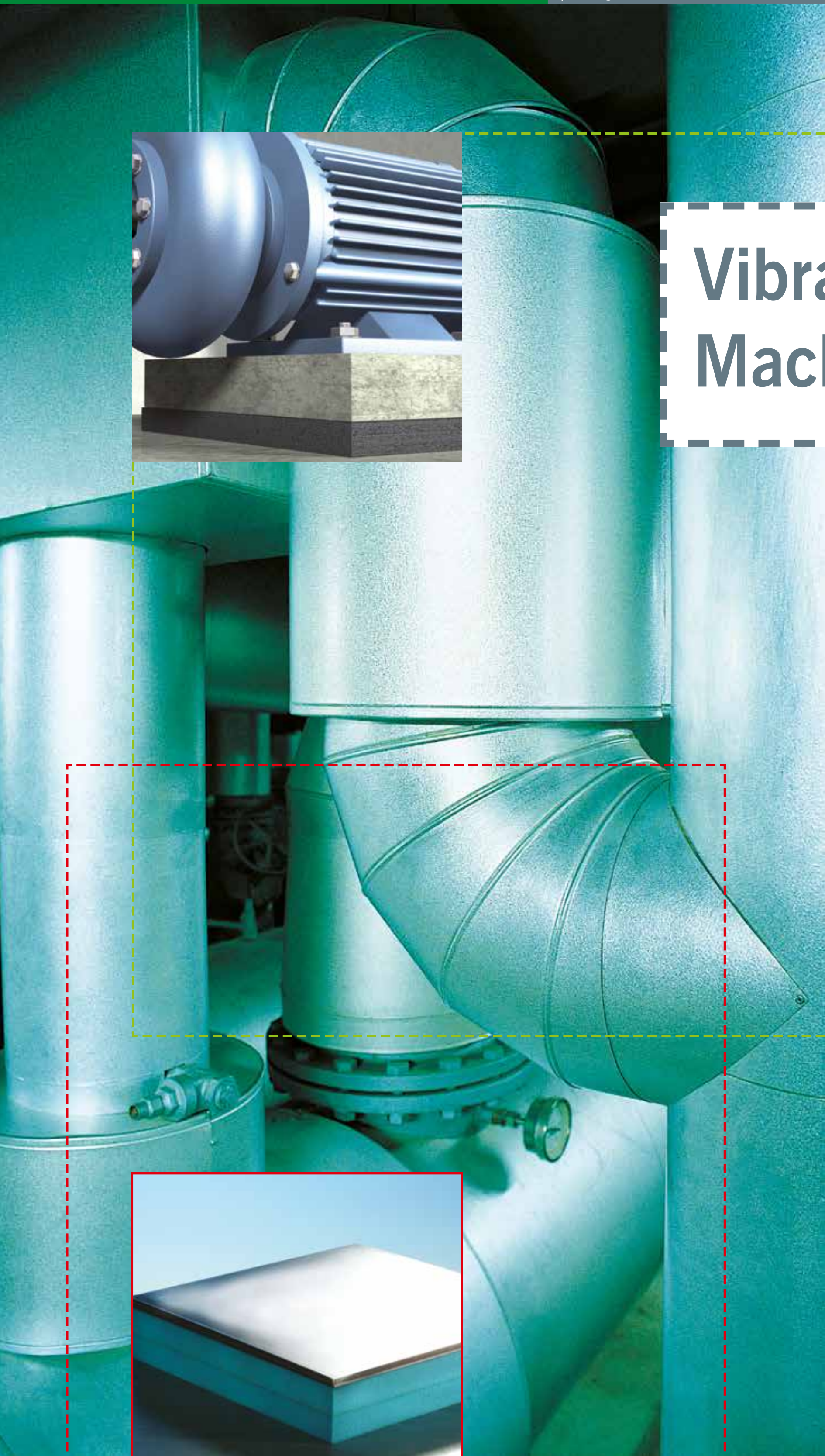


Vibration Isolation of Machine Foundations

Active and Passive Isolation

BSW

Vibration Isolation of Machine Foundations

Unwanted vibrations and shock impact occur in nearly all technical equipment and machinery – but elastic bedding with the well-known materials **Regupol®** and **Regufoam®** reliably prevent the distribution of these vibration forces.

BSW has produced, sized and supplied material for the vibration isolation of machine foundations for over 20 years.

The material **Regupol®** is composed of rubber fibres, rubber granulates (SBR, NBR) and polyurethanes, and **Regufoam®** is a mixed-cell polyurethane foam.

Probably the most important measure for reducing the vibration impact of machinery in a building structure and its surroundings is the elastic decoupling of the machine foundations.

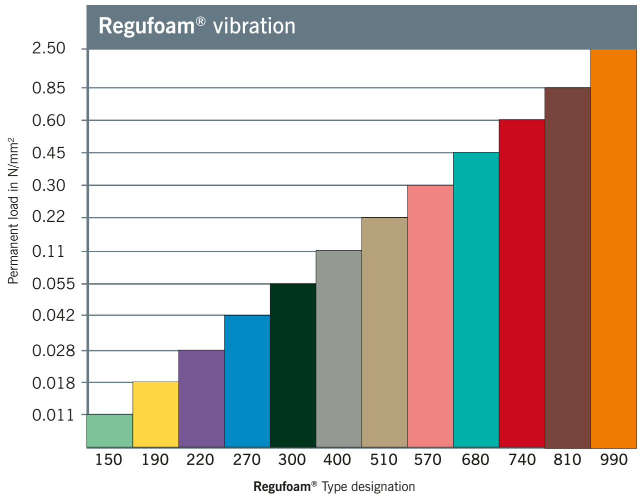
We distinguish between "active" and "passive" vibration isolation. In active isolation the spread of vibrations is reduced, and in passive isolation sensitive equipment is protected against ambient vibrations.

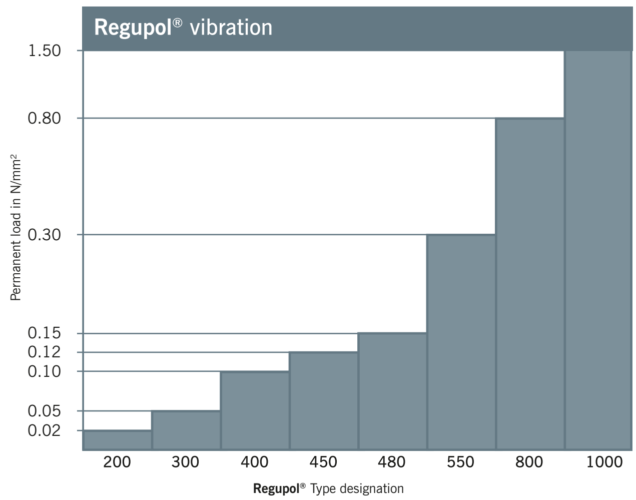
Generally speaking, active isolation of the source is the preferred solution, as this measure can protect larger impact areas and thus several objects.

Regupol® and **Regufoam®** are subdivided into 8 or 12 load ranges each. As a consequence, they can cover a broad spectrum of vibration-technology-related applications. Thanks to the rigidities of the selected materials, the settlement behaviour is the same for nearly all types.

This provides the expert consultants for vibration technology issues with two product groups that are helpful to them in developing the most economical and technically best solution possible.

Load Ranges:





Detailed technical data, including delivery formats, static and dynamic constants, long-term behaviour and further material constants are provided in the "Vibration Technology" technical catalogue or at www.bsw-vibration-technology.com

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The Single-Degree-of-Freedom System

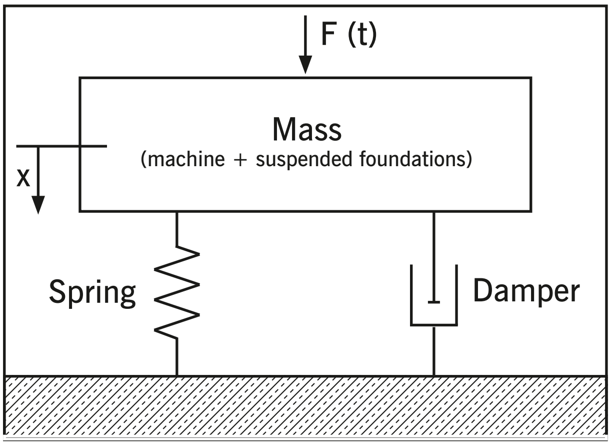
The easiest example to describe a vibrating system is a single-degree-of-freedom system (SDOF system). An inert mass is on a rigid base, separated by an elastic element.

The machine (= mass) is decoupled from its ambient area by way of a spring and a damper. Only one degree of freedom is applied and usually only the vertical movement is considered.

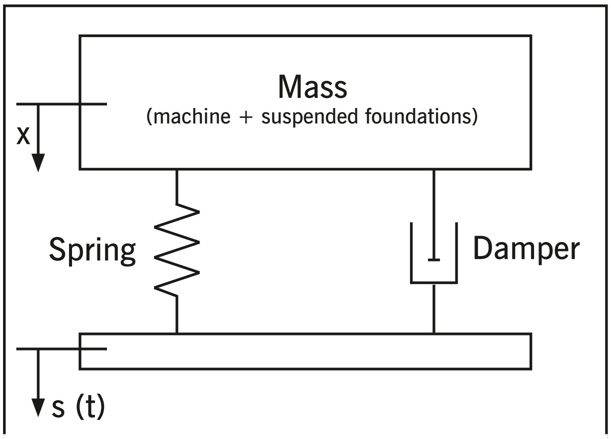
The special elastomers **Regupol®** and **Regufoam®** simultaneously serve as spring and damper.

The model is quite useful in explaining basic issues of vibration isolation and is helpful in selecting suitable elastomers.

The model can be applied to active as well as passive isolation jobs. A distinction is made between the time-dependent force and the kinematic excitation (auxiliary excitation) of the vibrator.



Force excitation for the vibration isolation of machines – active isolation.



Kinematic or auxiliary excitation for the vibration isolation of equipment – passive isolation.

Equation of motion of the force-excited vibrator

$$m\ddot{x} + b\dot{x} + cx = F(t)$$

Equation of motion of the auxiliary-excited vibrator

$$m\ddot{x} + b(\dot{x} - \dot{s}) + c(x - s) = 0$$

F(t) is the time-dependent force excitation and s(t) the time-dependent kinematic excitation / auxiliary excitation. The coordinate x describes the movement of the vibrator, whose parameters mass, damping and rigidity are designated as m, b and c.

The Natural Frequency

If a vibration-capable system is made to vibrate and then left to its own devices, it vibrates with the so-called natural frequency until it dies away.

In machine foundation isolation, the natural frequencies of this system can be deliberately influenced by varying its rigidity and inertial properties.

The natural frequency is calculated as follows:

$$f_0 = \frac{1}{2\pi} \times \sqrt{\frac{s}{m}}$$

s – dynamic rigidity; m – vibrating mass

The inertial properties depend on the geometry and the mass ratios of the machine and the intermediate foundation.

The rigidity properties can be set to a desired level with the **Regupol®** and **Regufoam®** elastomers. To achieve lower bearing frequencies in one load range, the thickness of the elastomer must be increased.

It is a fact that the frequency progressions of different types of **Regupol®** and **Regufoam®** are similar in the respective load range. The reasons are mainly as follows:

Achieving high load-bearing capacities requires minimum rigidities of the elastomer. Considering the greater mass and the load-bearing capacity that is therefore required (and hence also the greater rigidity), the above formula shows that similar bearing frequencies can be achieved again.

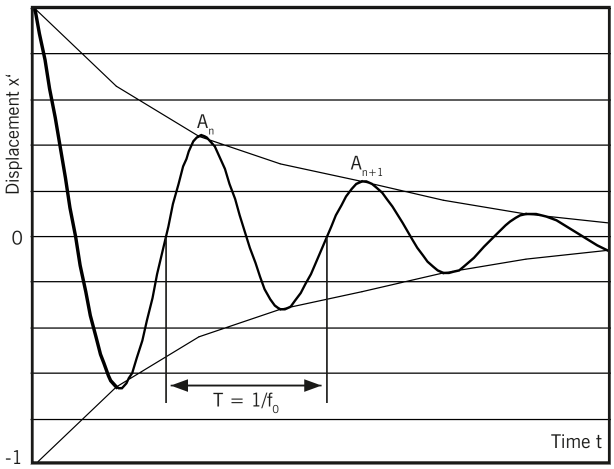
Thus lower bearing frequencies can be achieved by increasing the dynamic mass and by reducing the rigidity of the elastomer.

Damping in the Elastomer

When energy is withdrawn from sound we speak of damping. This typically occurs through dissipation, by transforming the sound energy into heat by way of friction.

In the case of elastomers we observe the mechanical damping η (loss factor). The loss factor is a measurement for the speed with which the amplitudes of free vibrations die away.

The higher the damping, the lower the resonance. At the same time, a very high degree of damping results in worse insulation capabilities in the material with respect to interfering frequencies with a ratio of $>\sqrt{2}$ to the natural frequency.



The chart shows the reduction of a vibration amplitude as a result of mechanical damping. It is defined by the mechanical loss factor η. The time of vibration T remains the same.

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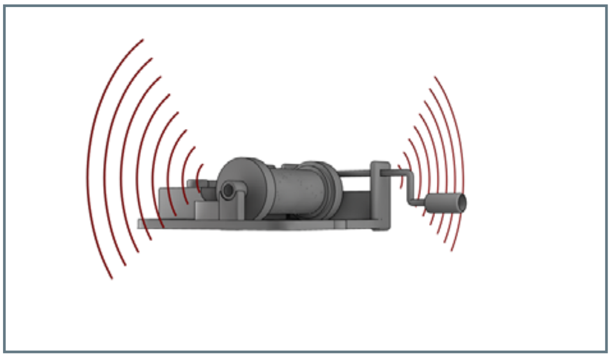
Airborne Sound Insulation / Structure-Borne Sound Insulation

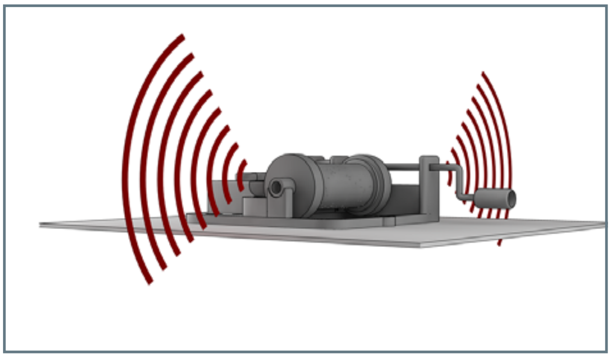
When it comes to machines, considering the airborne insulation often does not suffice. This is illustrated by the following example:

The music box in the illustration at the top represents our machine. When the clock mechanism is wound up, the barrel begins to turn, and the 18 pins generate a soft melody.

Due to the small geometric dimensions of the device, only a few of the oscillations are transformed into airborne sound.

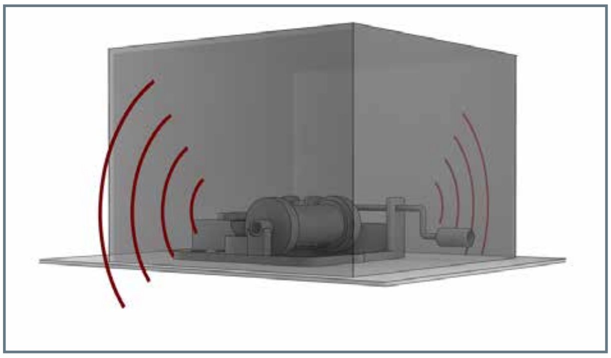


The melody only becomes louder when the vibration-distributing surface is enlarged. This happens as soon as the music box is placed on a table top. The vibrations from the music box are now transmitted to the table top. This part is called structure-borne sound.



Imagine that this machine is placed inside your business, causing unacceptable noise. Often the first measure to be suggested is a sound protection hood, which usually, however, has no effect whatsoever.

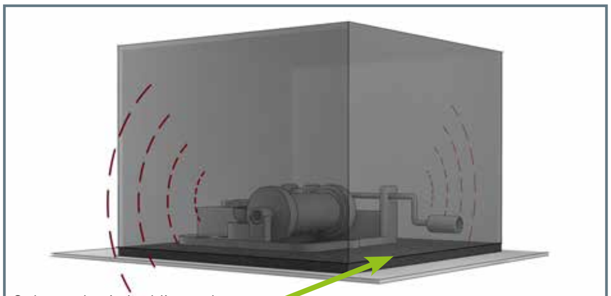
The reason for this is the big difference between the soft "airborne sound" and the loud "structure-borne sound". It makes it necessary to take primary measures that reduce the loud structure-borne sound.



Elastic bedding with **Regupol®** and **Regufoam®**, adjusted to the machine in question, reduces the generation of the structure-borne sound.

Placing in addition a sound protection hood over the machine removes the noise problem.

If you have any further questions about this issue or wish to communicate with an expert consultant, please feel free to get in touch with us at any time.

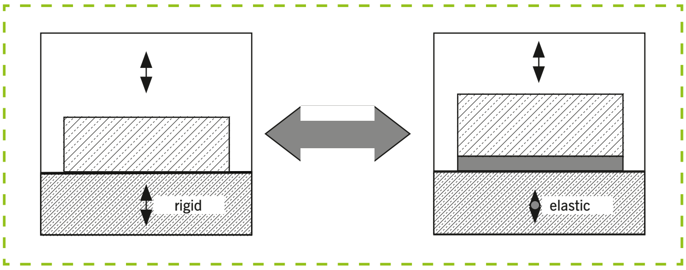


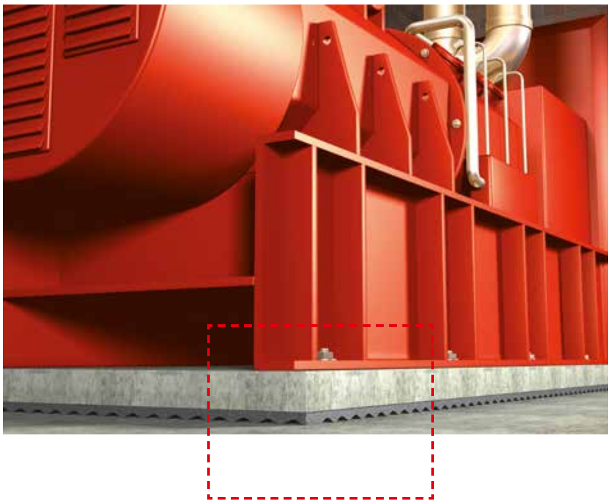
Only an elastic bedding reduces effectively the structure-borne sound.

Insertion Loss / Isolation Efficiency

The success of an elastic solution can be described using the example of insertion loss or the isolation efficiency factor.

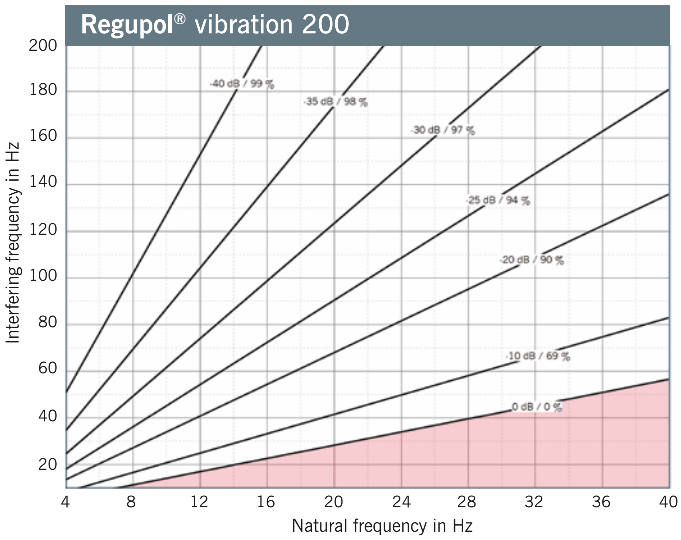
Insertion loss describes the difference between the application of force in the ambient area using “rigid” and “elastic” bedding.



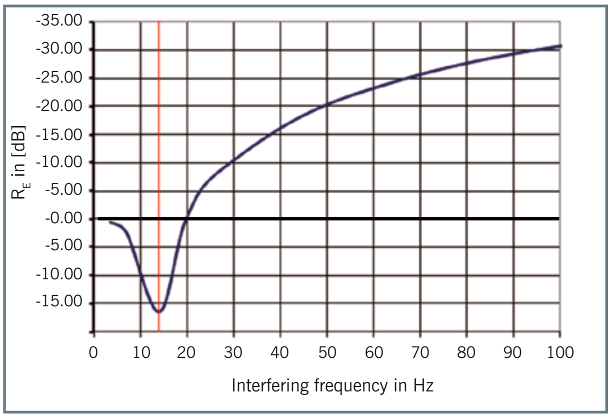


The isolation effect depends on the ratio between the natural frequency ω_0 and the interfering frequency ω. The natural frequency should be below the lowest interfering frequency (low adjustment). The softer the elastomer and thus the lower the natural frequency, the better the isolation effect.

The chart below shows the isolation efficiency and the insertion damping for **Regupol® vibration 200**. All documentation about the material reference values may be found in our technical brochure on vibration insulation.



It shows the insulation effect for a spring-mass system on a rigid base, using **Regupol®** vibration 200. Parameters: Force transmission in dB, degree of isolation in %.



Sample calculation of insertion damping of f_0 = 14 Hz for a single-degree-of-freedom system on a rigid substrate.

The isolation effect furthermore depends on the mechanical damping (loss factor) of the elastomers. For this reason, having precise material constants are absolutely necessary for the vibration-related measurements.

The material constants for **Regupol®** and **Regufoam®** were determined at the Technical University in Dresden, among other institutions, and are subjected to permanent quality control.

Dimensioning Machine Foundation Isolation

Dimensioning vibration-isolating measures is the duty of the expert consultant. He or she is the only person who can judge the complex overall building dynamics. When planning elastic machine foundation isolation, special care must be taken that component resonances are avoided. Attention should also be paid to the place where equipment is installed.

The simplified view of regarding the machine as a single-degree-of-freedom system is based on an ideal, rigid placement of the elastomer. When excitation masses are not very small compared to the mass of the foundation, it might be necessary to consider the foundation impedance.

For isolation to be effective, the following important planning parameters must be taken into account:

1. For machines with harmonious excitation, such as building equipment, the isolation effect is determined by the ratio of the interfering frequency ω and the natural frequency of the elastic bedding (natural frequency) ω_0.

2. The degree of the isolation effect depends on the damping behaviour of the elastomer.

3. Polyurethane foams and composite products made of rubber fibres, rubber granulates (SBR, NBR) and polyurethanes exhibit pronounced non-linear material behaviour. Consequently, it is necessary to perform precise material tests.

Typically an attempt is made to generate supercritical bedding for the machine. This means that the natural frequency ω_0 is smaller than the interfering frequency ω. To achieve a physical damping effect, it is absolutely necessary that the ratio is at least $\sqrt{2}$. In point of fact, the ratio should be at least 2 to 3. The higher the selected ratio, the higher the isolation effect to be achieved.

Ideally, planning measures for the vibration isolation of machines with **Regupol®** or **Regufoam®** is conducted according to the following pattern:

1. Calculation of the characteristic compression (without partial load factors) under the machine foundation from the dead weight of the foundation block and the dead weight of the machine.

2. Selection of the suitable **Regupol®** or **Regufoam®** type taking the maximum static permanent load into account.

3. Considering the crucial interfering frequencies of the machine (in the case of active isolation) or consideration of the crucial interfering frequencies of the ambient area (in the case of passive isolation).

4. Selection of the natural frequency taking the insertion loss / isolation effect that can be achieved and the ratio to the interfering frequency into account. An absolute requirement: a ratio between natural frequency and interfering frequency of $>\sqrt{2}$.

5. Installation of the floating machine foundation taking points 1–4 into account.

Recommendation and coordination of specialist planners for building acoustics.

Find out more on Page 63.

BSW Specialist planning service

Machine Foundation Isolation **Regupol®** vibration

Step 1:

Installing the **Regupol®** vibration isolation

Step 3:

Setting up the formwork for the machine foundation

Step 2:

Exact cut to the dimensions of the foundation

Step 4:

Putting in a PE foil with a minimum thickness of 0.2 mm

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Step 5:

Filling with concrete

Step 7:

Backfilling the remaining space with concrete and smoothing everything at the end

Step 6:

Putting in the foundation reinforcement

Step 8:

Allow to harden, then remove the formwork

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