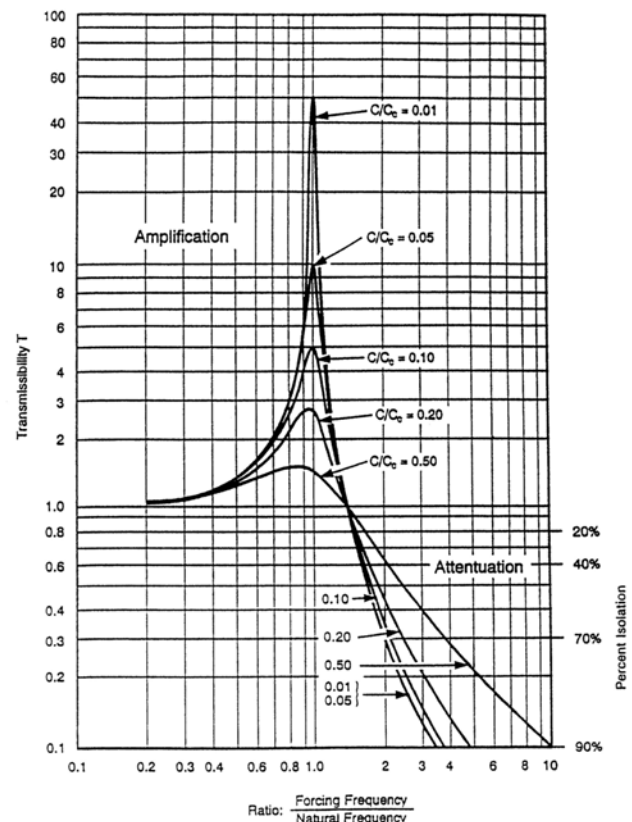
## Damping

The property of damping is neglected in the static evaluation [Equation (4)], and this can have a significant effect on the isolation efficiency. Damping in an isolator has a beneficial effect because it helps to suppress vibration, but can also lead to a loss of isolation efficiency. To appreciate the effects of damping, refer to the transmissibility curves in Figure 7.

The curves are developed using the known properties of the isolator - dynamic natural frequency and damping [Equation (2)]. Note that as damping is increased, the curve of transmissibility is flattened, so that in the region near to resonance, the curve is reduced, but in the region where isolation is required, the curve is increased. The curves show that if there is a significant amount of damping in an isolator, its natural frequency has to be reduced to retain a desired degree of isolation at the frequency ratio of concern.

The ideal isolator would have as little damping as possible in the isolation region and as much as possible at the isolator's natural frequency to reduce amplification at resonance.

With an understanding of the basic properties and dynamic characteristics of an isolator, it is possible to design for and calculate the true transmissibility of the isolator as a function of frequency. However, dynamic stiffness (natural frequency vs load) or a transmissibility vs frequency curve with the actual damping coefficient of the material is required.



Transmissibility vs. Frequency ratio for several values of damping.

Figure 7

Figures 8 and 9 show how isolation materials can be used in constructing and isolating a foundation below floor level. A concrete pit of the required size is lined with the isolation material. Then this material is covered with plastic sheeting, and the concrete is poured on the required reinforcing rods to form a rigid foundation. The desired natural frequency is obtained by using material of the appropriate thickness and area.

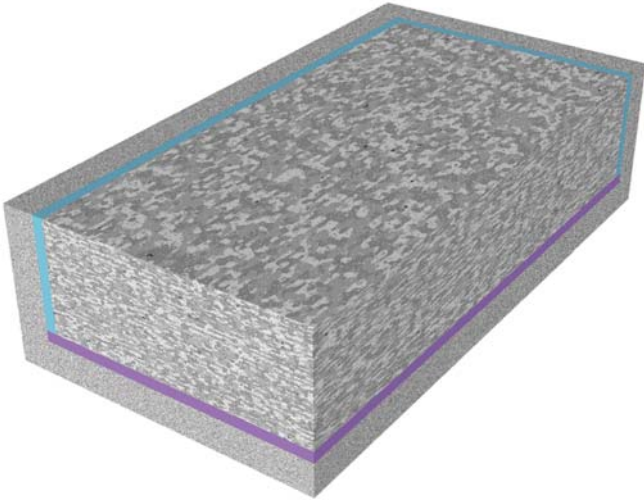


Figure 8

To obtain a low natural frequency for the isolated system, a large static deflection is required when using rubber or coil spring isolators. However, no static deflection is required when using pneumatic isolators (air springs) with low natural frequencies.

If the isolators are located substantially below the combined center of gravity of the foundation/machine, a tendency toward instability is introduced, an effect which becomes more important if the machine generates large forces during normal operation, or motion is created due to high acceleration/deceleration of moving parts.

"Rocking" can be minimized by installing the isolators in positions closer to the upper surface of the foundation, supported on abutments extending inward from the walls of the pit. A more refined version of this concept is the T-shaped foundation illustrated in Figure 9. With such a design, it is possible to locate the isolators in the same horizontal plane as the combined center of gravity of the machine and foundation and reduce or even eliminate motion on the isolation system.

"Snubbers" or restraints should only be used in seismic designs to prevent motion due to earthquakes and protect the supported equipment. Snubbers used for stability indicate a poorly designed isolation system.

Finally, external connections of a vibration isolated object can detrimentally affect the isolation efficiency. Mechanical attachment of conduits (service lines) including electrical, signal and other connections can affect the performance of a vibration isolation system, especially when installed under precision equipment being isolated. These connections create a good transmission path (short circuit) for vibration, which can be present at the connection source and transmitted to the support foundation. All rigid service conduits should be attached via flexible connections and in large loops to reduce stiffness and transmission.



Figure 9

# FABSORB™ Foundation Isolation

Fabsorb™ vibration isolation material is an economical approach to foundation isolation where moderate vibration control is required.

Fabsorb™ material absorbs machine-induced energy, limits the transmission of higher frequency disturbances and provides isolation from ambient and induced shock and vibration, which otherwise would affect the accuracy of the machine being installed.

Fabsorb™ material is specifically designed for vibration isolation applications of support foundations for machine tools, shock testing equipment, grinders and similar equipment.

The natural frequency of Fabsorb™ is dependent on load and type of material, and ranges from 12 Hz to 50 Hz.

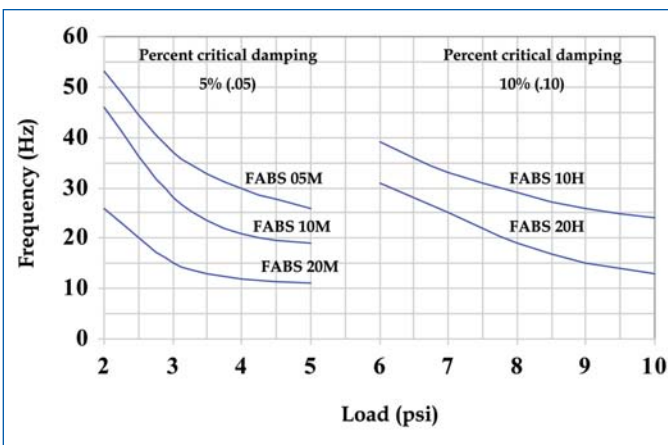
## Material Specification

Unlike other isolation materials, Fabsorb™ is not subject to deterioration through water absorption and wicking, which causes felt-like material to stiffen over time, losing its original isolation characteristics. By comparison, the stiffness of Fabsorb™ and, therefore, its natural frequency and isolation characteristics, are constant over time, resulting in reliable performance and durability. Fabsorb™ is a medium-density, closed-cell foam material, manufactured using a patented compound. It is designed specifically to perform as a vibration isolation and shock absorbing material. It is impervious to most chemicals and performs consistently over a wide range of temperatures and time.

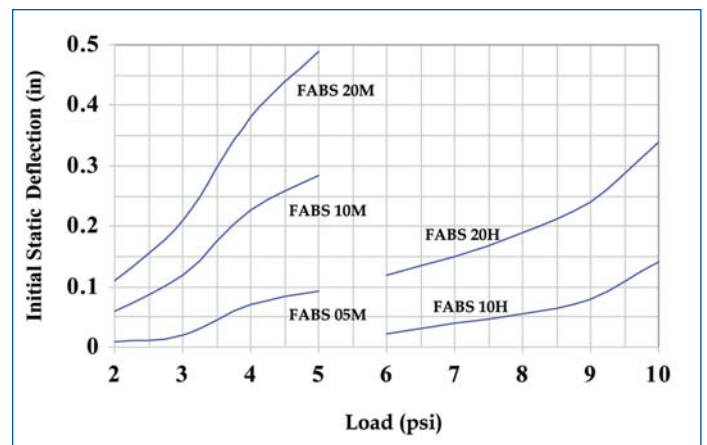


Fabsorb™ vibration isolation material is manufactured in the following standard sheet sizes for base and sidewall isolation.

Type	Sheet Size
FABS 05M	48" x 108" x 1/2" thick
FABS 10M	48" x 108" x 1" thick
FABS 20M	48" x 108" x 2" thick
FABS 10H	24" x 108" x 1" thick
FABS 20H	24" x 108" x 2" thick



Dynamic Natural Frequency



Load Deflection



## Fabsorb™ Compressive Creep Characteristics

### Maximum Percent<sup>1</sup> of Original Thickness

Load (psi)	Type M	
	10M	20M
2	4%	2%
3	40%	6%
4	40%	40%
5	40%	40%
	Type H	
	10H	20H
6	5%	1%
7	30%	20%
8	30%	30%
9	40%	30%
10	50%	30%

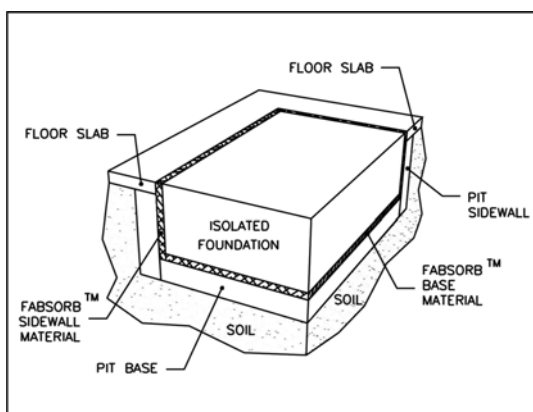
<sup>1</sup>Creep results at maximum stress after 700 hours under static load. Creep is in addition to initial static deflection.



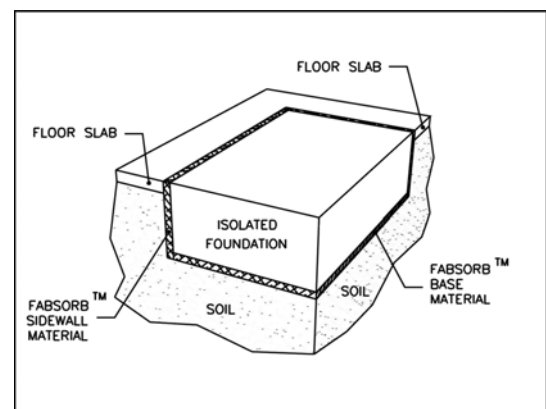
For ease of installation, Fabsorb™ is manufactured in sheets (4' x 9' and 2' x 9').

## Installation

The construction of the foundation and the installation of the isolation material generally are performed using either of two methods.



**Method 1**  
Installation site is excavated to specified depth and grade. Pit is formed and poured. Fabsorb™ base and sidewall panels are installed in pit. Foundation is poured.



**Method 2**  
Installation site is excavated to specified depth and grade. Fabsorb™ base panels are installed on grade, and foundation is formed and poured. Forms then are removed and Fabsorb™ sidewall panels are placed along foundation sides. Soil is backfilled up to isolated foundation. Floor slab is poured on grade.

### Installation Procedure (Method 1)

Following the layout drawings provided by Fabreeka, install the Fabsorb™ panels on the sidewalls of the pit. Sidewall panels should rest on pit floor.

Sidewall panels can be secured to the pit walls by construction adhesive or by 3" duct tape (lower right). Additionally, all vertical seams also should be taped to prevent concrete from creeping into any gaps.

Install Fabsorb™ base isolation panels. Base panels should not contact pit sidewalls - only sidewall isolation panels. Tape all seams.

Lay polyethylene sheeting over Fabsorb™ material on base and sidewalls. Tape all seams to prevent concrete seepage into the material.

Place reinforcement rod per structural design drawings using shim material to keep rod elevated and to prevent puncturing or tearing the sheeting and material.

Pour concrete, and trim polyethylene sheeting at floor level after fully cured.

A proven mastic sealer, Sika Type 125L or equivalent, should be used to seal the isolation material at grade between the floor and the foundation at the exposed edge.

### Installation Procedure (Method 2)

Following the layout drawings provided by Fabreeka, install the Fabsorb™ panels on grade. Allowable soil loading should be verified by soils survey / report. All seams should be taped using 3" wide duct tape.

Lay polyethylene sheeting over Fabsorb™ base material, and construct forming for foundation around base isolation panels.

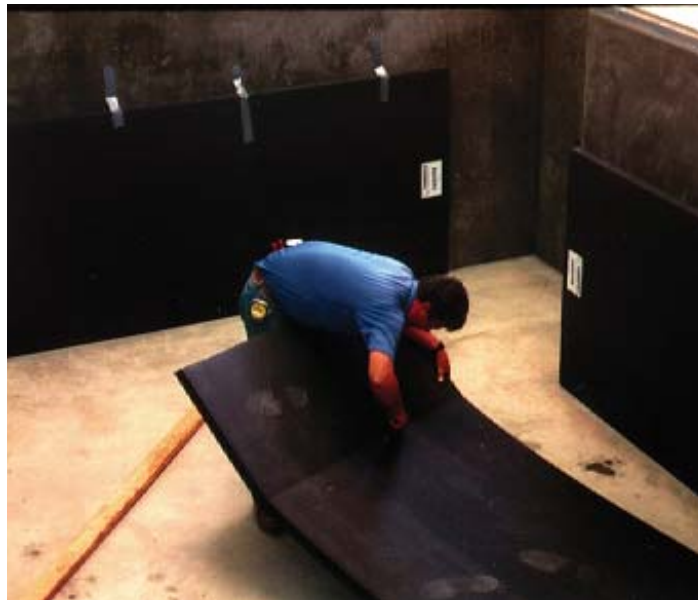
Place reinforcement rod per structural design drawings using shim material to keep rod elevated and to prevent puncturing or tearing the sheeting and material.

Pour concrete for foundation and allow for proper cure time. Remove forming and secure Fabsorb™ sidewall isolation panels to sides of foundation using construction adhesive or duct tape.

Backfill soil against sidewall isolation panels.

Pour floor slab on grade.

A proven mastic sealer, Sika Type 125L or equivalent, should be used to seal the isolation material at grade between the floor and the foundation at the exposed edge.



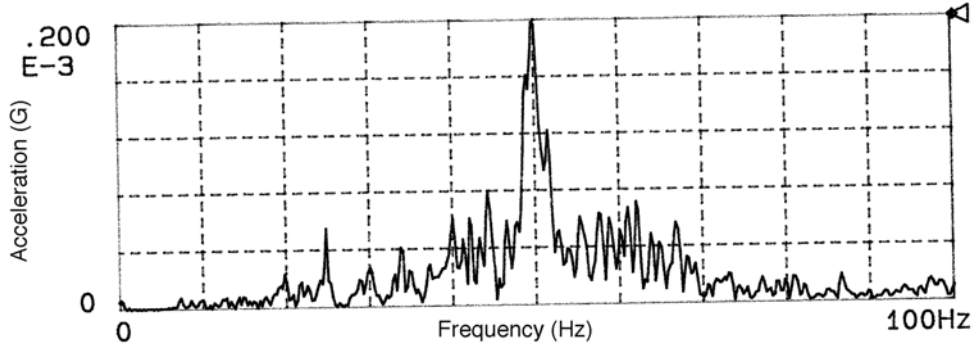
Fabsorb™ can be supplied cut to size, marked and furnished with detailed layout drawings for installation by contractors. Supplied in standard sheet sizes, it can be easily cut with a utility knife when the foundation dimensions vary.



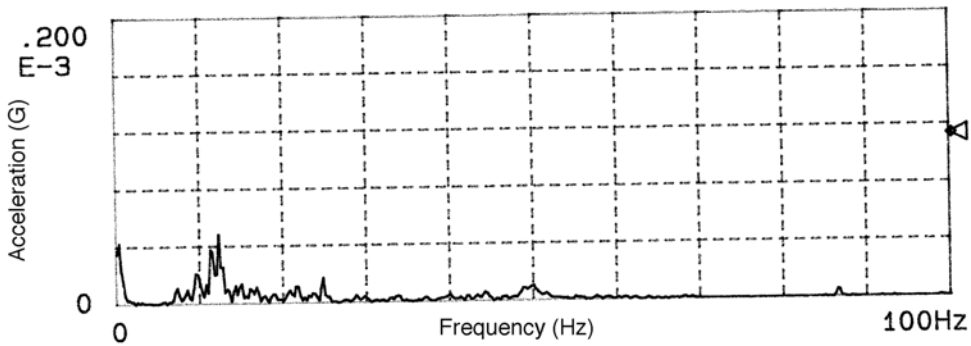
## Fabsorb™ Test Data

Following are the results from two case studies with and without Fabsorb™ isolation material in use.

### Case 1

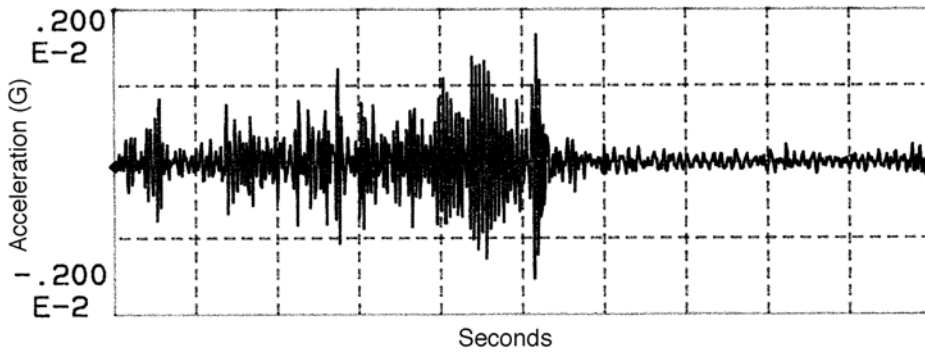


*Random vibration input on shop floor.*

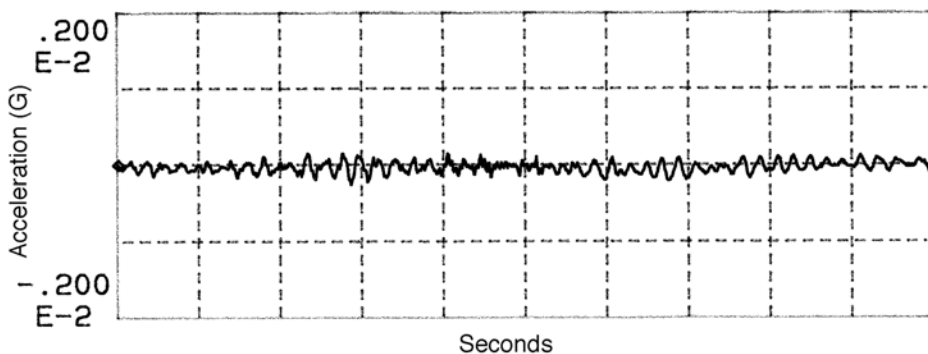


*Isolated response on foundation isolated with FABS 20M type material under 5 psi load.*

### Case 2



*Transient input from shear machine on shop floor.*



*Isolated response on foundation isolated with FABS 20M type material under 5 psi load.*



# Regufoam® Isolation Material

**Regufoam® vibration isolation material is a mixed cell polyurethane foam specifically designed to provide low frequency vibration isolation for building and machine foundation isolation and light rail applications.\***

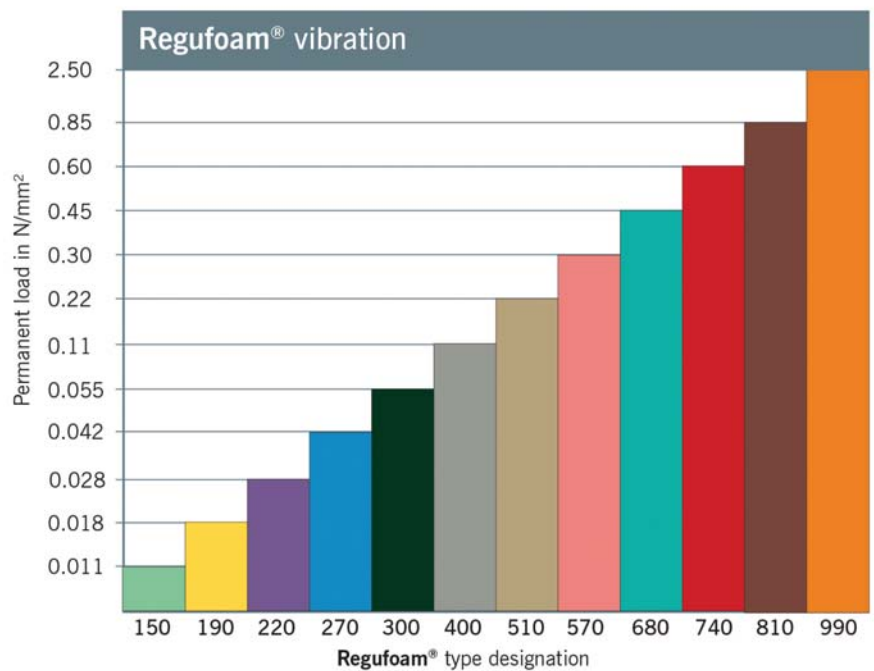
Regufoam material is manufactured in 12 different types, which allows for optimal loading to achieve increased isolator performance. The damping rate of the different material types is between 4.5% and 14%, and natural frequency can be as low as 6 Hz. Additionally, with increased thickness, the natural frequency is reduced, which also improves isolation. Regufoam is impervious to most chemicals, alkaline solutions and oil.

Regufoam material can be supplied and used in full sheet form, strips or even blocks. However, when used in full sheet form, the material becomes the base formwork for the concrete foundation. This advantage creates a simple construction method.

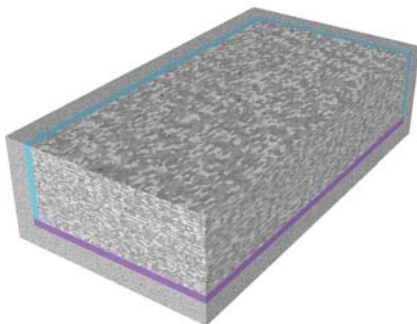
As with all non-linear, elastomeric isolators, Regufoam material reacts more stiffly under dynamic loads than under static loads. The degree of stiffness depends on the material type and the load applied. Additional small dynamic loads can be applied beyond the maximum static load for each type of material.



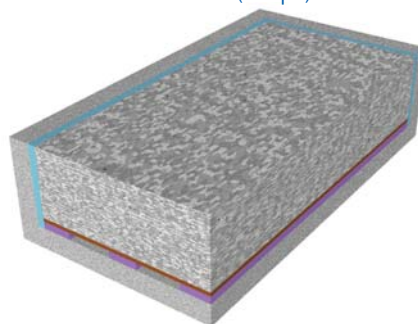
Permanent static loads cause a certain amount of creep (additional deflection) in all elastomeric materials. The long term creep of Regufoam material is very low (below 20% of its original thickness) when used in the static load range.



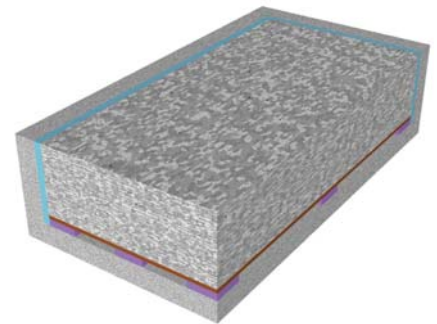
Full Surface Area



Partial Surface Area (Strips)



Individual Blocks



Sidewall isolation is optional for any of these methods of installation, depending on isolation requirements and machine type.

\*Please consult Fabreeka's Engineering department for additional information, performance data and engineering assistance for Regufoam® and Regupol®.

# Regupol® Vibration Isolation

Regupol® vibration isolation elastomers are composed of SBR and NBR rubber elements. Rubber granulates, rubber fibers and rubber crumbs are combined with one another, processed and elasticized with various polyurethanes using a special manufacturing method.\*



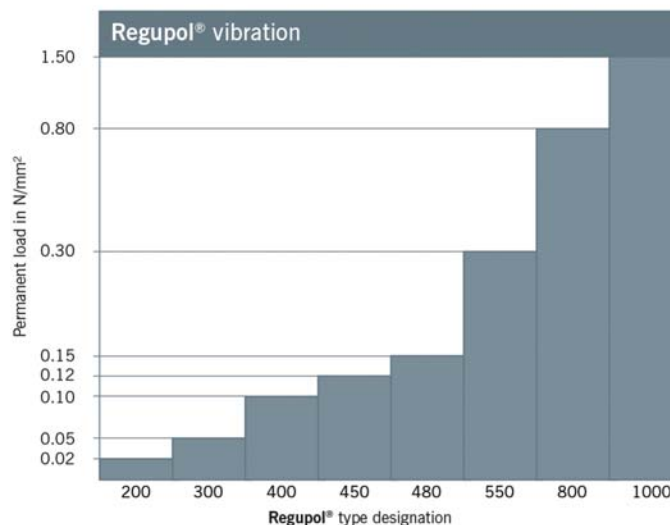
Eight different Regupol® elastomers are available. They can be used in a very wide load range if required. The Regupol® elastomers offer a solution that is technically sufficient, as well as the most economical one available for most building and machine foundation isolation jobs. The damping rate of the different material types is between 8% and 11%. The natural frequency of Regupol® can be as low as 7.5 Hz, and with increased thickness, the natural frequency is reduced, which also improves isolation.

The creep (or creep behavior) is low for all different Regupol® elastomers at approx. 5–7% of the total thickness. The admissible permanent load limits are kept, the only effect of overloading on the elastomers is increased rigidity (rise in dynamic rigidity and natural frequency), which shows in progressive deflection.

Additional benefits of Regupol® elastomers are their excellent moisture resistance, their rot-proof properties, their ozone resistance and their permanent elasticity even after frost-thaw cycles.

The use of Regupol® is therefore admissible not only inside but also outside of buildings. *The only exception here is Regupol® vibration 200.* Because of its rigidity and its cellular structure this material has to be protected against water uptake.

**Regupol® material is manufactured using 96% post consumer content.**



\*Please consult Fabreeka's Engineering department for additional information, performance data and engineering assistance for Regufoam® and Regupol®.

# INFAB™ Isolation Material

Fabreeka® Infab™ vibration isolators are composed of a molded elastomer, which has been compounded and designed to offer low frequency isolation and high load capacity.

Infab™ isolation systems have natural frequencies as low as 6.0 Hz and can be designed to exhibit low or high internal damping. Infab™ solutions are used under large concrete foundations supporting heavy machinery, buildings, measuring machines, roller mills and similar equipment.

Infab™ isolators are available in two types to suit a wide range of design options when considering the formwork required to provide proper support during the foundation construction process. Infab™ isolators may be supplied as individual units (blocks) or as isolation panels to facilitate ease of installation.

Type 1T and 2T isolators support loads from 800 lbs (3,600 kg) to 2,500 lbs (1,125 kg) each and have natural frequencies of 6.0 Hz to 9.0 Hz, with damping in the range of 2% to 6%. The Infab™ "T" series isolator's unique design utilizes a steel coil spring inside oil/ozone resistant neoprene. The spring portion of the isolator provides a low natural frequency, while the elastomeric/neoprene portion provides damping. Therefore, at higher loads, these isolators exhibit a slightly higher natural frequency with lower damping, since the elastomer (rubber) governs the spring rate. At lower loads, the coil spring portion of the isolator governs the spring rate, resulting in a slightly lower natural frequency but with higher damping due to the influence of the neoprene.



Type 2T Infab™ isolators positioned on pit floor prior to forming the foundation above.

## Infab™ Type "T"

### Dynamic Natural Frequency and Damping

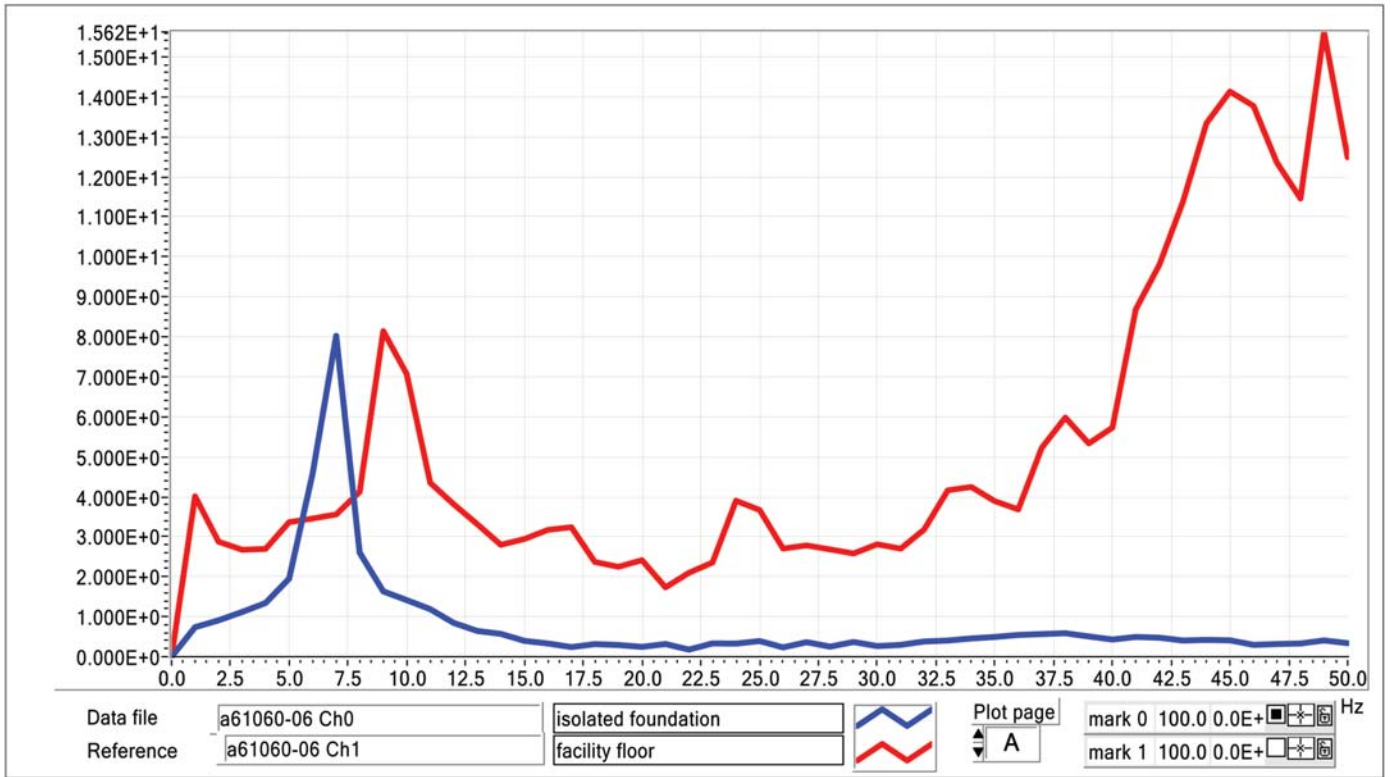
#### Type 1T

Axis	Load (lbs)	F <sub>N</sub> (Hz)	Damp (%)
Vertical	875	6.0	5
Horizontal	875	4.0	2
Vertical	1,750	7.0	5
Horizontal	1,750	3.0	3

#### Type 2T

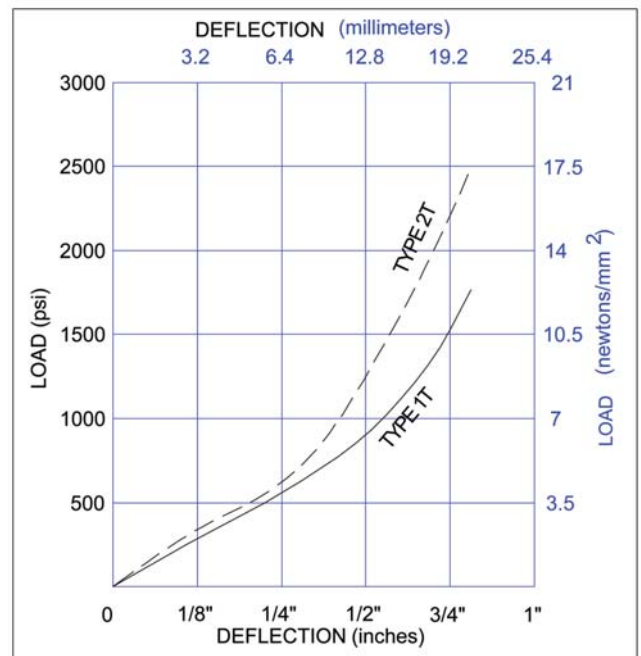
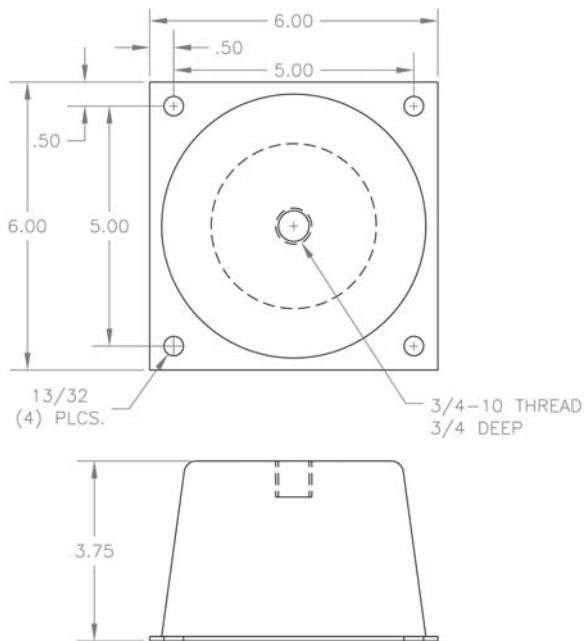
Axis	Load (lbs)	F <sub>N</sub> (Hz)	Damp (%)
Vertical	1,750	8.0	6
Horizontal	1,750	3.0	4
Vertical	2,500	9.0	3.5
Horizontal	2,500	4.0	4.5





### Acceptance Test Data

Vibration amplitudes are measured on the facility floor (red) and on the isolated machine foundation (blue). Note: The natural frequency of the Infab™ 1T isolators is 7.0 Hz and the input floor vibrations that occur from 10 Hz to 50 Hz are greatly reduced.



Infab™ Type 1T and 2T dimensions.

## Pneumatic Isolators

**Precision-Aire™ Leveling isolators provide superior low frequency isolation for metrology instruments, electron microscopes, MRI, coordinate measuring machines and precision manufacturing equipment.**

PAL pneumatic and air bag isolators can be designed to have natural frequencies as low as 0.5 Hz vertically and 0.4 Hz horizontally, while the standard line of isolators have natural frequencies of 1.5 Hz and 5.0 Hz. The natural frequency and isolation efficiency of these isolators remain constant throughout their load range.

Fabreeka® designs and manufactures large capacity pneumatic and air bag isolators, which support loads from 13,000 lbs (5,800 kg) to 120,000 lbs (54,000 kg) each for foundation isolation applications requiring low frequency vibration isolation. Air bag isolators provide a larger dynamic stroke than our standard PAL isolators and are used in applications where a low natural frequency (0.5 - 1.5 Hz) and large displacements must co-exist.

PAL isolation systems react quickly to position changes of support load and center of gravity shifts by automatically compensating and releveling. Settling time is minimal with optimum damping and correct valve gain.

For large machine tools and CMM's using automatic part handling systems where parts can weigh several tons, loading and unloading can generate vertical motion on the isolators. To avoid this problem, Fabreeka® can vary the internal pressure of the isolators to lower the support foundation onto hard stops.



Pneumatic isolators are installed after the foundation has cured and the machine/equipment has been installed and anchored properly. The isolators are positioned under the foundation at predetermined support points and then activated to float or lift the foundation and machine off the pit floor.



Air bag isolators provide a low natural frequency and large dynamic stroke where dynamic deflection is acceptable.

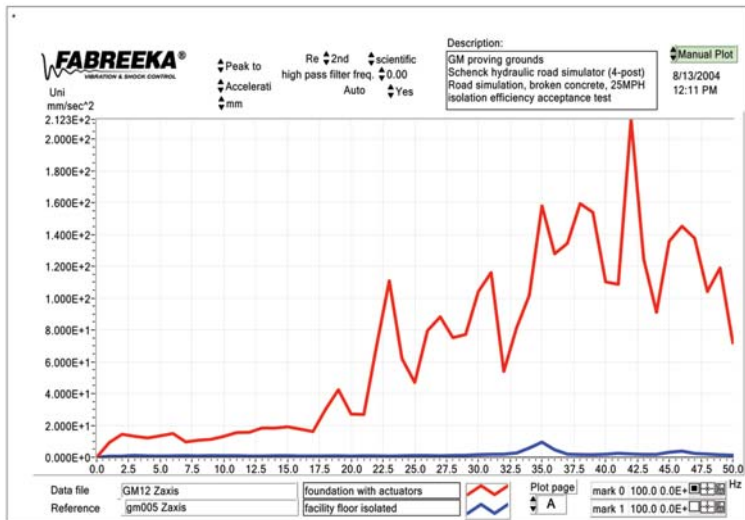


Pneumatic isolators with lifting capacities of up to 120,000 lbs each are used to provide low frequency isolation for large concrete reaction masses (foundations). The isolators shown above are 72" (1,830 mm) in height and have vertical and horizontal natural frequencies of 0.7 and 0.5 Hz respectively.

# Vibration Measurement & Analysis Services

Most precision machine tool and measuring machine manufacturers have established allowable vibration specifications for their machines. Fabreeka® utilizes highly accurate instrumentation to quantify the amplitude and frequency of vibration to make proper vibration control recommendations.

Fabreeka® engineers also conduct acceptance test measurements after installation. Acceptance test measurements provide the resultant vibration amplitudes after isolation is installed.



Fabreeka® can provide vibration measurement services from any of our worldwide facilities.

# Consultation & Project Management

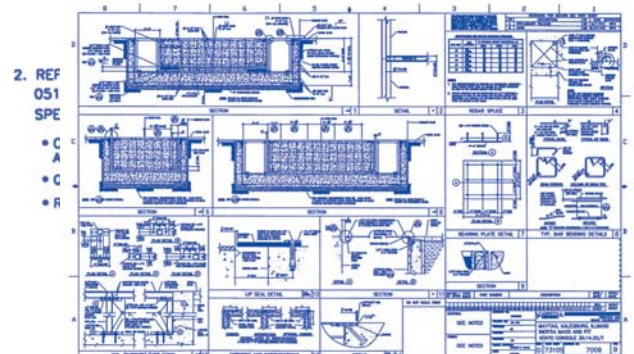
Fabreeka® provides complete, detailed design drawings and specifications for your construction or fabrication.

Our engineers can supervise critical phases of construction and provide oversight for the design, installation and testing of installed isolation systems. Design review meetings are held with customers as part of overall project management. *Design, service, installation and expertise since 1936.*



## MATERIAL REQUIREMENTS:

- CONCRETE FOR INERTIAL MASSES ONLY:**
    - ASTM C 33,  $f'c = 5000$  psi AT 28 DAYS.
    - MINIMUM CEMENT CONTENT: 6.25 SACKS/CY.
    - MAXIMUM WATER CEMENT RATIO: 0.55.
    - MAXIMUM SLUMP: 5".
    - MAXIMUM AGGREGATE: 3/4".
    - THE USE OF A PEA GRAVEL (3/8") CONCRETE MIX IS EXPRESSLY PROHIBITED.
- STEEL FOR IN BED  
STEEL FOR TR SHAI RAIS





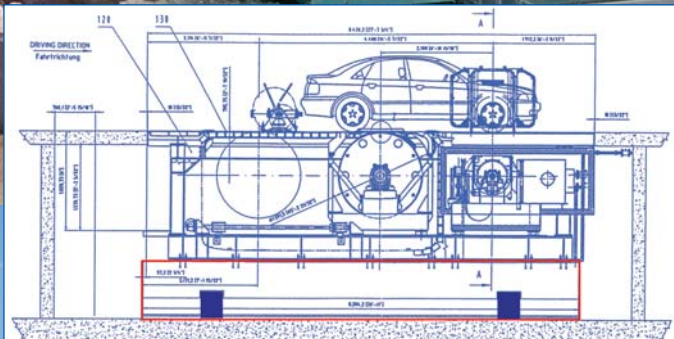
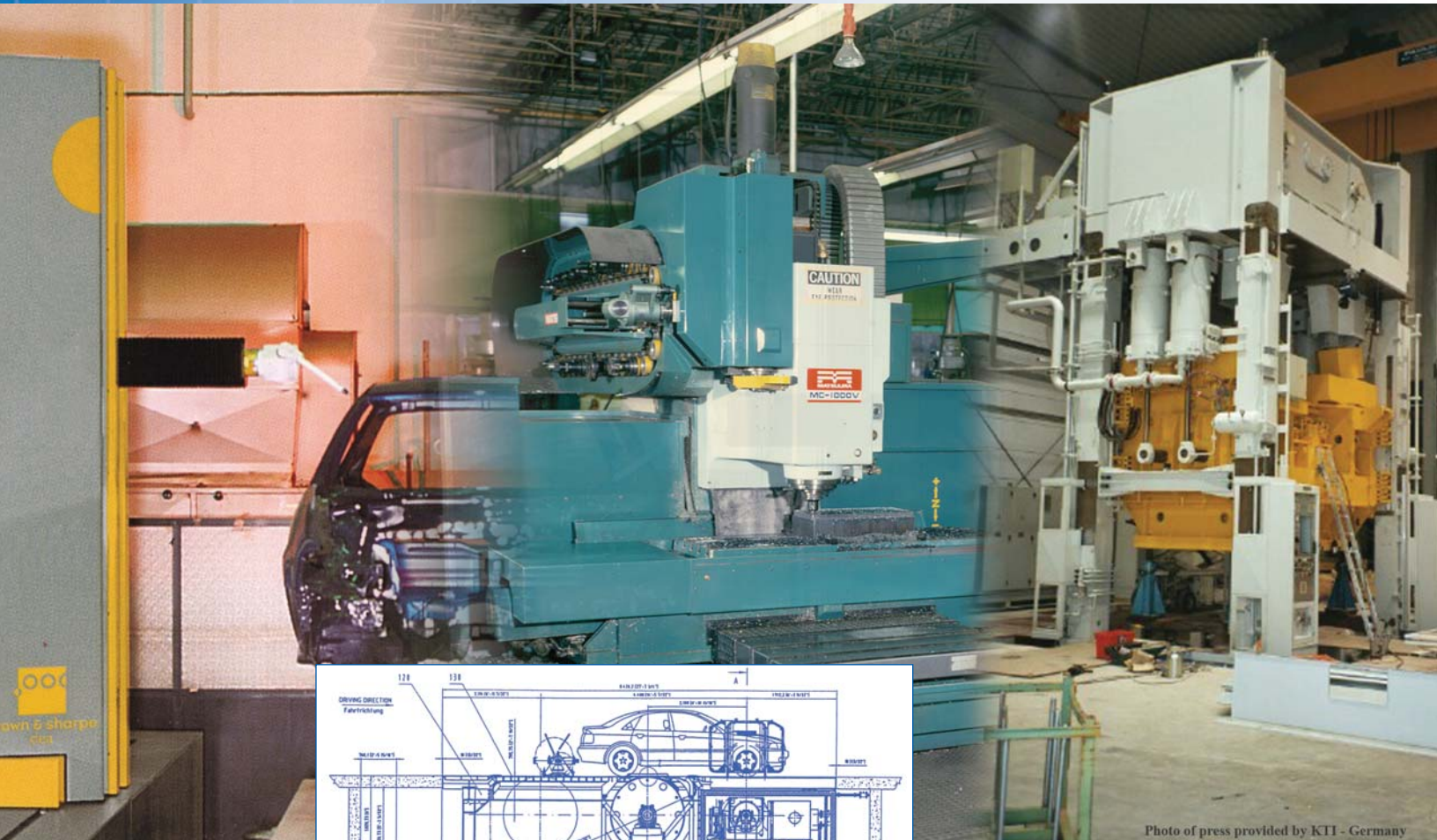


Photo of press provided by KTI - Germany

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Regupol and Regufoam are registered trademarks of BSW GmbH.  
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