Generic Vibration Criteria Curves for Vibration-Sensitive Equipment

Environmental vibration is an important issue for facilities using sensitive tools and machines. Examples are photolithography in microelectronics, equipment for manufacturing nano-electronic devices, scanning electron microscopes (SEM) or transmission electron microscopes (TEM) in biomedical and biopharmaceutical research. In some cases acceptable limits have been specified by the manufacturer of the equipment but sometimes the limits are unknown. For this case “Generic Vibration Criteria” have been elaborated in the 1980s, among others, by IEST.

Generic Vibration Criteria (VC) are measured in three directions as third-octave band velocity RMS spectra. The curves are labeled VC-A through VC-G.

Vibration criteria	**Vibration level (RMS third-octave spectrum)**	**Application**	**Size of structure**
Perception threshold	100 µm/s (4 to 80 Hz)	Threshold of human perception, for sensitive sleeping areas, opera halls, theaters, microscopes with 100× magnification	30 µm
VC-A	50 µm/s (4 to 80 Hz)	Microscopes with 400× magnification	8 µm
VC-B	25 µm/s (1 to 80 Hz)	Inspection instruments, high-quality laboratories, lithography equipment (including steppers)	3 µm
VC-C	12.5 µm/s (1 to 80 Hz)	Microscopes with magnifications up to 1000×, good standard for most lithography and inspection equipment	1 µm
VC-D	6.25 µm/s (1 to 80 Hz)	high-quality electron microscopes (REM, TEM), electron beam systems	0.3 µm
VC-E	3.1 µm/s (1 to 80 Hz)	Compliance with this criterion is very difficult and may only be possible in a few cases, preferably on foundation slabs without an underlying cellar. Necessary for equipment of the highest precision.	0.1 µm
VC-F	1.6 µm/s (1 to 80 Hz)	Extremely still research rooms, very difficult to achieve; only suitable for characterization and not as a design criterion.	
VC-G	0.8 µm/s (1 to 80 Hz)	Extremely still research rooms, very difficult to achieve; only suitable for characterization and not as a design criterion.	

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Vibration criteria for nanotechnology can be found in VDI 2038-2:

Nano Criterion	**Vibration level (RMS third-octave spectrum)**	**Application**	**Size of structure**
Nano-D	1.6 µm/s from 1 to 5 Hz 6.4 µm/s from 20 to 100 Hz	Very hard to observe criterion for REMs in nanotechnology, upper floors with high requirements regarding dynamic stiffness and natural frequency	1 nm
Nano-E	0.8 µm/s from 1 to 5 Hz 3.2 µm/s from 20 to 100 Hz	Extreme criterion for REMs in nanotechnology, compliance only possible on very massive foundation slabs and with very favorable soil conditions	0.2 - 0.5 nm
Nano-EF	0.53 µm/s from 1 to 5 Hz 2.1 µm/s from 20 to 100 Hz	Strictest criterion for REMs and TEMs in nanotechnology for resolutions in the sub-Ångström range, compliance only possible under very special conditions and with special building designs	0.1 nm

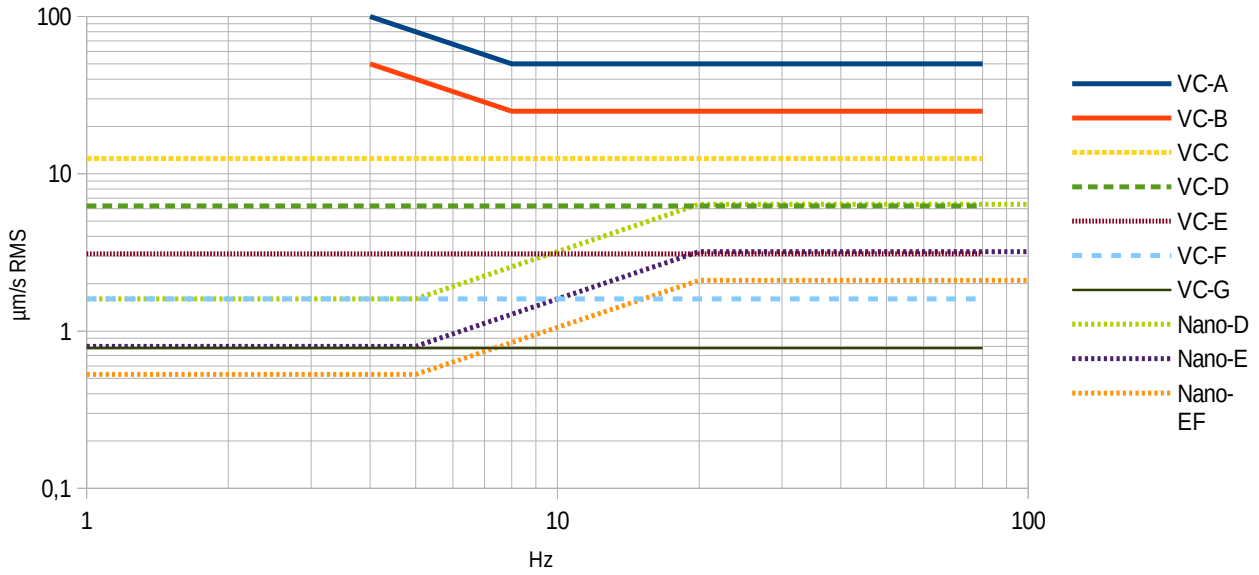

Figure 1: VC and Nano limit lines

For comparison, the limit for perceptible vibration is between 100 and 200 µm/s.

Another method for the classification of vibration in buildings with sensitive equipment has been formulated by in ISO/TS 10811.

For the selection of a suitable sensor it is most important to compare noise at the lower frequency end where the lowest acceleration components occur.

As an example, the triaxial accelerometer KS823B has a noise density of 0.8 µg/sqrt(Hz) at a frequency of 1 Hz. Using the method described above for a frequency range from 1 to 10 Hz the noise density at the lower frequency is multiplied with the square root of the difference between the upper and the lower frequency limit. The approximate noise contribution of the sensor will be 2.4 µg or 24 µm/s². At 1 Hz this corresponds to a velocity of $v = a/\omega = 3.8$ µm/s. Doing the same calculation for 10 to 80 Hz where the noise density is 0.2 mg/sqrt(Hz) at 10 Hz we get a noise value of 1.7 µg which corresponds to 2.7 µm/s at 10 Hz. Thus the KS823B can be used down to vibration criterion VC-D.

Even lower vibration can be detected with the accelerometer KB12VD with its noise density of 0.06 µg/sqrt(Hz) at 1 Hz. This sensor is suitable for measurements down to VC-F and Nano-EF under the assumption that the noise of the signal path is in the same range as the noise of the sensor.

Metra offers the VM100 vibration analyzer and the module VM-OCT+ of the VibroMetra system for the measurement of VC and Nano criteria.

Links

Evolving criteria for research facilities: vibration
https://spie.org/Publications/Proceedings/Paper/10.1117/12.617970?SSO=1

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