SUB BALLAST MATS & BEARINGS FOR MASS-SPRING SYSTEMS
made of rubber granulate & polyetherurethane foam
Products for reducing noise and vibration emissions in the rail sector

Engineered solutions against noise.
KRAIBURG HOLDING
GLOBAL PLAYER IN ELASTOMERS

Rubber mixtures
*Ideas and solutions in rubber compounding*
Gummiwerk KRAIBURG GmbH & Co. KG, D
KRAIBURG Bulgaria EOOD, Bulgaria
KRAIBURG Rubber Co. Ltd., Korea
KRAIBURG Rubber [Suzhou] Co. Ltd., China

Composite applications
*Rubber improves composites*
Gummiwerk KRAIBURG GmbH & Co. KG, D

TPE compounds
*Custom-engineered TPE & more*
KRAIBURG TPE GmbH & Co. KG, D
KRAIBURG TPE Corp., USA
KRAIBURG TPE [M] SDN, BHD, Malaysia
KRAIBURG TPE China Co. Ltd., China
KRAIBURG TPE [Shanghai] Co. Ltd., China
KRAIBURG TPE Pvt. Ltd., India
KRAIBURG TPE Italia Srl, Italy
KRAIBURG TPE Ltda., Brazil

Tyre retreading materials
*We power your retreads*
KRAIBURG Austria GmbH & Co. KG, Austria

ERGOLASTEC® Anti-Fatigue Matting
KRAIBURG Austria GmbH & Co. KG, Austria

Flooring systems for animal housing cattle/pig/camel
BELMONDO® Rubber Floorings for Horse Farms
Gummiwerk KRAIBURG Elastik GmbH & Co. KG, Germany

STRAIL® Track Crossing Systems
STRAIL®astic Track Damping Systems
KRAIBURG STRAIL GmbH & Co. KG, Germany
STRAIL® France S. A. S., France

Products made from PU foam for construction, transportation, railway, automotive and health care
KRAIBURG PuraSys GmbH & Co. KG, Germany

Building protection, acoustic and vibration isolation, construction and railway, impact protection, sports floor coverings,
KRAIBURG Relastec GmbH & Co. KG, Germany

EPDM granules for elastic floor coverings
Gezolan AG, Switzerland

Rubber rollers and roller coverings
KRAIBURG Walzenfertigung GmbH, Austria
KRAIBURG PRODUCTS IN THE RAILWAY SECTOR
WORLDWIDE EXPERIENCE IN THE RAILWAY SECTOR

KRAIBURG Relastec - Expert

solutions for acoustic and vibration reduction
in railway transportation

For more than 40 years, the KRAIBURG group has been dealing with solutions for reducing emissions in the rail sector. As part of KRAIBURG Holding, KRAIBURG Relastec and its DAMTEC® division has specialised in ballast mats and bearings for mass-spring systems on sand can look back on nearly 20 years of experience.

Consequently, KRAIBURG Relastec has been established on the international market for a long time as a result of many projects using DAMTEC® products to solve acoustic and vibration problems caused by railway transportation.

DAMTEC® products have been tested against the often very stringent requirements at recognised external testing institutes and meet the approval criteria of the Deutsche Bahn.

KRAIBURG Relastec is of course certified to ISO EN 9001, thus guaranteeing consistently high quality and total traceability of its products. The company has also been certified and audited by DB and also approved as a supplier.
Sound (German “Schall” from Old High German: scal) is the term generally used for noise as it can be perceived audibly by humans through the sense of hearing. Sound represents the propagation of the smallest pressure and density fluctuations in an elastic medium (gases, liquids, solids).

Noise (German “Lärm”, derived from Alarm, from the Italian call to arms “all’arme”; also disorganised noise) refers to sounds that by their structure have a disruptive, irritating or harmful effect on the environment. Whether sounds are consciously perceived as noise depends particularly on the assessment of the sound source by the listener.

Airborne sound is caused by sound waves that propagate through the air. In physiology, this is called air conduction. Airborne sound consists of pure longitudinal waves, since fluids (gases) do not transmit shear forces. In a narrower sense, the term “airborne sound” is used for the frequency range of human hearing that begins at about 16 Hz, with an extreme upper limit of 20 kHz depending on age.

Structure-borne sound is sound that propagates in a solid object. This includes various phenomena such as tremors and earthquakes, the transmission of vibrations in buildings, vehicles, machinery, etc., or the ultrasonic waves used for material testing.

Active isolation (emission) is the reduction of the transmission of vibrations of an machine or other source into the environment directly at the source.

Passive isolation (immission) is the shielding of machines, equipment or buildings against vibration influences from the environment.
### REDUCING ACOUSTIC AND VIBRATION EMISSIONS

#### NOISE SENSITIVITY AND PERCEPTION

<table>
<thead>
<tr>
<th>Source of noise</th>
<th>Sound power W</th>
<th>Sound level dB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saturn rocket</td>
<td>100,000,000</td>
<td>200</td>
</tr>
<tr>
<td>Jet fighter engine</td>
<td>100,000</td>
<td>170</td>
</tr>
<tr>
<td>Jet plane taking off</td>
<td>1,000</td>
<td>150</td>
</tr>
<tr>
<td>Propeller plane taking off</td>
<td>100</td>
<td>140</td>
</tr>
<tr>
<td>Machine gun</td>
<td>10</td>
<td>130</td>
</tr>
<tr>
<td>Orchestra</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jet fighter from passenger ramp</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heavy thunder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Accelerating motorcycle</td>
<td>0.1</td>
<td>110</td>
</tr>
<tr>
<td>Heavy metal, hard rock concert</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chainsaw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Car at highway speed</td>
<td>0.01</td>
<td>100</td>
</tr>
<tr>
<td>Helicopter, passing train at distance of 25 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Traffic jam in the city</td>
<td>0.001</td>
<td>90</td>
</tr>
<tr>
<td>Aircraft cabin during normal flight</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alarm clock</td>
<td>0.0001</td>
<td>80</td>
</tr>
<tr>
<td>Toilet flushing</td>
<td>0.0001</td>
<td>70</td>
</tr>
<tr>
<td>Loud office</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Restaurant/Canteen</td>
<td>0.00001</td>
<td>60</td>
</tr>
<tr>
<td>Hairdryer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiet office</td>
<td>0.00001</td>
<td>50</td>
</tr>
<tr>
<td>Quiet home</td>
<td>0.000001</td>
<td>40</td>
</tr>
<tr>
<td>Birds chirping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quiet conversation</td>
<td>0.0000001</td>
<td>30</td>
</tr>
<tr>
<td>Rustling of leaves</td>
<td>0.00000001</td>
<td>20</td>
</tr>
<tr>
<td>Whispering</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breathing</td>
<td>0.000000001</td>
<td>10</td>
</tr>
</tbody>
</table>
Rail transport is a major source of noise. Representative surveys show that a third of the population feels disturbed or bothered by noise caused by rail transport. "Hot spots" along the railway routes with high freight traffic are especially problematic. A primary goal of improving the quality of life is therefore to reduce noise emissions through appropriate measures both in the planning and expansion of railway tracks, as well as the existing rail network.

Rail vehicles generate rolling noise and vibrations during vehicle operation. The reasons for this are roughness and imbalance both on the wheels and on the rail running surfaces. Surface defects such as head checks, grooves and rail corrugations on the rails are among the most common sources of disturbance.

**Typical sources of acoustic and vibration emission and the generation and effect of primary and secondary immissions by rail transport**
These vibrations are transmitted to the substrate via the track system and spread out from there as structure-borne sound. If buildings are located beside or in close proximity to the track system, a transfer also takes place via their foundations. The buildings begin to vibrate, and if this becomes intense enough, it is also perceived by the people as a noticeable vibration or disturbing noise.

Another consequence of this transmission chain is the emission of vibrations from parts of buildings, for example ceilings and walls, to the environment. This takes place through the air, which itself starts to vibrate and then becomes audible as "secondary airborne sound".
DAMTEC® Sub Ballast Mat K (rubber granulate)

DAMTEC® vibrafoam® & DAMTEC® vibradyn® (Polyetherurethane)
DAMTEC® rubber and elastomer products DAMTEC® Sub Ballast Mat K, DAMTEC® vibrafoam® and DAMTEC® vibradyn® consist of a special rubber compound, a cellular polyetherurethane foam with open or closed pores. These products can be used to minimise both static and dynamic forces occurring during vehicle operation. They effectively counteract the multifrequency oscillations and vibrations that are transmitted to the environment.

DAMTEC® products for track construction are made of high quality elastomer materials. With the exhaustively tested formulas, the products meet specific requirements associated with the stresses and strains in the track area. DAMTEC® is produced in rolls or sheets, and can therefore be used as a point, strip or surface layer. These elastomeric materials are also used in other demanding fields, such as civil engineering and tunnelling. Particularly noteworthy is the long-term performance that ensures consistently high effectiveness for decades. In this way, these products counteract the multifrequency oscillations and vibrations that are transmitted to the environment.

DAMTEC® Sub Ballast Mat K
High quality rubber granules, granules made of foamed rubber and polyurethane are used as part of the waste management cycle for this product. Only good-as-new material that originates from faulty batches or punching waster is used. As a result, any aging effect on the rubber granules can be ruled out. Here in particular, end-of-life tyres are not used.

DAMTEC® vibrafoam® and DAMTEC® vibradyn®
DAMTEC® vibrafoam® (made of open-cell PU foam) and DAMTEC® vibradyn® (made of closed-cell PU foam) are cellular elastomers and consist of a special polyetherurethane. DAMTEC® vibrafoam® elastomers have excellent properties both as a compression-loaded and thrust-loaded springs. Basic types with various properties are available for nearly every application case. Adaptation to individual application cases is simple and is done by selecting the DAMTEC® vibrafoam® type, the shape and the contact area.
PROPERTIES, PERFORMANCES AND APPLICATIONS
REDUCING ACOUSTIC AND VIBRATION EMISSIONS
PROPERTIES AND ADVANTAGES OF DAMTEC® PRODUCTS

- Protect the sensitive sealing layer against damage from ballast stones
- Extend the service life of the ballast
- Protect adjacent buildings by reducing vibrations
- Environmentally friendly
- Extremely economical
- Uncomplicated installation
- Low water absorption
- Extremely durable
- Reduction of track maintenance costs
- Reduce the transmission of structure-borne sound
- Reduce secondary airborne sound
- Track position remains stable for longer
OUR COMPREHENSIVE SERVICES FOR YOU
WE SUPPORT YOU THROUGHOUT THE RAIL PROJECT

Solution development & detailed solutions
Our many years of experience and know-how with products for noise and vibration reduction are a guarantee for solving even the most complex problems. Together with you, our specialists will develop effective systems for eliminating or minimising disturbing factors in the problem areas. Besides standard solutions based on experience, of course we have the personnel and technical capabilities to create completely new solutions that are precisely matched to your requirements.

Calculations, simulations and efficiency forecasts
You do not have to wait until the measures have been implemented to find out how successfully they are dealing with an emission problem. After a first inspection and analysis of the local conditions, our specialists are capable of initially creating a mathematical model, in which all relevant factors relating to vibration generation and damping behaviour are taken into account for different material properties. This results in a realistic simulation that allows fine tuning of these factors and enables our engineers to develop the optimum solution. At the end of the planning stage, you will receive proof of the expected effectiveness of the system. This efficiency forecast gives you the assurance in advance that your expectations will be met successfully.

All services at a glance
- Material testing and measurement on our large in-house test bench
- Project support from the start
- Installation consulting and acceptance
- Vibration-related, mechanical and acoustic measurements
- Solution development
- Detailed solutions
- Calculation and simulation
- Effectiveness forecasts
Track systems for rail transportation consist of tracks, switches, junctions and railway crossings. Construction can be divided roughly into three levels: **superstructure, substructure** and **substrate**, in which the superstructure can also be divided further into **ballasted** and **slab track**. The substrate can be an earth structure or an engineered structure (bridge, tunnel). Figures 01 and 02 show the schematic structure of both superstructure constructions and the possible applications of elastic elements to reduce sound and vibration emissions.
DAMTEC® SUB BALLAST MAT K, DAMTEC® VIBRAFOAM® AND DAMTEC® VIBRADYN®
APPLICATION TYPES

APPLICATION TYPES

Sub Ballast Mat

- Sub ballast mat combined with side mat

Mass-Spring System

- Point-like support
- Strip-like support
- Area support

Typical field of application:

- Structure-borne noise isolation on track systems in urban centres, especially in the immediate vicinity of buildings
- Reducing the noise and vibration emission to buildings with particularly high requirements for noise prevention (for example, opera houses, concert halls, test institutions, hospitals)
- Protecting against low-frequency vibrations caused by space-limiting surfaces (secondary airborne sound)
- Stabilising track constructions; particularly in high-traffic routes
Embedding the mass-spring system in our DAMTEC® products reduces the peak pressure in the track ballast, allows the track geometry to remain stable for longer and effectively reduces structure-borne sound.

Embedding the entire track system into DAMTEC® products creates a mass-spring system that with the appropriate dimensions acts as highly effective acoustic and vibration isolation. This effect also occurs with complicated track geometries. In mass-spring systems, DAMTEC® products are installed at points, in strips or covering the whole area. The mass-spring systems in the form of track supporting layers and track troughs are generally individual solutions that we are happy to work out for you.

**Mass-Spring System**

The interaction between an inertial mass (slab track) with elastic elements (spring) has the effect of isolating the vibration. Therefore one refers to a “mass-spring system” for these kinds of construction. A crucial factor for effectiveness is the exact tuning between mass and stiffness and the spring dynamics of elastic members. This is referred to as the tuning frequency \( f_0 \) (deepest vertical natural frequency of the superstructure system that is elastically spring-mounted on the substructure). These relationships can be explained very well using the model of the “single-mass oscillator”.

\[
 f_0 = \frac{1}{2\pi} \sqrt{\frac{c}{m}}
\]

**Mathematical Model**

- \( m \) = dynamic effective mass
- \( c \) = spring stiffness
- \( F_a \) = excitation force
- \( F_b \) = bearing force
- \( Fa \) = bearing force
- \( Fb \) = bearing force

\( f_0 \) = tuning frequency

*Thickness and arrangement in layers according to requirements*
Static bedding modulus

With bedding theory, the track is imagined as an infinitely long rod that is laid on a continuous, elastic base. The bedding modulus is the elasticity value of the whole system, rail - railroad tie - ballast - substructure - substrate, and is used to estimate the static deflection of the operating load. This quantity is a measure of the stiffness that must be determined experimentally. The static bedding modulus basically indicates how deep the rail sinks under slow traffic conditions or a stationary train.

The bedding modulus is the ratio of the stress to the deflection. Usually, the secant modulus is measured, for example, between 0.02 N/mm² and 0.10 N/mm². Alternatively, the tangent modulus can be determined.

Deflection

A distinction must be made between the deflection and subsidence of the elastomer and the rail deflection. The deflection can be determined using the spring characteristics and is the distance in millimetres by which the material is compressed under a certain tension.

The rail deflection when in use takes into consideration the stiffness in the track superstructure from the vehicle to the substrate. It is calculated statically for the stationary and dynamically for the moving train. Depending on speed, axle load, superstructure type, sub-type and DAMTEC® type, the deflection is usually between 1 mm and 3 mm.
Dynamic bedding modulus
A distinction must be made between the low-frequency (superstructure dynamics) and the high-frequency dynamic bedding modulus (damping of structure-borne noise). With the first-mentioned characteristic value, the bending deformation of the rail under the rolling wheel can be estimated from the interaction of bending elasticity of rails and railroad ties, including ballast.

The higher-frequency dynamic bedding modulus of a ballast mat influences the natural frequency of the elastically mounted superstructure as a vibratory system as a whole and thus the insertion loss. The test is performed with a static preload.

Insertion loss
The insertion loss $\Delta L_e$ [in dB] is a characteristic value that expresses the extent to which inserted measures contribute to reducing the structure-borne noise introduced into a system. The insertion loss $\Delta L_e$ is the ratio of the structure-borne sound power "without installed measures" to "with installed measures". It is a characteristic value of the entire system - from the vehicle to the substructure.

Forecast calculations
Since the mechanisms for the generation and propagation of structure-borne sound associated with rail transport are widely known, the expected effect of mitigation measures can be calculated in advance after a thorough evaluation of the system in the way they are to be used. There are many tried and tested calculation models available for this purpose. The combination of advanced materials that meet all modern requirements for effective sound and vibration protection, as well as the vast experience in implementing more effective measures make DAMTEC® the ideal partner for sound and vibration reduction in the railway sector.
KRAIBURG reference products in the railway sector

DAMTEC® Project
Wiener Linien, Austria
REFERENCE PROJECTS
KRAIBURG reference products in the railway sector

DAMTEC® Project
Lichterfelde, Berlin, Germany

DAMTEC® Project
Lichterfelde, Berlin, Germany
REFERENCE PROJECTS

DAMTEC® Project
Chaussee de Charleroi, Brussels, Belgium

DAMTEC® Project
Lichterfelde, Berlin, Germany
ENVIRONMENTAL MANAGEMENT AT KRAIBURG RELASTEC
HIGH QUALITY PRODUCTS MADE OF RUBBER, PRODUCED IN HARMONY WITH NATURE

KRAIBURG Relastec is one of the most famous and important specialists in the recycling of industrial rubber materials worldwide. In a long tradition of commitment to the environment, we recycle about 85,000 tons of cellular rubber, spew and punchings made from rubber materials per year for the purposes of the rubber cycle. More than 90% of the raw material basis is used for our finished products. From this we manufacture high quality rolls and sheet goods according to proprietary formulas developed in-house. All products are fully recyclable and are fed back into the manufacturing process with no loss of quality.

At KRAIBURG Relastec, environmental protection is a key strategic role. We are fully aware that sustainable growth is only possible if we meet our obligations and responsibilities with regard to environmental protection. Therefore, KRAIBURG Relastec has developed a systematic approach for this: Environmental protection is part of our daily routine!

Our environmental logo “pro environment” not only stands for 40 years of sustainable and consciously lived use of our resources and high product quality, but also for our unceasing commitment to continuous improvements in environmental performance beyond legal requirements.

We process excess rubber materials to make a new raw material and new products, and so make a valuable contribution to environmental protection.

We are committed to investing in environmentally friendly production.

Our products are subject to continuous testing and further development in terms of environmental protection and we are continuously looking for more environmentally acceptable alternatives to further reduce emissions and conserve resources.

All employees of KRAIBURG Relastec are committed to implementing an environmentally friendly operation.

Our suppliers are also subjected to continuously monitoring.
Under the brand name DAMTEC® our customers can find a variety of products for sound reduction and vibration isolation for various requirements and areas of application. Additionally, brochures on these areas are available for you which we will be happy to provide on request. Additional information can also be found on our website www.kraiburg-relastec.com/damtec
SOUND AND VIBRATION ISOLATION
made of recycled rubber granulate

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