Development of low-vibration foundations for 11 test environments in a newly built precision laboratory

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As a **global leading provider** of high-quality vibration isolation systems, the company **Bilz Vibration Technology AG** from Leonberg, Germany, was awarded the contract for the implementation and installation of the air spring isolation systems in the new building of the precision laboratory of the Max-Planck-Institute for Solid State Research in Stuttgart.

Purpose and objective of the vibration-isolated mounting was the isolation of disturbing ground vibration of 11 foundations in 11 measurement boxes. The components to be characterized in the boxes are becoming increasingly smaller and thus generate high demands on the equipment used. Certain operations may only take place in special labs, protected from external disturbances which are reduced to an absolute minimum. This article describes how such laboratories were realized in terms of vibration isolation.

An electron beam writer, for example, has a beam just over three nanometers wide, which is also used in computer chip development. This beam is as thin as 1/30,000 of a human hair. With a so-called transmission electron microscope (TEM) researchers can e.g. analyze nanostructures within atomic resolution. Unimaginably small floor vibrations are already enough to prevent the high-tech equipment from providing the desired precision. The measurement foundations should therefore be designed for very high vibration requirements. The aim was to reach a vibration level on the foundations, which is - in the terminology of the VC curve according to IEST-RP-CC-121 - below the VC-E line by a factor of 256. This level corresponds to a non-normed VC-M line with a constant 1/3-octave-band velocity spectrum of 0.012 microns/s in the frequency range of 8-100 Hz following an acceleration-constant

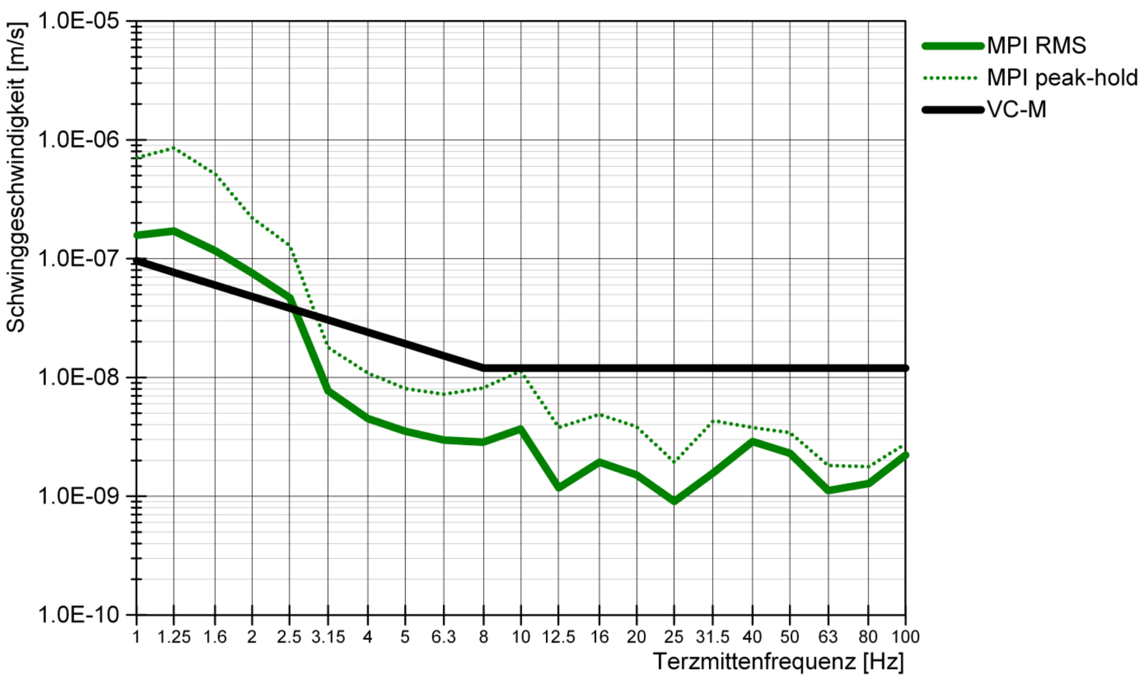

Fig. 1: Result of the vibration measurement on the foundation block isolated with Bilz membrane air springs

continuation between 8 Hz and 1 Hz (see Fig. 1). **This requirement exceeded former technical experience especially in the field of vibration isolation!**

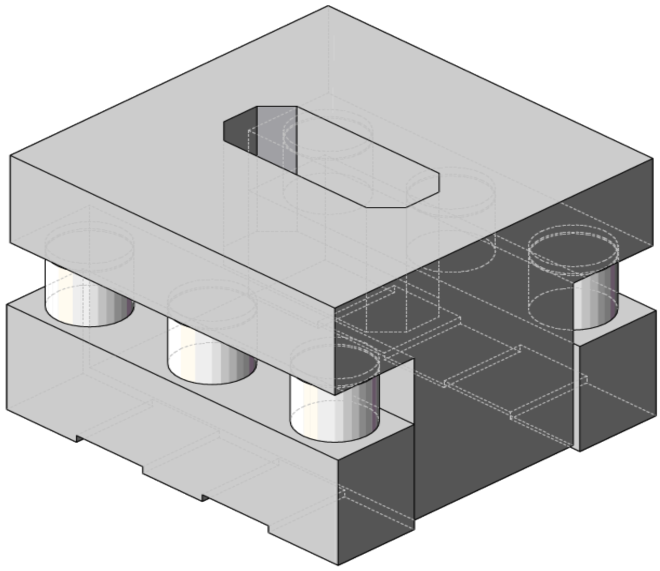

Fig. 2: Schematic display of a foundation block

The vertical eigenfrequency of the foundations (natural frequency of rigid body motions in vertical mode) should be 1 Hz. The corresponding horizontal eigenfrequency should not exceed 2 Hz. The damping rates should, based on the translational vertical and horizontal natural frequencies, be about $\zeta = 0.1$ and be adjustable as far as possible in this area. A particularly important requirement was that the air spring elements should be realized out in a non-magnetic material. The masses of the six different types of foundations (see Fig. 2) and the thereon installed devices were between approx. 110 t and 160 t. Added to this was a small foundation with a mass of about 20 tons.

Position control of the foundations

Fig. 3: Level monitoring system installed outside the chamber

Future experiments on the isolated foundations include measurement times of up to 100 hours. During this time, the relevant measuring boxes are closed and operated without access by people and without active cooling or ventilation. Within this measuring period, the air spring elements should be operated with closed valves and without any operating pneumatic position control. However, there should be a monitoring of the foundation block level including a level display and warning signals (see Fig. 3). The use of electronic or mechanical-pneumatic level-control systems for the operation of the air bearing is to be avoided under these circumstances or should be reduced to a minimum.

As an innovative manufacturer, Bilz designed an air spring of the type BiAir® -Max consisting of a cast aluminum base body and all components of the pneumatic level control out of non-magnetic materials (see Fig. 4). Furthermore, new grounds were also broken for the conception of a switching mode for the air springs to be used from outside the chamber (Active = level control ON / Passive = level control OFF), as well as for a level moitoring operating independently from the pneumatic system. The frequency-dependent air spring properties as well as the resulting global vibration level on the foundation blocks in the operating mode were checked by Müller-BBM (NL BFB Stuttgart) GmbH as an independent source (see Fig. 1).

Fig. 4: Membrane air springs BiAir® 5-ED/HE-Max under the foundation block

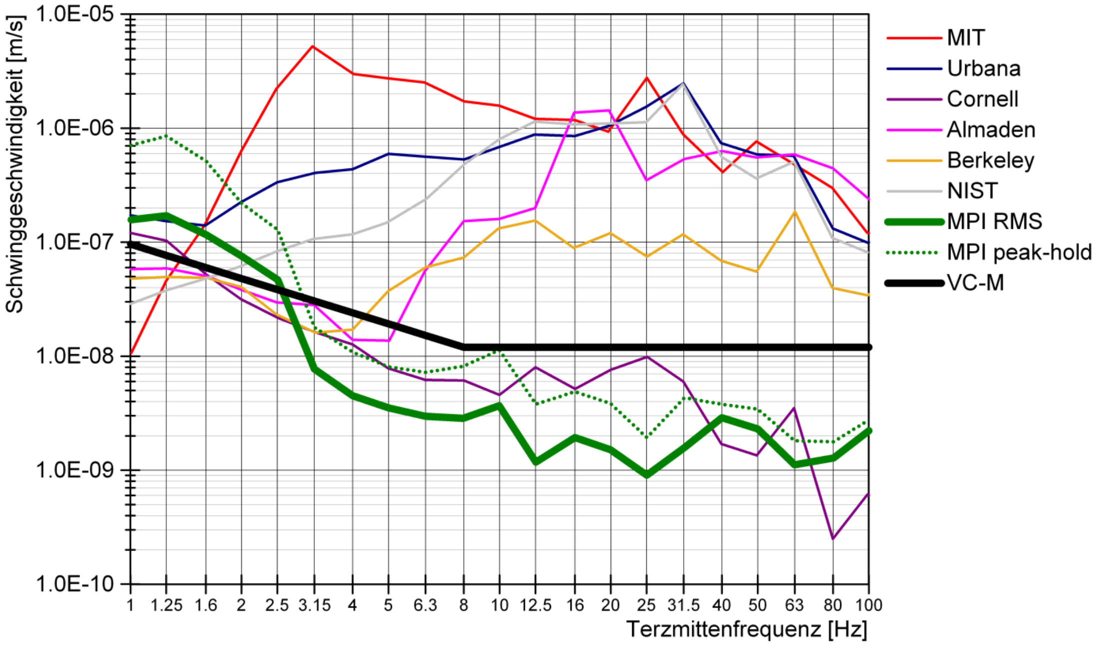

Fig. 5: Requirements for vibration-isolated foundations in comparison

Fig. 5 shows the results of the vibration measurement carried out by Müller-BBM on one of the isolated foundation blocks compared to the requirements of other globally accepted institutes. In the relevant frequency range between 3 Hz and 30 Hz the results are well below the requirements for the VC-M criterion and are thus unique in international comparison.

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