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A pathway to a low-vibration laboratory

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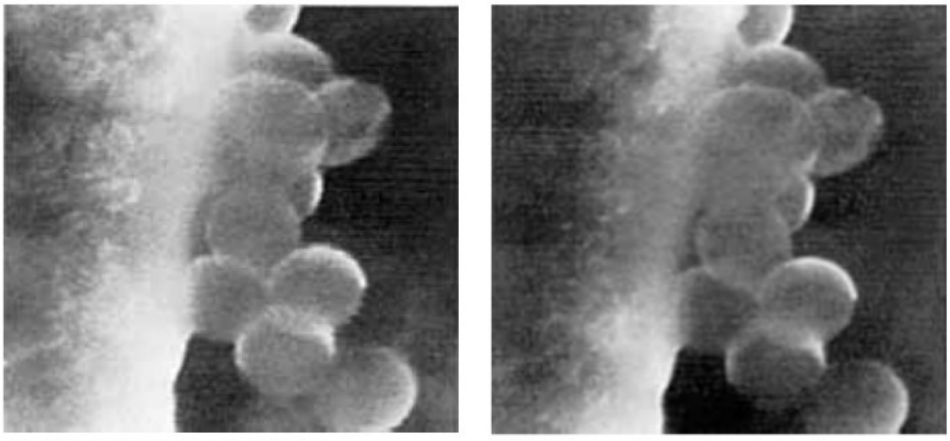
The evolution of research, fabrication and application of micro- and nanostructures requires devices with higher accuracy on a smaller scale. Due to this increasing imaging demands, vibration levels in laboratories become critical. When experiencing disturbance in the current facilities or when considering purchasing new equipment with stricter vibration demands, a vibration research of the laboratory, building and nearby site can reveal the normative vibration sources and possible solutions.

f1.1 Influence of mechanical vibrations on SEM-image [1]



(a) Influenced by mechanical vibration (b) Uninfluenced by mechanical vibration

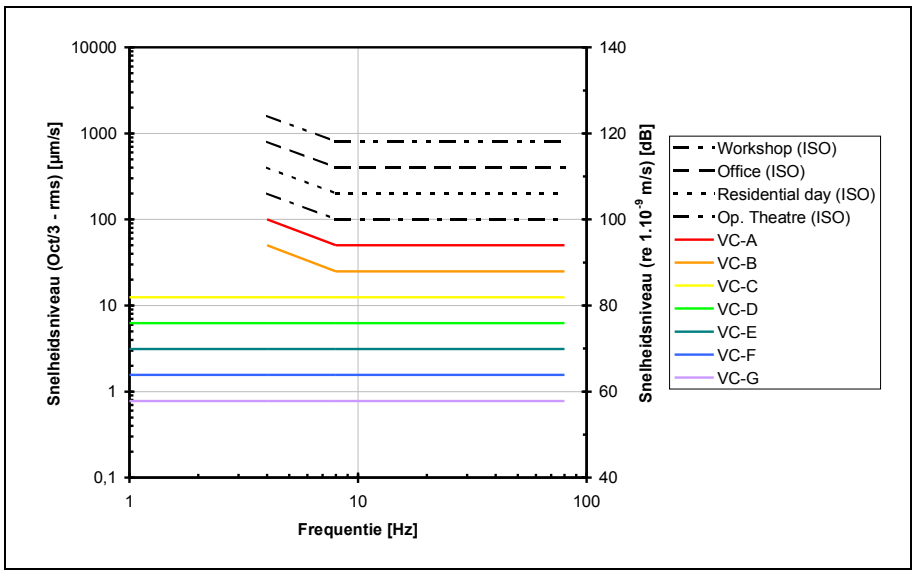
1 Low-vibration laboratories and generic criteria

Low-vibration laboratories are primarily intended to house research institutes which use sensitive equipment. Structure-borne vibrations are the main concern for researchers. In addition, acoustical noise, electromagnetic fields, radiation, air flows, particulates and temperature fluctuations are disturbing phenomena, which lead to strict requirements for the research facilities.

Research institutes demand facilities which are suitable for a wide variety of instruments and equipment. This has led to generic requirements of the floor quality. Implementation of these requirements results in a flexible layout and multifunctional utility of the laboratories. Generic requirements for vibration criteria are used to describe the performance

requirements, such as the VC-curves (vibration criteria) [2]. The VC-curves associate vibration levels to maximum resolution scale and thus indicate which research is possible when a certain VC-criterion is met.

f1.2 Generic performance requirements, VC-curves (vibration criteria) [2]



2 Vibration research, meeting demands

When the vibration levels in a research laboratory cause disturbance or dis-functioning of research equipment a vibration research can give insight in the problem. By narrowing down the problem to the dominant vibration sources an implementable solution can be developed [3].

When experiencing vibration disturbance, the first step of a vibration research is to measure the background vibration levels. The measured background vibration levels can be compared to the VC-curves in order to see where the vibration levels deviate from the desired levels in accordance with the type of research. In some cases the manufacturer of research equipment has included vibration criteria in the equipment specifications. Comparing the measured background vibration levels with the vibration criteria reveals the frequency range where problems occur.

From our experience with vibration research in many different laboratories often the measured background vibration levels reveal the nature of the dominant vibration sources. This helps when trying to figure out which type of vibration sources cause disturbances.

f2.1 *Background vibration level measurement in laboratory at UTwente (left) and TU Delft (right)*

3 Identifying the vibration sources

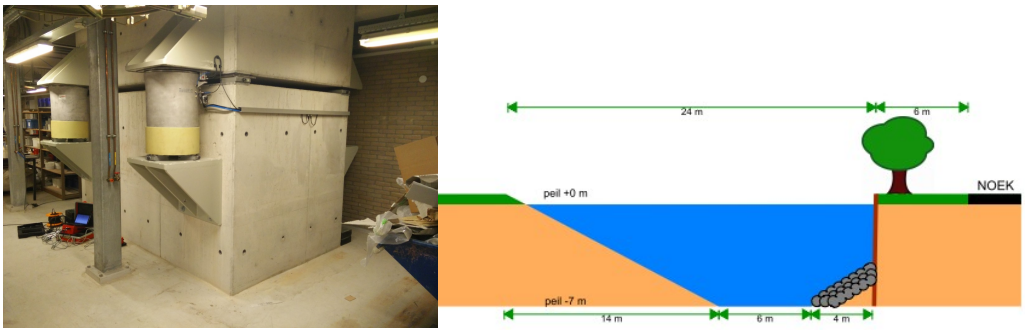
After acquiring the background vibration levels in the laboratory the second step of a vibration research is to identify the dominant vibration sources. Possible vibration sources in the laboratory (e.g. compressors, air-conditioning units), in the building (e.g. HVAC, elevators) and in the area surrounding the building (e.g. traffic, electrical transformers) are identified based on experience, visual inspection and in consultation with the laboratory users. In order to measure the specific vibration characteristics of the identified sources, near field vibration measurements are performed.

f3.1 *Near field vibration measurements next to compressor (left), elevator (middle) and traffic (right)*

4 Solutions to reduce vibration disturbance

The results of the vibration measurements of the identified vibration sources reveal the dominant vibration sources. The third step of a vibration research is to develop appropriate vibration reducing solutions. Preferably, the vibration reducing solutions are implemented at the dominant vibration sources. Possible solutions are relocating the dominant vibration source, positioning a dominant vibration source on vibration isolators (springs with low eigenfrequency) or place some sort of obstruction in the soil in order to shield the vibrations. The possible vibration reducing solutions are optimized using both simple and complex calculation models [4, 5].

f4.1 Examples of vibration reducing solutions, active vibration damping system (left) and vibration shielding using a water pond parallel to a road (right)



After implementation of the vibration reducing solutions, the background vibration levels in the laboratory and the vibration levels near the dominant vibration sources are measured in order to verify the effect of the vibration reducing solutions.

5 Resources

[1] JEOL, A guide to Scanning Microscope observation

[2] H. Amick, M. Gendreau, T. Busch and C. Gordon, Evolving criteria for research facilities: I - Vibration, SPIE Conference (2005)

[3] B. Snoeij, Eisen en ontwerp van trillingarme laboratoriumvloeren, de ontwikkeling van een trillingarm kennispark, Nationaal Congres Geluid, Trillingen en Luchtkwaliteit (2013)

[4] M.L.S. Vercammen, Vibration in buildings, Internoise Leuven (1993)

[5] J.F.W. Koopmans and F.C. van Eekhout, Onderzoek naar trillingen in de bodem met behulp van Eindige Elementen Methode, publicatie in Geluid (december 2003)