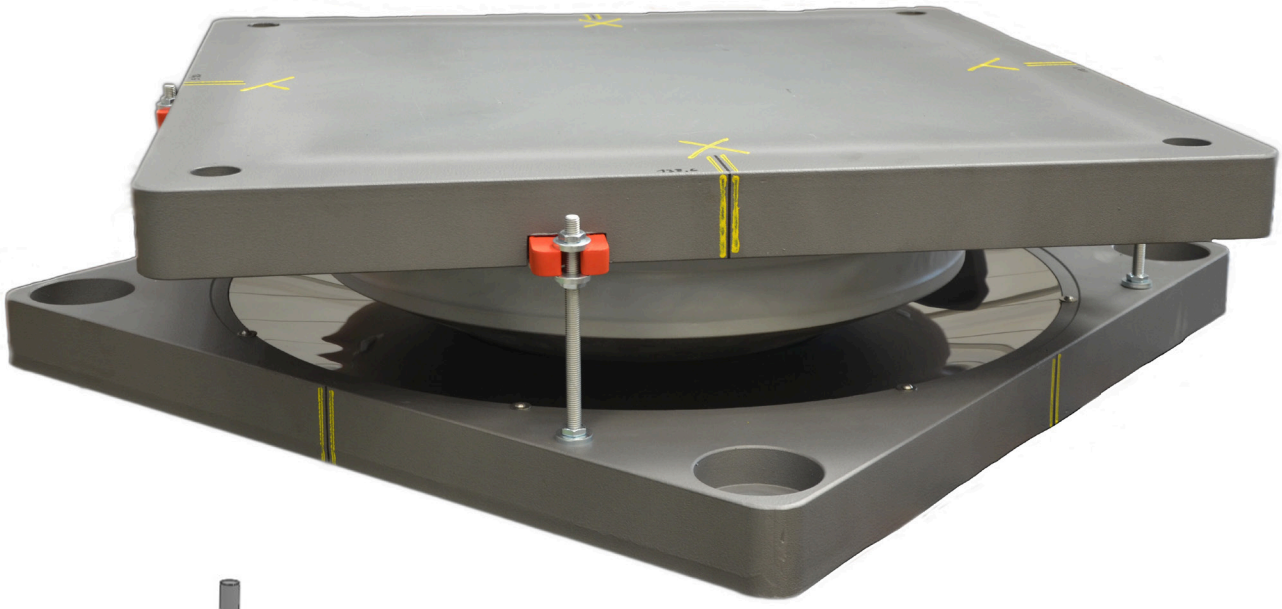
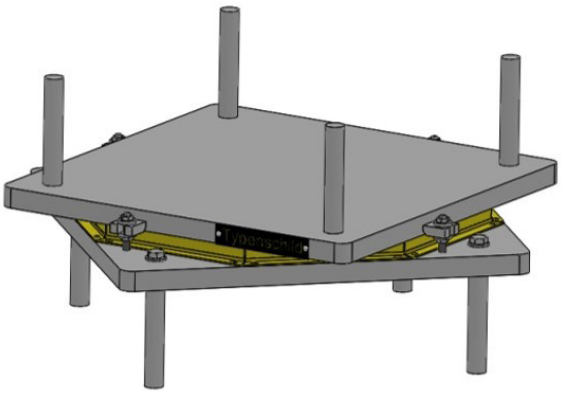
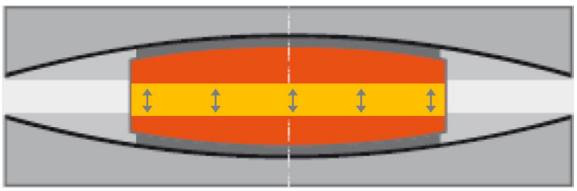
MAURER

MAURER Sliding Isolation Pendulum with integrated Vibration Isolation SIP®-V

Safety meets Comfort

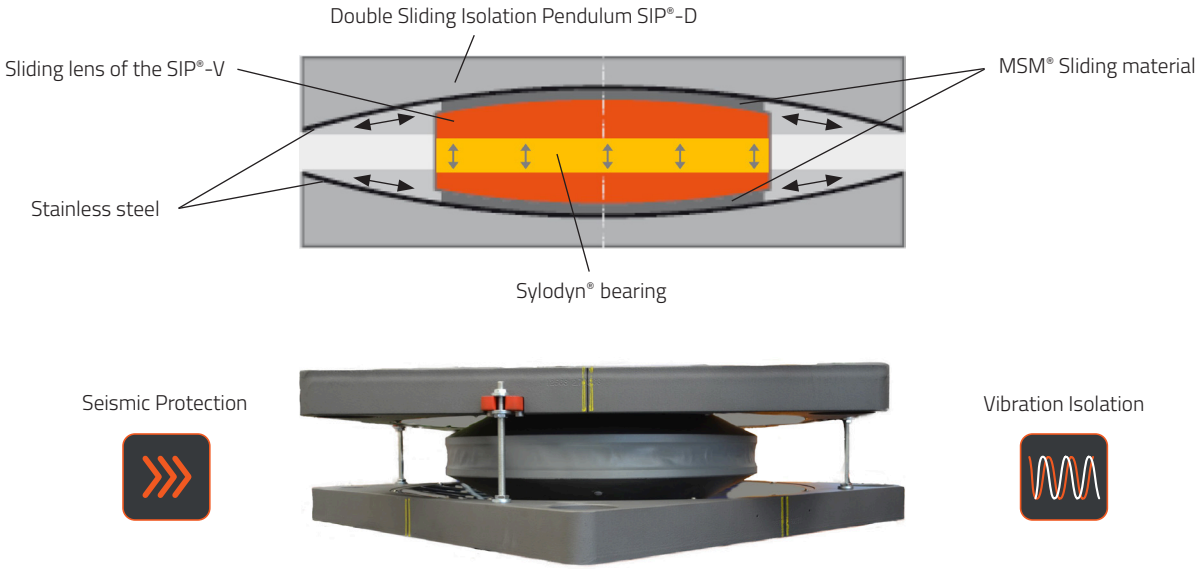






The SIP®-V Sliding Isolation Pendulum combines seismic protection and vibration isolation in which the sliding lens of the classic Double Sliding Isolation Pendulum SIP®-D is equipped inside with a bearing made of the highly effective dynamic material Sylodyn®. Depending on the earthquake intensity, the horizontal seismic isolation is individually adjusted by the effective radius of the main sliding surfaces and the friction of the sliding pair stainless steel against sliding material MSM®. Mechanically precise machined surfaces and approved sliding pairs ensure outstanding properties and a maximum service life. The 3D-vibration isolation and the structural isolation from micro vibrations of the ground caused by traffic and construction equipment is provided by the embedded Sylodyn® bearing with a vertical natural frequency of 8 to 12 Hz and the effective damping ratio of 5%.

Schematic representation SIP®-V



Characteristics

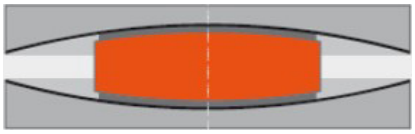
- Horizontal isolation of the structure from earthquake excitation
- 3D-isolation of the structure from vibrations caused by traffic and heavy equipment
- Earthquake-induced structural accelerations/shear forces are reduced by a factor of 2 to 5
- Tested system with long-term proven and approved materials
- Service life of more than 50 years
- Simple installation
- Complete solution from a single supplier

Advantages

- "Two-in-One System": Optimal simultaneous protection of the structure and its contents or equipment against earthquakes and ambient vibrations
- Maximum user comfort and quality of life by avoiding vibrations and secondary airborne noise
- No, or only minor, damage after the earthquake with low life-cycle costs
- Protection of sensitive equipment against vibrations and increase in the real estate value

Seismic Protection

The basis for the SIP®-V is the Double Sliding Isolation Pendulum (MAURER SIP®-D) with two main sliding surfaces and the wear-resistant sliding material MSM® applied for seismic protection since 2004. These seismic isolators can be manufactured for vertical loads of up to 200 MN or more and movements in the range of +/-1,000 mm and more. Further information can be found in the brochure "MAURER Seismic Protection Systems".



>> Characteristics

- Precisely machined surfaces and approved sliding pair
- Elasto-plastic behaviour of 8 mm thick sliding material MSM®
- No failure, even at maximum movement combined with maximum vertical load

>> Advantages

- No wear, even after 3 design earthquakes
- Long-term reliability and re-centring
- Stable behaviour, no buckling or tilting
- Stable stiffness and reliable damping behaviour with lowest tolerances
- Service life of more than 50 years
- Simple installation

>> Tests

Excessive seismic tests at highly qualified and certified test institutes such as U.C San Diego (CALTRANS) and EUCENTRE (Pavia, Italy).

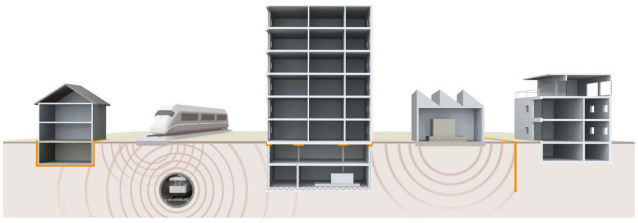
The tests were successfully completed following various standards, including EN15129, ASCE 7, and AASHTO.

>> Implementation of a SIP®, New Acropolis Museum in Athens

- Custom design for load, isolation period and damping required
- Long service life without damage to structure and isolator

Vibration Isolation

The material Sylodyn® of Getzner Werkstoffe GmbH has been successfully used worldwide for more than 25 years to isolate structures from excitation sources from nearby traffic routes. Sylodyn® is a closed-cell elastomer with distinctively dynamic properties that are excellently suited for 3D-vibration isolation and thus effectively prevent disturbing vibrations and secondary airborne noise. The Sylodyn® HRB HS types for maximum loads provide high-performance vibration protection in the smallest space and are therefore ideally suited for use in the Sliding Isolation Pendulum SIP®-V. More detailed product specifications are available on request from the corresponding material data sheet.



Sylodyn® is primarily used as a vibration protection solution on railway projects, for isolating noise in buildings, and as a bearing under machinery.

>> Characteristics

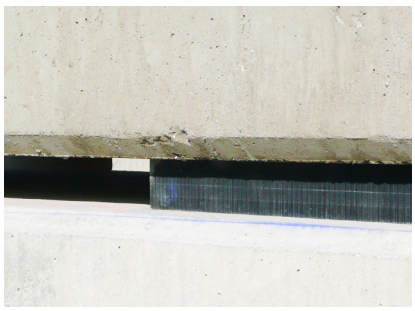
- Specific spring characteristics without creep due to its closed-cell pore structure
- Range of application for static loads up to 30 N/mm² and combined static and dynamic loads up to 52 N/mm²
- Very low amplitude dependence
- Stiffening factor (k_{dyn}/k_{stat}) from 1.3 to 2.0

>> Advantages

- Excellent fatigue strength and proven long-term behaviour
- In horizontal and vertical direction an approximately linear and static stiffness behavior
- Adherence to international comfort criteria
- Maintenance-free
- One component fully integrated into the Double Sliding Isolation Pendulum
- Service life of more than 50 years

>> Implementation of Sylodyn®, Music Hall in Helsinki

Especially designed for geometry, loads and required isolation effect.

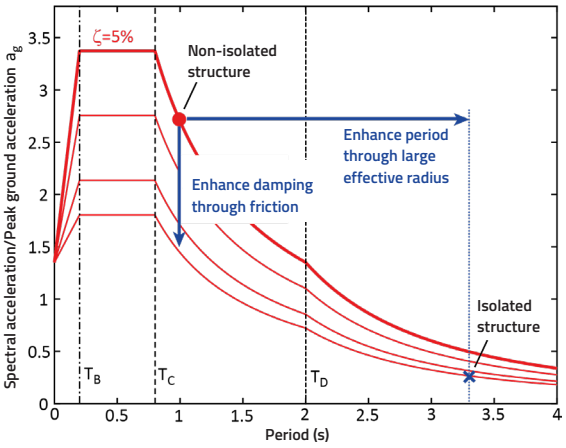


Dimensioning and Proofs for the SIP®-V

The MAURER Sliding Isolation Pendulums with integrated vibration isolation SIP®-V are designed as one component according to the available specifications for seismic protection and vibration isolation.

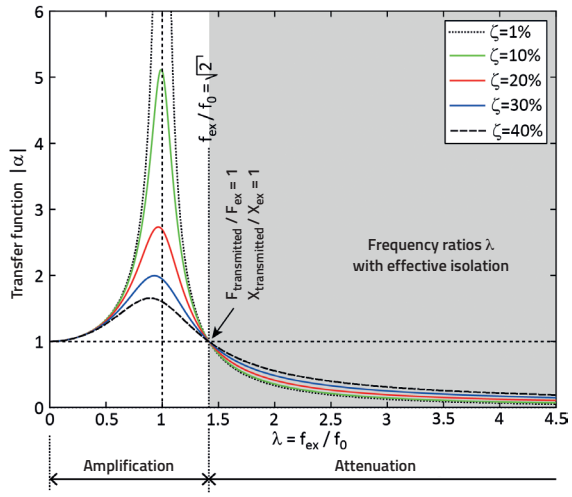
Necessary data for the design of the SIP®-V:

- Vertical permanent load, maximum vertical load under seismic action and maximum service load of the isolator
- Horizontal response spectrum or compatible accelerograms
- Permissible peak floor accelerations (PFA) and permissible shear force of the seismic isolator (base shear) for the design earthquake
- Wind load
- Vertical natural frequency f_0 of the vibration isolation



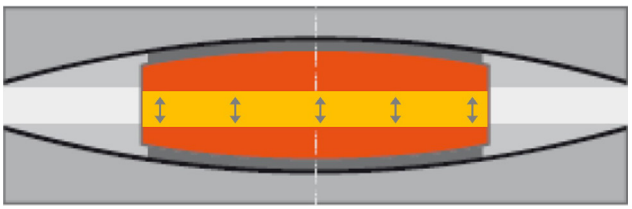
Step 1: Design of the horizontal seismic isolation by modal analysis or non-linear time history analysis by MAURER

Based on the response spectrum or compatible accelerogram respectively, MAURER optimises the Sliding Isolation Pendulums through linear modal analysis or non-linear time history analysis. Hence, the required seismic behaviour (max. base shear, max. PFA) of the structure can be achieved also, taking into account the wind load to be transmitted within the Sliding Isolation Pendulum.



Step 2: Design of the integrated vibration isolation

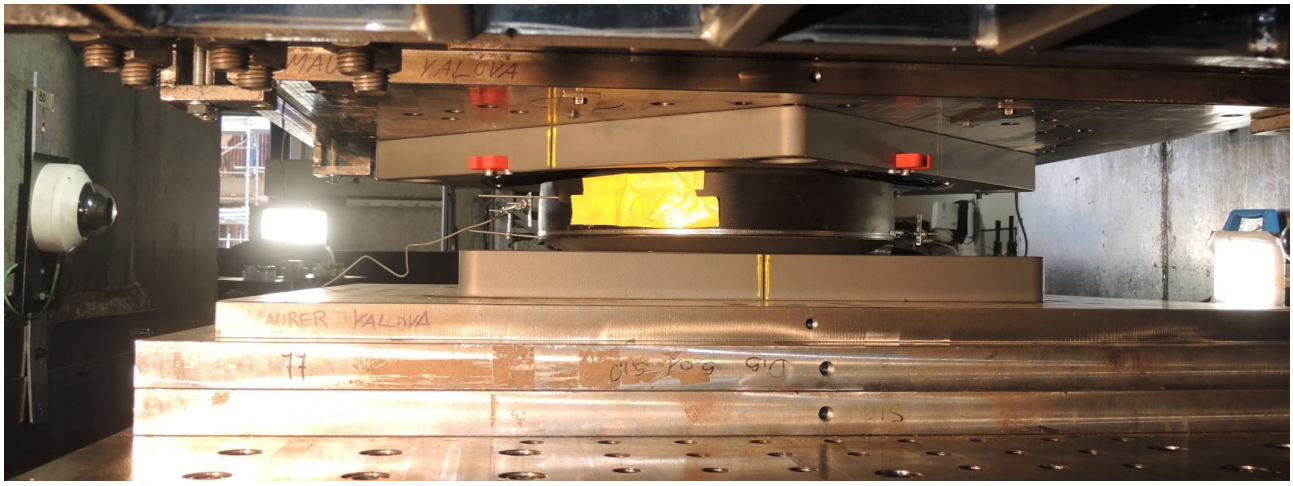
Traffic and machines cause vibrations of the foundation soil. High-intensity ground vibrations often occur with frequencies above 17 to 20 Hz. The diagram on the left shows that vibration isolation becomes effective from the frequency ratio $\sqrt{2}$ = 1.4 between the stimulating ground vibration f_{ex} and the natural frequency f_0 of the vibration-isolated structure. The vibration isolation system becomes more and more efficient with increasing excitation frequency. The natural frequency of the structure isolated with SIP®-V is mostly tuned to 8 to 12 Hz.



SIP®-V in centre position

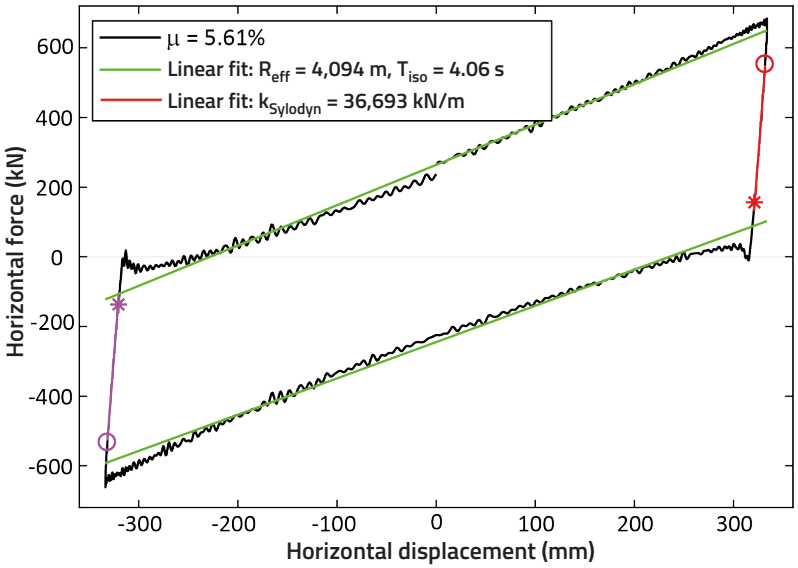
Tests

The tests were carried out at the EUCENTRE testing laboratory in Pavia, Italy according to EN 15129. Vibration damping parameters such as natural frequency, effective damping, and load capacity were proven.

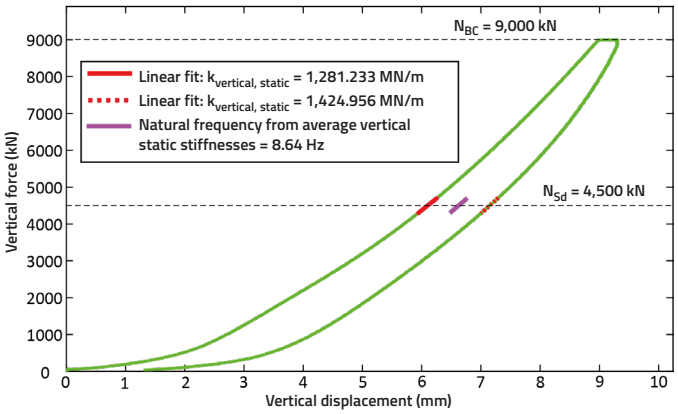


Test results

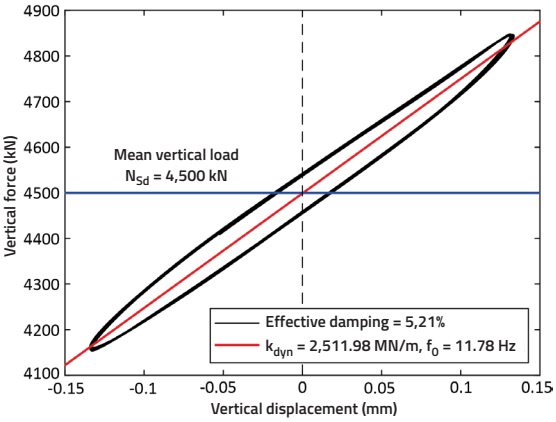
Horizontal force-displacement-plot of the SIP®-V under 4,500 kN vertical load and horizontal displacement d_{bd} = ± 330 mm



- The Sylodyn® bearing reduces horizontal stiffness (≈ 37 kN/mm; red and violet in the graph) before sliding. This elastic horizontal deformation of 5 to 10 mm reduces jerky start effects or start accelerations in the structure. The experimentally determined natural vertical frequency of the vibration isolation lies, on average, at 11.5 Hz, which is very close to the design value of 12 Hz.
- Effective reduction of the horizontal seismic acceleration by factors of 2.5 to 5 compared to the structure without base isolation. Even during of strong earthquakes, damage to the structure, its content, and the SIP®-V is avoided.



Vertical deflection up to the max. service load



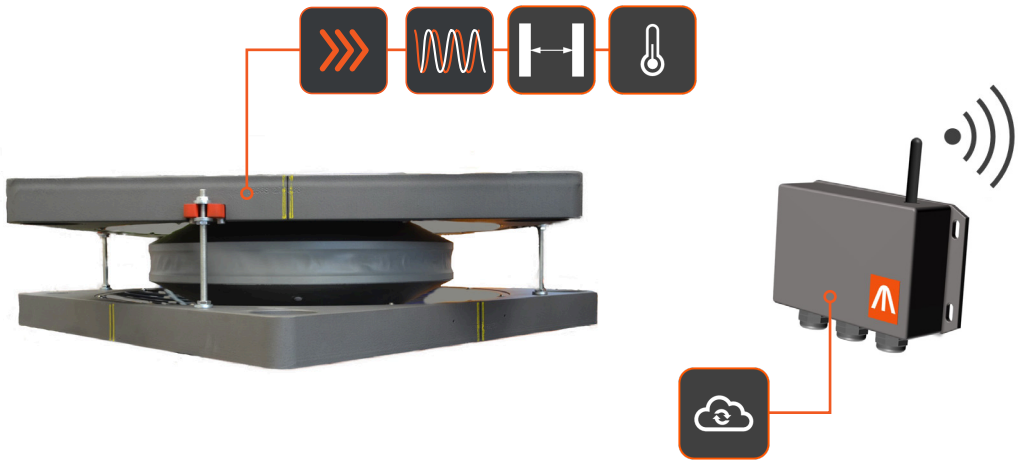
10 Hz at ± 360 kN vibration load

- At the vertical design load N_{Sd} of 4,500 kN including operational loads, the test shows a linear stiffness behaviour (presented in red in the left graph), which produces efficient vibration isolation.
- The vertical natural frequency f_0 is adjustable in the range from 8 to 12 Hz; the damping of 5% (see graph on the right) results in a very effective noise proofing in the audible frequency range of the secondary airborne noise.
- The vertical spring behaviour resulting in vertical deflection under load ensures even load distribution to all bearings within the entire structure.

Monitoring

When required, MAURER offers monitoring configured on a project-related basis. The following data can be provided on an online platform or directly at the bearing.

- Triaxial accelerations during earthquakes
- Spatial natural frequency in operating condition
- Biaxial horizontal displacements of the isolator during earthquakes
- Temperature of the structure



Reference for SIP®-V with Sylodyn®

BioSens research building for sustainable agriculture in Novi Sad/Serbia

The 3D-vibration isolation is required to facilitate the continuous operation of the sensitive laboratory equipment. Seismic protection has to prevent damage to the laboratory equipment and the structure. The installed bearings had to shield vibrations of at least 15 Hz and reduce the 0.2 g horizontal seismic acceleration of the unprotected structure by a factor of at least 2.

Specification

- Max. superimposed load of 4,000 kN
- Max. horizontal seismic displacement d_{Ed} = ± 100 mm
- Horizontal period of the pendulum T = 2.84 s during an earthquake
- Friction damping optimised for design earthquake
- Accelerations of the structure are between 0.03 g up to max. 0.1 g
- Natural vertical frequency of 3D-vibration isolation f_0 = 10 Hz
- Bearing size SIP®-V is 650 x 650 x 210 mm