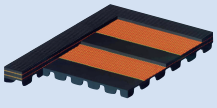
CALENBERG INGENIEURE

USM® Track Mats



Track mats to reduce vibration

and structure-borne sound

planmäßig elastisch lagern

Introduction

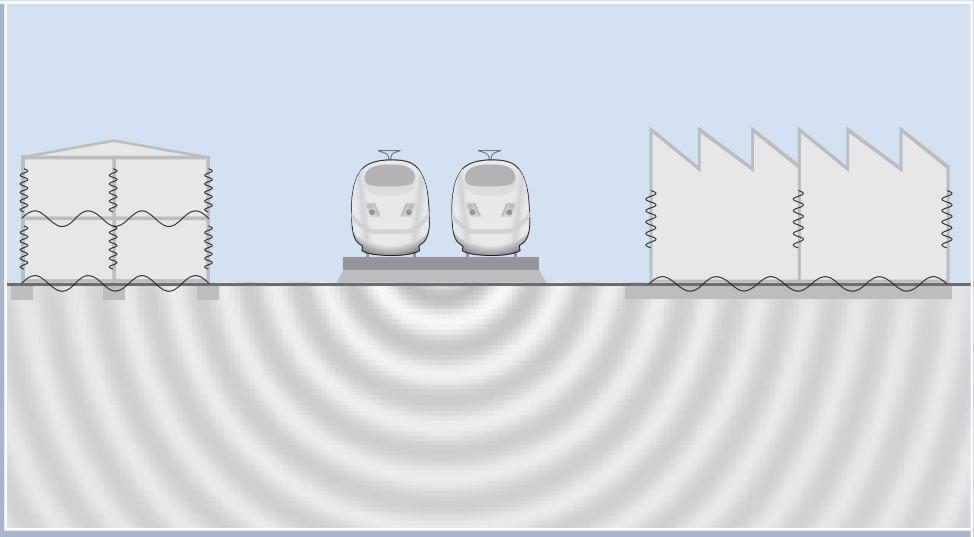
Rail traffic generally causes vibration and noise by:

- wheel out-of-roundness
- wheel flats
- rail corrugations
- track displacement
- passing of crossings or points/ switches
- inhomogeneity of subgrade

The vibrations thereby caused may be irritating to humans or critical to structures and technical equipment within different frequency ranges (see Figure 1).

Due to dense building development near tracks and an increasing need for protection of residents and business, rail tracks in cities have to be equipped with adequate vibration and noise protection. Without such protection residential land and buildings adjacent to a railway line may decrease in value.

The future urban development along a railway line should be considered right from the outset of the line's planning stage.



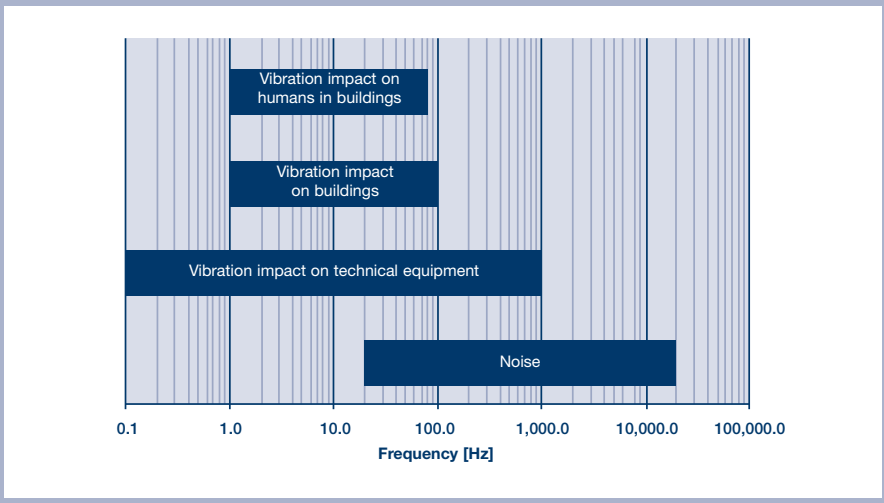


Figure 1: Frequency ranges and their effects on people, buildings and facilities

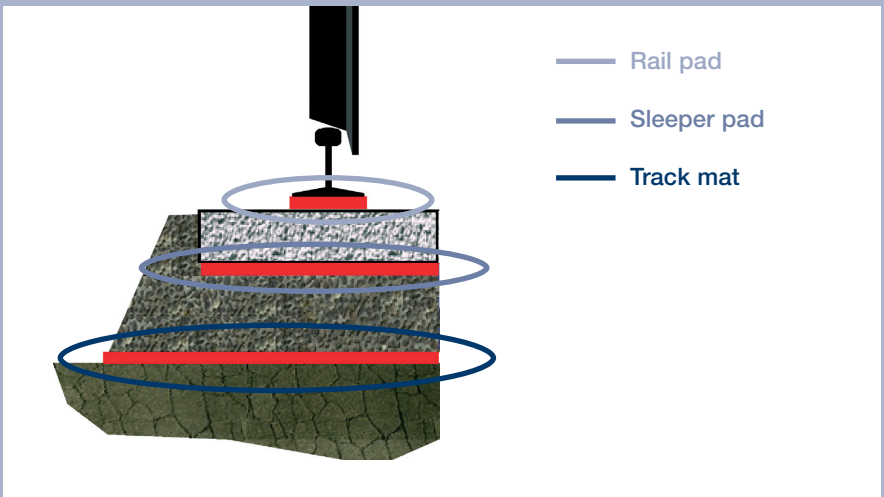


Figure 2: Position of elastic elements in the permanent way

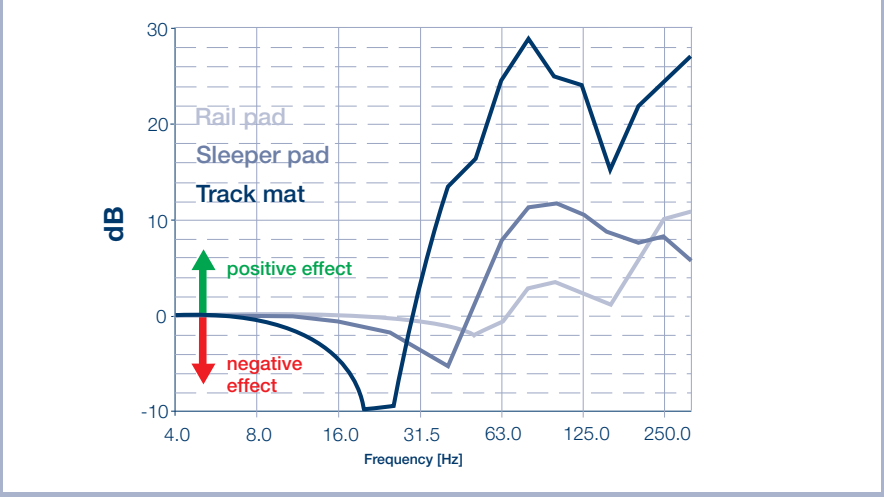


Figure 3: Insertion loss in the permanent way achieved by using different elastic elements

Already at this stage, measures to protect against vibration and noise should be part of the planning process. Upgrading of existing structures is, however, much more complex and costly. Effective protection against vibration and structure-borne noise is achieved with specially selected elastic elements. USM® track mats are proven elastomeric products made from both high-quality natural rubber and synthetic rubbers. They are used as highly effective and durable protection as they decrease the vibration and noise emissions caused by the rail-bound traffic and ensure more homogeneous characteristics of the permanent way.

Figure 2 shows a schematic cross section of a permanent way and the positions at which the elastic elements can be placed. Figure 3 shows for selected cases the efficiency (insertion loss) of different noise mitigation approaches. In general, the farther the mitigation measure is located from the wheel-rail contact the more effective it is. The mass above the elastic layer is increased and thereby the natural frequency of the system is reduced.

Design Considerations

On the basis of national regulations such as “DIN 4150 – Vibration in Civil Engineering” the designer determines the required limit values (e. g. allowable vibration velocity as a function of frequency) which must not be exceeded in the structures to be protected from noise and vibration. Prognosis calculations for train operation on new lines without mitigation measures at the track show to what extent the limit values are exceeded. The structural conditions of adjacent buildings have to be considered. The requirements on the mitigation measures depend on the magnitude the limit values are being exceeded as well as on the frequency ranges.

Figure 4 compares schematically the mitigation effect of the USM® track mats for ballasted track and a light mass-spring-system depending on the type of floor of an adjacent building.

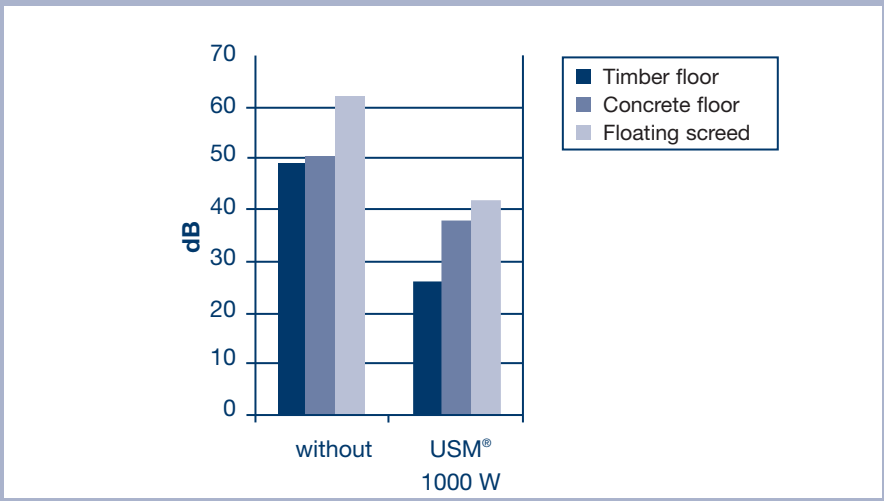


Figure 4: Effect of track mats for different types of floors

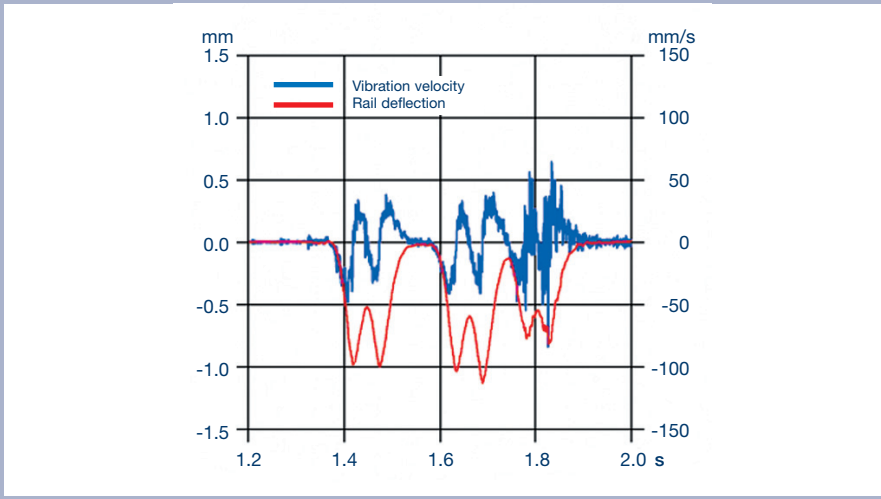


Figure 5: Measured vibration velocities and rail deflections due to a passing train

The entire system of rail vehicle and track needs to be considered when selecting a suitable mitigation measure. Without detailed knowledge of the situation an incorrect choice of the elastic elements may lead to unsatisfactory conditions that cannot be corrected later on and may also result in an increase in emission. The following influences should be taken into account:

- Rail vehicle properties
- Train speed
- Type of permanent way
- Properties of subbase and foundation
- Required natural frequency of system

Selection Criteria

Fields of Application

USM® track mats are mainly used on load-bearing subbases such as:

- Tunnels
- Bridges
- Elevated track

(Figures 6 – 9)

On ballasted concrete bridges or other track sections with concrete base USM® track mats should always be used so as to protect the ballast. Furthermore, on steel bridges track mats are also required to reduce noise emission.

USM® track mats are suitable for all types of tracks.

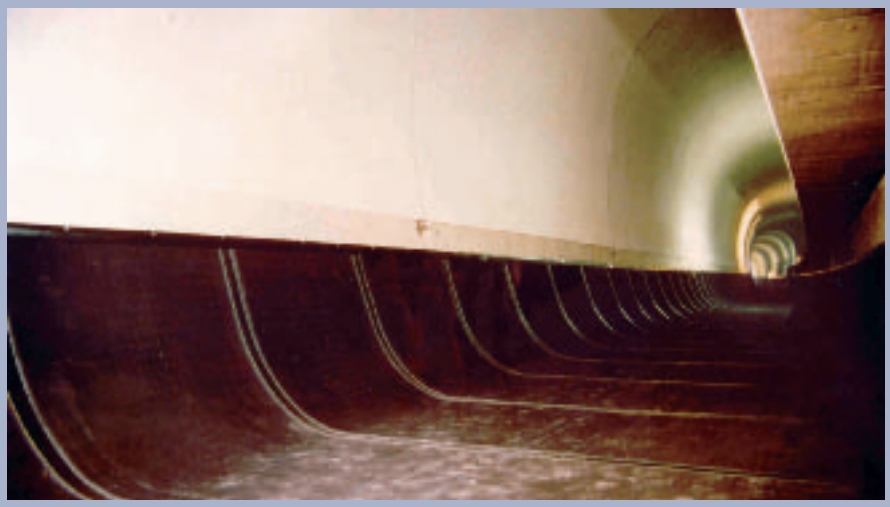


Figure 6: USM® track mats in a tunnel before ballasting

Figure 7: USM® track mats on a concrete bridge before ballasting

Figure 8: USM® track mats placed under concrete on an elevated track

Figure 9: USM® track mats used for a track on a bridge

Placing track mats underneath ballast not only reduces noise and vibration emissions but has other advantages such as:

- Reduction of ballast wear (the energy transferred into the track is transformed by the elastic mat and thereby preventing damage to the ballast)
- Increase of long-term track stability
- Reduction of dynamic wheel forces
- Reduction of stresses in track and vehicle
- Possible reduction of ballast height (advantageous for bridges as it results in reduced dead load)
- Lower track maintenance cost
- No material replacement required because of high durability
- Expected service life of min 60 years (= service life of the permanent way)

Ballasted Track

Slab Track

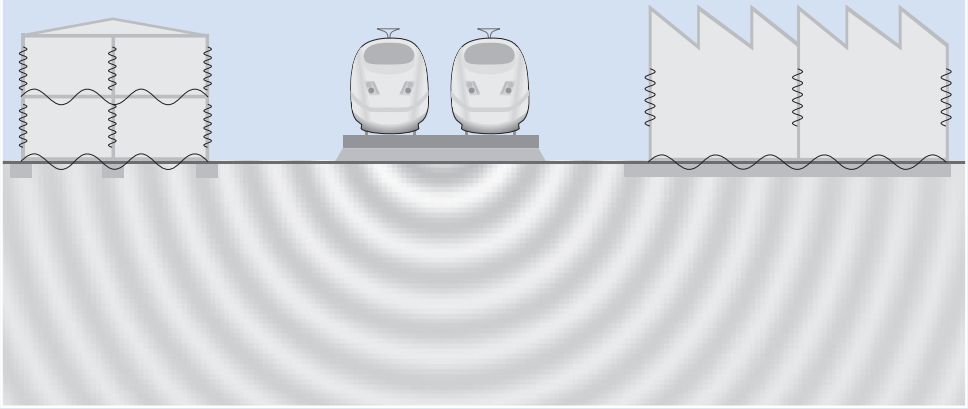
In recent years various types of slab track systems have been developed and constructed as an alternative to the traditional ballasted track – particularly in high speed lines. The main advantage of the ballastless track is low maintenance cost. A disadvantage is the high stiffness of the track which may lead to noise and vibration emission in particular when constructed on bridges (Figure 10).

The track mats are placed underneath the concrete and serve as permanent formwork. This type of design is called “light” mass-spring-system (Figure 11). Adding the elastic elements to the track increases the resilience which considerably reduces noise and vibration emission. In addition the advantages mentioned above apply analogously.

Figure 10: Cable-stayed bridge across the Rio Pinheiros in Sao Paulo (Brazil)

Figure 11: Stripped “light” mass-spring-system with USM® track mats

Figure 12: "Light" mass-spring-system with USM® track mats for road tracks



If even more noise abatement is required or if on client request the elastic element needs to be replaceable a so-called "heavy" mass-spring-system can be used. A heavy concrete component (with or without ballast) is placed on individual elastic supports. Further information can be found in our product brochure "Elastomeric Bearings for Mass-Spring-Systems".

Buildings adjacent to railway lines are subject to vibration impact from passing trains. The use of elastomeric mats for such buildings provides an effective solution. They can be applied if the building has a cellar, between the ground floor and the cellar walls or for instance between a rigid basement floor and the foundation slab. In the latter case the basement walls usually also have to be covered with resilient mats so as to provide adequate vibration abatement for the structure.

Mass-Spring-System & Buildings on Elastic Foundation

Product Range

General

Since 1977 USM® track mats have been used successfully worldwide. In various projects more than 700,000 m² have been specified and laid in over a 100 cities. Due to our very wide product range individual solutions for almost any vibration problem can be found.

Using a specially developed prognosis program for determining the insertion loss, Calenberg Ingenieure can provide optimal product advice for a particular project as this program has been proven to provide very realistic results. As a service, relevant calculations are carried out if required. Apart from engineering application support, training of site staff can be offered as well as on site product installation supervision.

Features of USM® Track Mats:

- High degree of insulation against structure-borne noise and vibration
- Reduced stress and wear of track and vehicle components
- Reduced rail corrugation
- Low dynamic stiffening
- Excellent electrical isolating properties
- Adaptable for special applications
- Excellent resistance to ageing and weathering.
- Design life of 60 years

The USM® track mat range comprises three different mat types with varying characteristics and stiffnesses (see Figure 13) and is well-suited for applications, such as in trams, underground systems, metropolitan/commuter and main line railways.

Type of mat	Width [mm]	Weight [kg/m²]	Thickness [mm]	Static Bed Modulus [N/mm³]
USM® G-1015	1500	14.0	15	0.100
USM® G-1023	1500	18.5	23	0.060
USM® G-1027	1500	22.0	27	0.030
USM® G-1032	1500	26.0	32	0.024
USM® 1000 W	1536	14.0	30	0.019
USM® 2020	1536	13.0	27	0.020
USM® 2025	1536	13.0	27	0.025
USM® 2030	1536	13.0	27	0.030
USM® 3000	1536	13.0	27	0.046
USM® 4010	1554	11.0	14	0.100
USM® 4015	1554	11.0	14	0.150

Figure 13: Technical data of track mats

Figure 14: Series USM® 1000, 2000, 3000

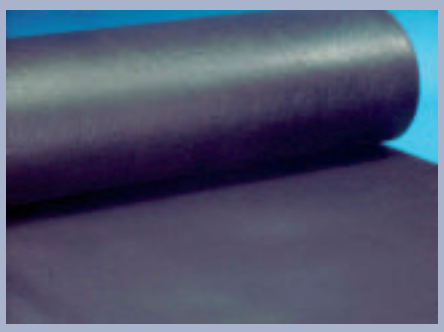


Figure 15: Series USM® G-1000

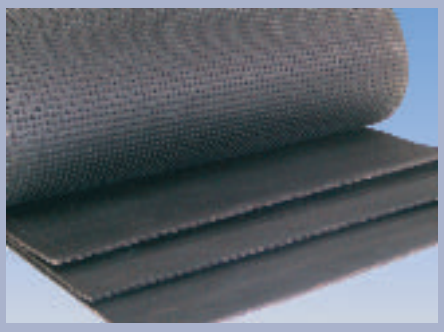


Figure 16: Series USM® 4000

Series USM® 1000, 2000, 3000

Characteristic for these types of mats are truncated cone-shaped spring elements situated on the underside of the mat. This special feature ensures

- Drainage underneath the mat
- Adequate ventilation so as to prevent condensation moisture underneath the mat

Series USM® G-1000

This type of track mat has a damping layer consisting of bound rubber granules and is covered on both sides with an abrasion resistant protective layer of chloroprene. This layer is to protect the damping layer from possible mechanical damage as caused for instance by sharp edges of ballast.

Series USM® 4000

This profiled type of track mat was specially developed for the use in high speed railway lines.

USM® track mats comply with the technical specifications TL 91 80 71 of Deutsche Bahn AG. The mats are subject to rigorous quality control in order to ensure constant quality and are produced according to the DIN EN ISO 9001 quality assurance system.

USM® track mats have been tested and approved by the following testing institutes:

- Technical University Munich
- Technical University Berlin
- RWTH Aachen
- DB VersA Munich
- TÜV Rheinland
- SNCF
- Hoechst AG
- Müller-BBM, Munich
- EMPA, Switzerland

Test and measurement reports and data sheets on the different types of mats are available on request.

Proof of Suitability

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Figures 17 and 18 show the frequency dependent reduction of the vibration velocities when using the track mats USM® G-1023 or USM® 1000 W compared to a conventional ballasted track without resilient track mats.

Calenberg track mats are internationally patent-protected. USM® is a registered trademark of Calenberg Ingenieure GmbH.

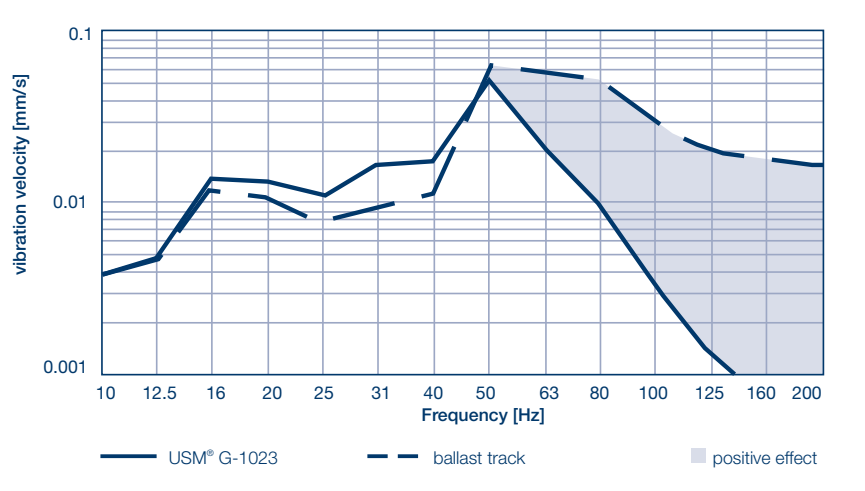

Figure 17: Effect of USM® G-1023

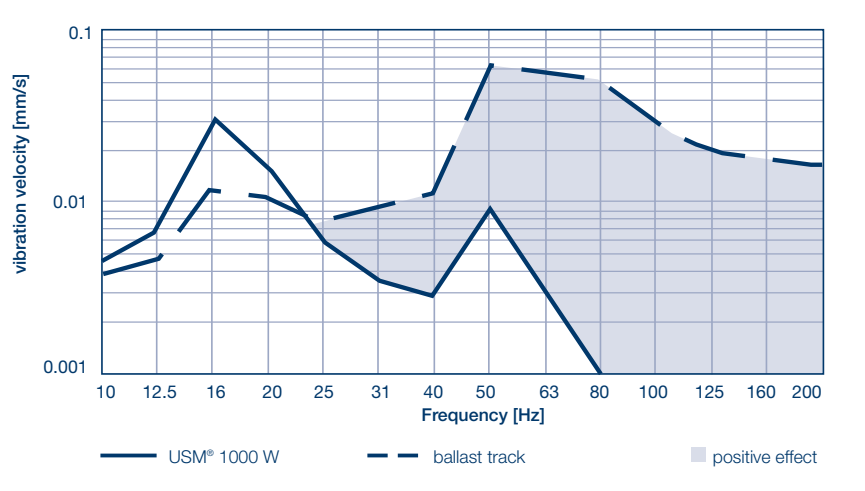

Figure 18: Effect of USM® 1000 W

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