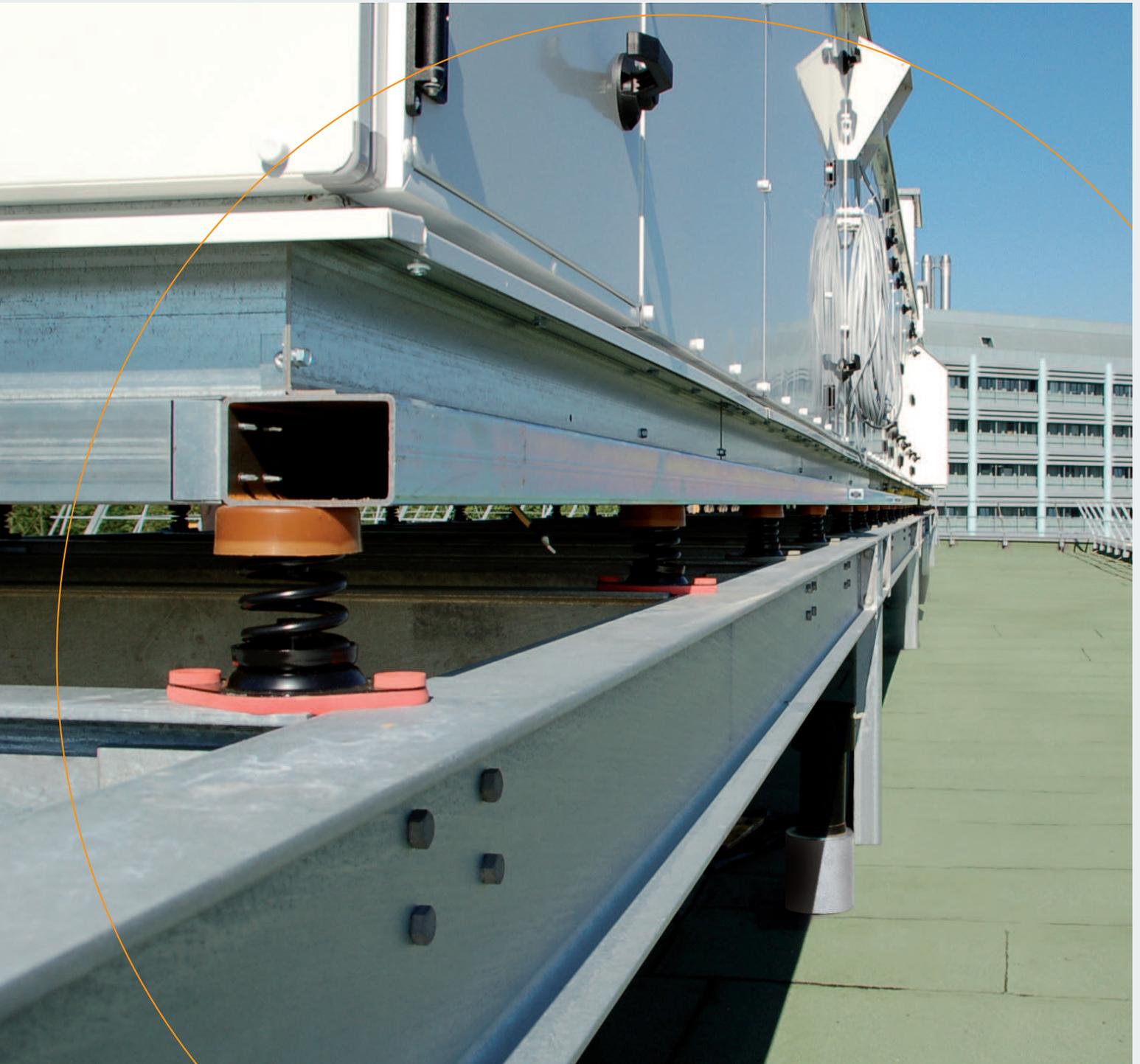


# Vibration Solutions for **Technical Facility Equipment**



# 1 | Values and Visions





# Reinicke creates silence.

*Vibration can have a  
negative impact on  
people's health and  
wellbeing ...*

At Reinicke solutions to minimise vibration and structure-borne noise have been at the heart of creation for almost 40 years - for building services equipment as well as for civil engineering and the industry.

**M**odern buildings are becoming ever more complex in terms of construction and equipment. Even lightweight constructions - mainly concrete and steel structures with extensive glass facades - are more susceptible to vibration. They amplify and transmit structure-borne noise from the facilities installed inside. When these devices are operational, they emit vibration that is transferred as structure-borne noise to other parts of the building via solid objects such as floors and walls. Humans perceive this as vibration or noise. Vibration has an adverse impact on quality of work and life in places where lots of people get together.

Consulting vibration isolation experts during the planning stage of a building pays off in the end: subsequent changes which most likely turn out to be expensive may be avoided from the start. The result: silence, enhanced functionality and improved wellbeing.

## Reinicke offers

- Solutions offering the best possible cost-benefit ratio; not least thanks to the hundreds of thousands of successfully stored air conditioning and ventilation systems
- Quick implementation owing to expert calculation and manufacturing in Germany
- Efficient, established and approved products to meet various requirements
- A holistic approach to relevant framework conditions - starting from the planning phase
- Less financial and technical effort thanks to professional consultancy

## 2 | Technical Challenges

Reinicke reduces vibration at its source.

**W**hen planning, constructing and equipping buildings, architects and other construction specialists have to rise to the challenges of avoiding structure-borne noise.

### Be smart from the start

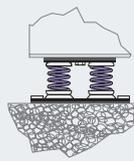
To comply with the provisions of the construction industry and the new Energy Saving Ordinance (ESO), it is necessary to plan the Building Services Equipment (BSE) across the various sectors. This is the only way to reduce airborne and structure-borne noise as effectively as possible. **With its extensive expertise in vibration isolation, Reinicke provides a valuable contribution to implementation - even during the planning phase.** Individual solutions offering the best possible cost-benefit ratio in order to avoid unwanted vibration are developed in close cooperation with the planners.

### Appropriate anti-vibration measures

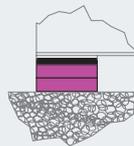
Vibration technology differentiates between:

- Source isolation: isolation of the machine that generates the vibration.
- Recipient isolation: isolation at the site of the effect: sensitive laboratory facilities, emergency operating rooms, etc.

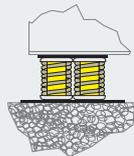
Source isolation is generally preferable for reasons of efficiency.



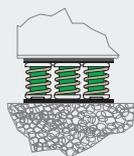
Isotop® BL 2



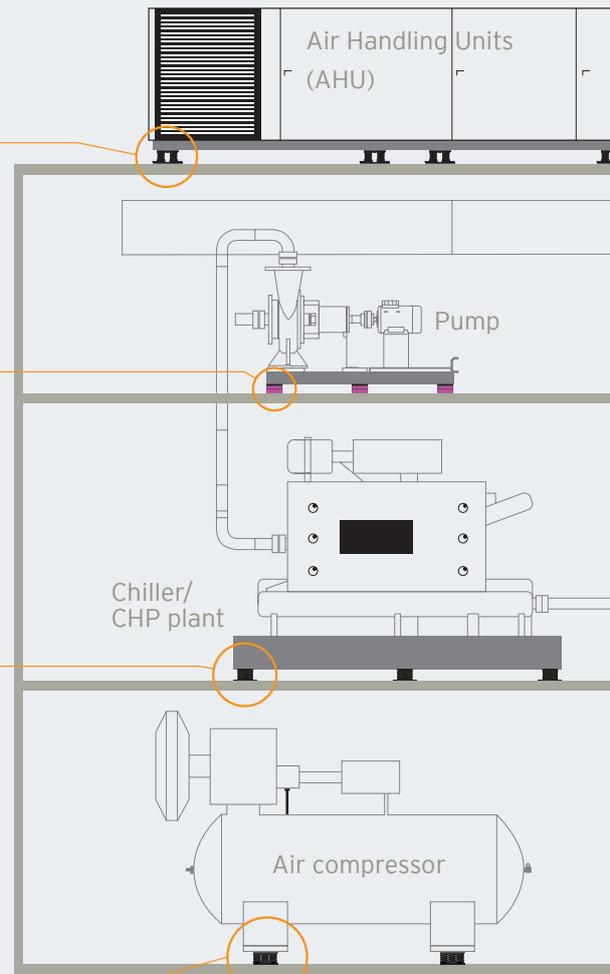
Isotop® SE



Isotop® DSD-BL 4

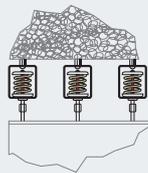
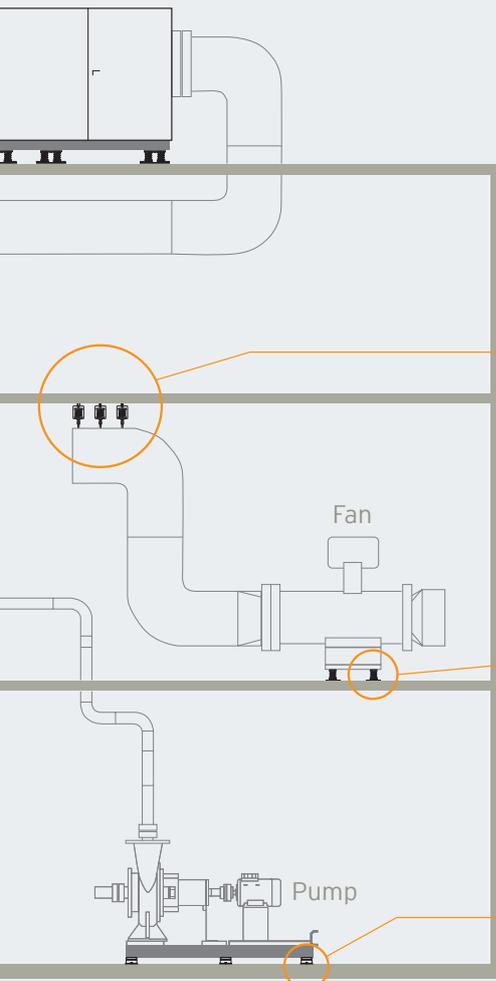


Isotop® DSD-BL 6

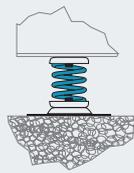




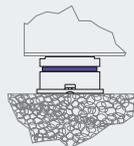
Sylomer®, Sylodyn® or Isotop® products can be used dependent upon the individual requirements.



Isotop® SD/Z



Isotop® SD



Isotop® DZE

Noise and vibration protection requirements

- Technical Instructions on Noise /10-16 (German Standard)
- DIN 4109
- DIN EN ISO 10052

## Vibration sources in technical facility equipment

### Air Handling Units (AHU)

The main reason for the occurrence of structure-borne noise is usually the motor-fan unit.

### Combined heat and power plants (CHP plants)

Vibration isolation is implemented both on site and with a solution integrated directly in the device.

### Chillers

Compressors in cooling units generate structure-borne noise that can be transferred to the building.

### Cooling towers

Cooling towers which are placed on the roof of a building distribute structure-borne noise from operations.

### Fans

The fan transports and compresses a gaseous medium by means of an integrated rotating impeller.

### Pumps

The transport of liquid materials with pumps also causes structure-borne noise.

Reinicke solutions reduce vibration to a level that is no longer perceptible, with a positive effect on quality of work and life.

# 3 | Products for outstanding Efficiency



## Vibration insulation products (summary)

- Isotop® steel spring isolators MSN/SD/SD-KTL <sup>1</sup>
- Isotop® isolators with damping core DSD <sup>2</sup>
- Isotop® compact block elements MSN-/SD-BL <sup>3</sup>
- Isotop® block elements with damping core DSD-BL <sup>4</sup>
- Isotop® tension elements MSN/Z, SD/Z <sup>5</sup>
- Isotop® pressure/tension elements DZE <sup>6</sup>
- Isotop® pressure/tension elements DZE/DZE-BL - mobile applications <sup>7</sup>
- Sandwich elements, custom-made products, etc. <sup>8</sup>
- Sylomer® bearing
- Sylomer® HD bearing
- Sylomer® FR bearing (flame-retardant) <sup>8</sup>
- Sylodyn® bearing
- Sylodyn® HRB bearing <sup>6</sup>

## Product selection

Isotop® steel spring isolators are mainly used for low-frequency mounting: for fans, combined heat and power plants, refrigeration units, compressors, fans, pumps, emergency power generators, etc. Depending on their calculated load, they have a natural frequency (resonance frequency) of up to 3.0 Hz.

Sylomer® and Sylodyn® are used mainly for applications with natural frequencies above approx. 10 Hz. HRB construction bearings are used for high loads with smallest footprints.

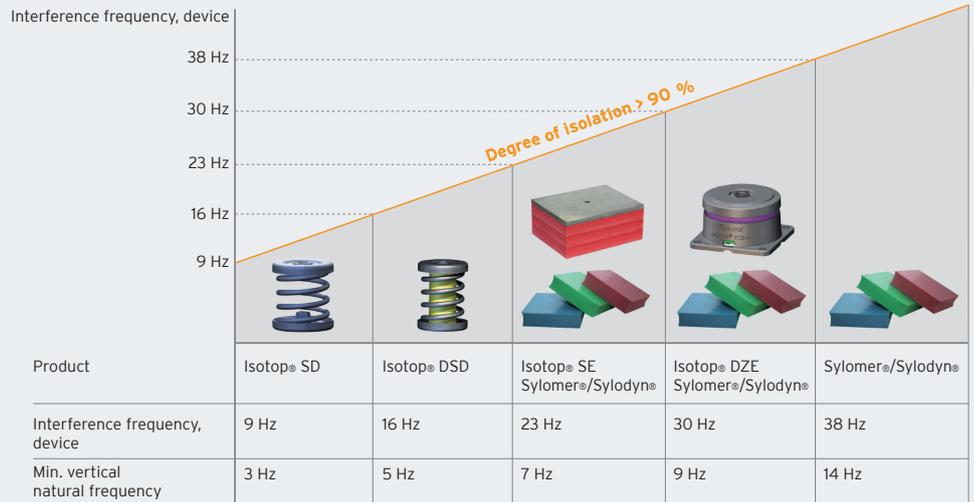




**Product selection dependent upon interference frequency, natural frequency and degree of isolation**

At a required degree of isolation of at least 90 per cent

Speed [rpm<sup>-1</sup>] =  
interference frequency [Hz] x 60



**Product benefits**

- Perfect solutions to customer requirements thanks to a broad range of products
- Easily interchangeable owing to consistent heights throughout the product range
- Durable, compact construction
- Increases the life time of the equipment
- Less maintenance
- Maximisation of precision and quality in technical facility equipment

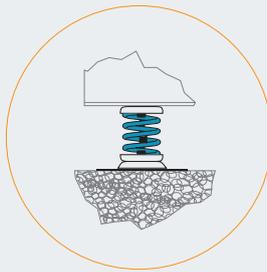
# 4 | Solutions



Vibration protection for fans



AHU system resiliently isolated

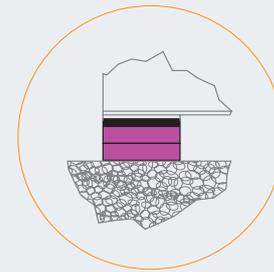


Fans  
Isotop® type SD

**Task:**  
Resilient isolation of a tunnel fan  
Low natural frequency < 4 Hz  
Minimum installation height

**Solution:**  
Reinicke Isotop® SD with footplate

**Result:**  
Natural frequency of 3.5 Hz achieved  
Degree of isolation at 1000 rpm  
(16.7 Hz) = 95 %



Air conditioning  
(AC) systems  
Isotop® type SE

**Task:**  
Installation of an air conditioning system decoupled from structure-borne noise in the air space of a historical building on timber ceilings  
Natural frequency < 12 Hz minimum installation height

**Solution:**  
Reinicke Isotop® SE sandwich elements with pressure distribution plate and multilayer Sylomer® structure as point supports beneath the device frame

**Result:**  
Natural frequency of 11.4 Hz achieved  
Degree of isolation at 1500 rpm  
(25 Hz) = 73 %

Individually tailored products and detailed fitting plans result in efficient solutions to reduce noise and vibration.

## Framework conditions for professional solutions

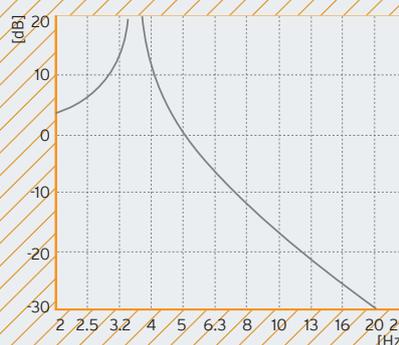
- Definition of all excitation forces
- Consideration of the effects of isolation on the exciter and the object to be protected
- Universal procedure
- Compliance with legal requirements for structure-borne noise protection

## Noise and vibration protection requirements

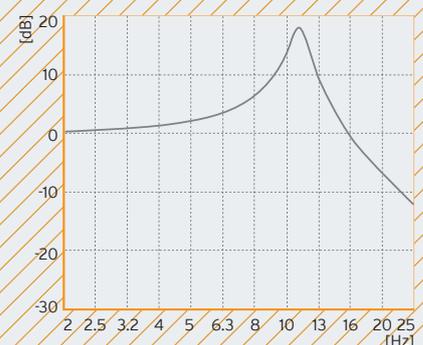
Technical Instructions on Noise/10-16 (German Standard, valid in Germany only) defined the following immissions guide values for locations outside buildings:

- Industrial estates: 70 dB(A)
- Business parks: 65 dB(A) during the day, 50 dB(A) during the night
- Central areas, villages and mixed use zones: 60 dB(A) during the day, 45 dB(A) during the night
- General residential areas and small housing estates: 55 dB(A) during the day, 40 dB(A) during the night
- Purely residential areas: 50 dB(A) during the day, 35 dB(A) during the night
- Nursing homes/hospitals and convalescent homes: 45 dB(A) during the day, 35 dB(A) during the night

Insulation curve, natural frequency



Insulation curve, natural frequency





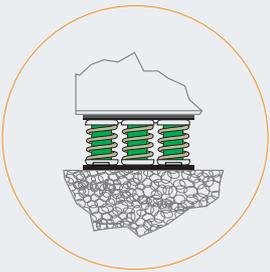
Isolation for combined heat and power plants



Efficient heat pump isolation



Resiliently isolated cooling tower

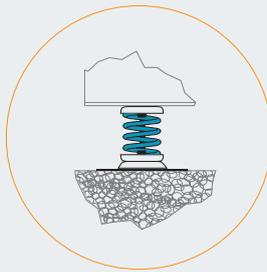


Combined heat and power plant (CHP plant)  
Isotop® BL 6

**Task:**  
Low natural frequency < 6 Hz  
Isolating element with damping  
High amplitudes

**Solution:**  
Reinicke Isotop® BL 6 DSD with footplate

**Result:**  
Natural frequency of 5 Hz achieved  
Degree of isolation at 1500 rpm (25 Hz) = 95 %



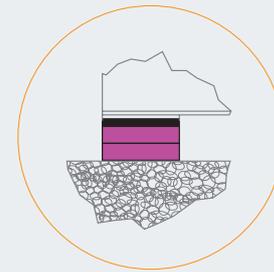
Heat pumps  
Isotop® SD

**Task:**  
Vibration-suppressing mounting of a compressor unit  
Low natural frequency < 5Hz  
Compact design

**Solution:**  
Reinicke Isotop® SD with footplate type FP/K decoupled from structure-borne noise

**Result:**  
Natural frequency of 4.8 Hz achieved

Degree of isolation at 1500 rpm (25 Hz) = 94 %



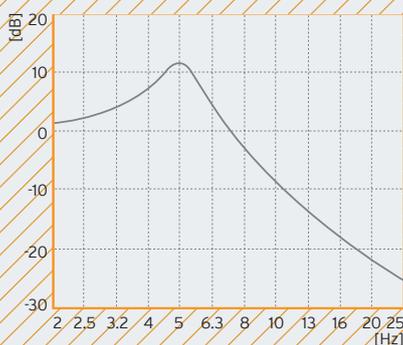
Cooling towers  
Isotop® sandwich element type SE

**Task:**  
Rooftop installation  
Natural frequency < 10 Hz  
Point supports

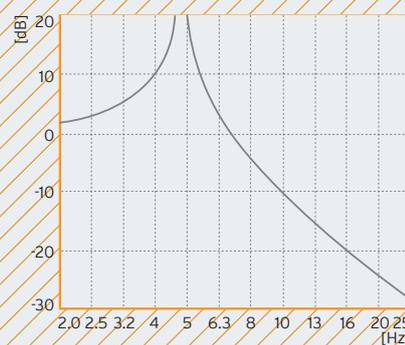
**Solution:**  
Reinicke Isotop® sandwich element type SE

**Result:**  
Natural frequency of 9 Hz achieved  
Degree of isolation at 1500 rpm (25 Hz) > 90 %

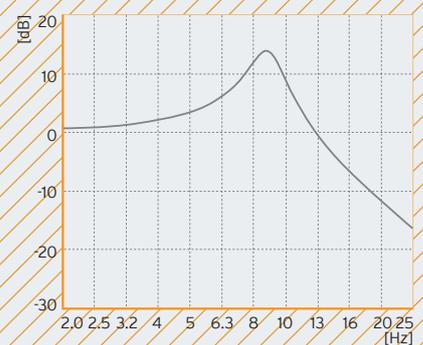
Insulation curve, natural frequency 5.0 Hz



Insulation curve, natural frequency 4.8 Hz



Insulation curve, natural frequency



# Reinicke creates Silence

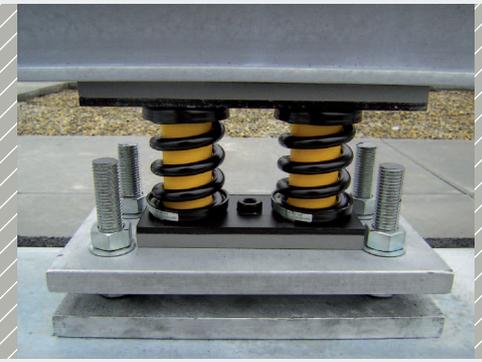




Indestructible pump bearings



Resilient special design for a chiller



Air conditioning device decoupled from structure-borne noise

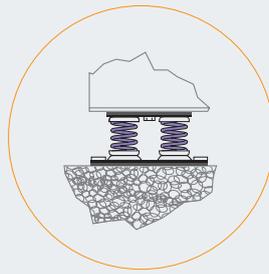


Pumps  
Isotop® type DZE

**Task:**  
Low natural frequency < 8 Hz  
Easy-fit installation

**Solution:**  
Reinicke Isotop® DZE

**Result:**  
Natural frequency of 7.5 Hz achieved  
Degree of isolation at 1500 rpm  
(25 Hz) = 90 %

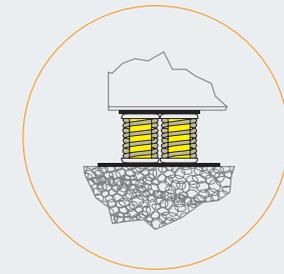


Chillers  
Isotop® type BL 2

**Task:**  
Roof installation of a chiller decoupled from structure-borne noise on on-site steel structure  
Natural frequency < 5 Hz

**Solution:**  
Reinicke Isotop® BL 2 steel spring block elements with footplate and pressure plate decoupled from structure-borne noise

**Result:**  
Natural frequency of 3.5 Hz achieved  
Degree of isolation at 1500 rpm  
(25 Hz) = 90 %



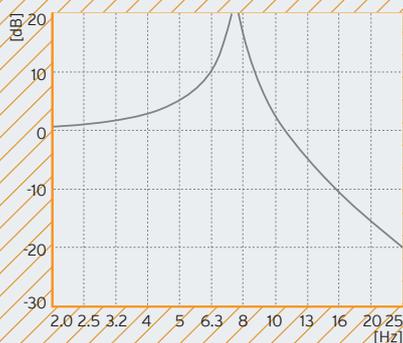
Air conditioning devices Isotop® type DSD-BL 2

**Task:**  
Roof installation of air conditioning devices decoupled from structure-borne noise for protection of lecture halls and event rooms  
Required natural frequency < 7 Hz

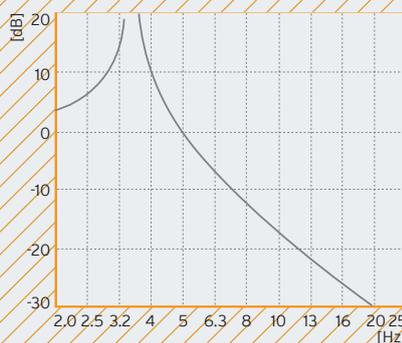
**Solution:**  
Reinicke Isotop® DSD-BL 2 steel spring block elements with damping core and decoupled footplate and pressure plate  
Special feature: height-adjustable design for offsetting the roof pitch

**Result:**  
Natural frequency of 4.8 Hz achieved  
Degree of isolation at 3000 rpm  
(50 Hz) = 99 %

Insulation curve, natural frequency



Insulation curve, natural frequency 3.5 Hz



Insulation curve, natural frequency 4.8 Hz





Reinicke stands for customer focus, experience and service

## The difference

**R**einicke develops customised solutions to meet stringent demands for all industry sectors. The difference between Reinicke and other suppliers:

- More focus on customers
- More experience
- More service

### Holistic solution development

Reinicke works on projects all the way from planning to implementation. Production at its own site allows the company to ensure that projects are implemented on time. The team of experts is flexible and able to react quickly to changed requests.

### Smart from the start

Each device isolation is planned individually according to customer requirements and constructional considerations.

### Setting up devices made easy

Reinicke ascertains the appropriate measures for isolation of structure-borne noise - according to position and with an appropriate centre of gravity. What customers receive is a precise calculation, indicating the degree of isolation, damping efficiency and natural frequency for the isolation of their system. A detailed CAD plan simplifies the installation of the products, nearly eliminating the possibility of inappropriate mounting.

**The result:** effective vibration isolation as intended.

### "Swabian virtues"

Although often mocked, the basic virtues of the people of Swabia are a great benefit when it comes to success in business. Reinicke focuses on diligence, a rapid response, precision and thoroughness - ideal for meeting the high quality standards that the company stipulates for its own work and products. A universal quality assurance system guarantees high quality products.

### The following data is required in order to deal with enquiries

- Design of the machine or device (application description)
- Dimensions and weight of the machine or device
- Position of the support points and centre of gravity
- Required bedding type (foundation, point or strip)
- Minimum excitation frequency occurring [1/s]
- Static and dynamic machine loads

### One-stop shop

- Advice
- Planning
- Optimisation
- Calculation
- Vibration measurement
- Vibration isolation prognosis
- CAD installation plans
- Prototype production
- Pilot series production
- Series production

# 6 | References



Integration in the CHP plant series production

## Trust and expertise

**R**enowned manufacturers in the processing industry, engineering and planning offices, and technical facility equipment companies across the world trust the experience and quality of Reinicke. As a recognised system partner, the company is involved from the moment concepts are developed and throughout the design phase and on into the planning process.

### Extract

- CHP plant mounting using ISOTOP elements: bedding of an 18-tonne, 2MW CHP plant using ISOTOP BL 9 block elements
- ECE, Rhein-Galerie, Ludwigshafen: AHU device isolation for the shopping centre, 30,000 sq m in area
- Airport Berlin Brandenburg-International: Lift beddings for the new Berlin airport
- Rolls Royce Mechanical Test

- Operations Centre (MTOC): Foundation bedding of test benches
- Oslo Opera House: AHU system bedding
- FFM-Tower 185: Foundation isolation for HVAC devices



## Air conditioning (AC) systems

AC systems treat the air (filtration, heating, cooling, humidifying), but also generate vibration due to the masses moved. The core – the motor-fan unit – is generally the most significant cause of structure-borne noise. Most AC systems are modular. This promotes and intensifies structure-borne noise, which can affect the entire building.

## Amplitude

The characteristic size of a vibration; this is the deviation of a physical quantity from its neutral position (zero point) to a positive or negative value; the amplitude is expressed as a physical quantity (e.g. force, displacement). Amplitudes are expressed either as instantaneous values or, more frequently, as peak values.

## Centre of mass

The point at which the total mass of a system can be reduced; the centre of gravity of the mass is extremely important to the design of a resilient machine bearing.

## Chillers

Chillers require compressors in order to generate industrial levels of refrigeration. However, these generate structure-borne noise that is transferred to the building from where it can propagate.

## Combined heat and power plants (CHP plants)

Their central and decentralised supply options mean that combined heat and power plants are becoming increasingly important. However, their design, comprising a motor and generator, helps to promote the generation of structure-borne noise.

## Cooling towers

Cooling towers to be fitted on the roof of a building distribute mainly structure-borne noise from operations; this distribution is promoted by the structure of the building.

## Damping

Conversion of kinetic energy into another form of (recoverable) energy that is no longer relevant to the vibration system (e.g. heat through friction, plastic deformation, etc.); energy is removed from the mechanical system by means of damping (energy dissipation). To keep vibration within acceptable limits where resonance is present, mechanical systems require sufficient damping. Vibration damping and vibration insulation are two different measures of vibration isolation.

## Damping ratio

Ratio of the *–excitation frequency* to the *–natural frequency* of a resiliently bedded system; also termed *frequency ratio*; the excitation frequency and *–natural frequency* must differ by a factor of at least  $\sqrt{2}$  in order to achieve insulation of the system.

## Decibel [dB]

Unit indicating the decadic logarithm to base 10 of the ratio of physical quantities,  $10 \log(v1/v2)$ . Logarithmic ratios are designated as levels or quantities, e.g. *–velocity level*, *–insertion loss level*, etc. If, for example, the ratio of sound field dimensions whose square is proportional to an output, the 2 of the square below the logarithm is normally placed before this so that we now have  $20 \log(\dots)$ . Example: the *–velocity level*:  $L_v = 10 \cdot \log(v2/v0^2) = 10 \cdot \log(v/v0)^2 = 20 \cdot \log(v/v0)$  dB.

## Degree of freedom

Describes the possible directions of motion of an oscillatory system; there are 3 translational degrees of freedom in the 3 spatial axes and 3 rotational degrees of freedom about the 3 spatial axes.

## Degree of isolation [%]

In respect of *–vibration isolation*, characterises the *–isolation effect* as the ratio between the input and output forces or the input and output amplitudes.

## Eigenmode

Systems capable of vibration have eigenmodes, which are described by *–natural frequency*, *natural damping* and vibration form. A system can have eigenmodes in the form of a translation, rotation or bending.

## Excitation frequency [Hz]

*–Frequency* at which an oscillatory system is excited; e.g. cyclical forces of a machine.

## Fans

A fan is a powered fluid-flow machine that generally transports and compresses a gaseous medium by means of a rotating impeller integrated in a housing.

## Frequency [Hz]

Number of vibrations per second in a periodic signal.

## Hooke's Law

Hooke's Law (named after Robert Hooke) describes the elasticity of a solid whose elastic deformation is proportional to the load applied to it.

## Insertion loss

Ratio of the power of the vibration (e.g. structure-borne noise) transmitted into the adjacent structure without a resilient element/bedding to that which is transmitted when a resilient element or bedding is present. Note: insertion loss is only independent of the selected measurement site if the boundary conditions (e.g. subsurface, building design, tunnel design, etc.) are similar.

## Insertion loss level [dB]

Tenfold decadic logarithm of the *–insertion loss*. Parameter for characterisation of the effectiveness of structure-borne noise insulation measures. The insertion loss level can be measured as the difference of structure-borne noise level with and without resilient bedding. The insertion loss level is dependent on frequency.

## Insulation

See *Vibration isolation*.

## Interference frequency

See *–excitation frequency*.

## Isolation efficiency

See *→ Degree of isolation*.

## Mass-spring system

A mass-spring system is a type of superstructure consisting of a steel concrete trough or plate and an elastomer bearing. The large mass of the steel concrete trough permits very low natural frequencies.

## Multiple mass oscillator

An oscillatory system consisting of several linked oscillatory subsystems with various masses and springs, each subsystem consisting of a mass and a spring; a multiple mass oscillatory system has as many *–natural frequencies* as it does subsystems.

## Natural frequency [Hz]

*–Frequency* by which an oscillatory system oscillates freely once set in motion; the duration of the vibration is dependent on the *–damping*.

## Natural frequency [Hz]

The minimum vertical *–natural frequency* of a resiliently bedded system (machine, railway superstructure, building, etc.); the lower the natural frequency, the higher the *–vibration isolation*.

## Noise

Mechanical →*vibration* and waves in an elastic medium within the human hearing range, from approx. 16 Hz to 20,000 Hz, e.g. airborne noise, structure-borne noise, liquid-borne noise. At lower frequencies, we refer to infrasound, while higher frequencies are referred to as ultrasound.

## Noise emission

Noise emission is understood to mean →*structure-borne* or airborne noise radiated by a noise source; the source of the noise is located at the emission location.

## Noise immission

Noise immission is the →*structure-borne* or airborne noise striking a recipient, regardless of the location of the →*noise emission* (source of the structure-borne or airborne noise). The location of the recipient is referred to as the immission location, and the level of sound measured there is known as the immission level.

## Noise reduction index [dB]

The noise reduction index is defined as a base 10 logarithm of the quotient of the acoustic energy striking a component (external) (power: W1) to the acoustic energy transferred through the component (power: W2).  $R = 10 * \log(W1/W2)$ .

## Pumps

Pumps are work machines that are used to displace liquids (incompressible fluids). This also includes mixtures of liquids and solids, pastes and liquids with a low gas content. For this purpose, the propelling work is converted into the kinetic energy of the medium.

## Recipient isolation

Vibration isolation that protects a system (recipient) from disruptive vibrations from the surrounding area.

## Resonance

When the →*excitation frequency* of a system is equal to the natural frequency of the system, resonance occurs. Occurrence of resonance can lead to the destruction of the entire oscillatory system. →*Damping* the vibratory system makes it possible to keep vibration within acceptable limits if resonance is present. Resilience to an alternating force is particularly strong within the resonance range.

## Resonance frequency [Hz]

Frequency at which →*resonance* occurs.

## Shock

Sudden, non-periodic →*vibration* (generally caused by impulse excitation), which can generally be characterised by a triangular-shaped acceleration impulse. The duration of rise is usually shorter than the duration of the decay, while the crest factor is greater than 3.

## Shock isolation

Resilient bedding for the passive →*vibration isolation* of machinery and equipment, providing this with protection from →*shocks*.

## Shock isolation [%]

Reduction of the transmission of force of a sudden, repetitive shock pulse using a resilient bedding; transformation of the sudden shock pulse into a longer pulse with lower forces.

## Shock pulse

Sudden application of force; characterised by shock duration, maximum shock force and shock form (half-sine pulse, square pulse).

## Shock pulse damping

Describes the →*damping* during a shock; see →*Shock reduction*.

## Shock reduction

The aim of shock reduction is to reduce the path or the delay of the impacting mass or to reduce the transmission of force in the case of single or repeated shocks. During this process, the impact energy of the impacting mass is transformed into heat or →*deformation energy*.

## Single degree-of-freedom (SDOF) oscillator

Vibration isolation applications are often idealised on the basis of an oscillatory system consisting of a mass and a spring.

## Sound pressure [Pa]

Changes in the static air pressure due to oscillation of the air molecules in a sound field.

## Source isolation

Vibration isolation that is resiliently bedded in the case of an oscillatory system so that no disruptive vibration is emitted to the surrounding area.

## Spring force [N]

The restoring force of an elastomer in relation to an external force as a result of its elasticity.

## Structure-borne noise

→*Vibration* in solid bodies within a frequency range of 20 Hz to 20 kHz.

## Transmission factor [dB]

In respect of →*vibration isolation*, characterises the isolation effect as a logarithm of the ratio between the input and output forces or the input and output amplitudes.

## Transmission function

In respect of →*vibration isolation*, characterises the →*isolation effect* as the ratio between the input and output forces or the input and output amplitudes.

## Vibration

Movement, progressively propagating in the surrounding area, of mass particles about a neutral position; a distinction is made between transverse waves (vibration normal to the direction of propagation, e.g. waves in water) and longitudinal waves (vibration in the direction of propagation, e.g. density variations: noise).

## Vibration damping

See →*Damping*.

## Vibration dampening

A method of vibration reduction involving the removal of energy from an oscillatory system by the attachment of a vibration dampener; the dampener consists of an oscillatory system (e.g. mass, spring and damper) and vibrates at its resonance frequency.

## Vibration insulation

See →*Vibration isolation*.

## Vibration isolation

Reduction of the transmission of mechanical vibrations by the installation of intermediate elastic components; a distinction is made between the reduction of vibration transmission from a vibration exciter into the surroundings (reduction of emissions, isolation of the exciter), and the shielding of an object from the impact of vibrations from the surroundings (reduction of immissions, isolation of an object). See also →*Recipient-* and →*Source isolation*.

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