BRIEF TECHNICAL NOTES ON
VIBRATION MONITORING & CONTROL

An Informational Series V9711

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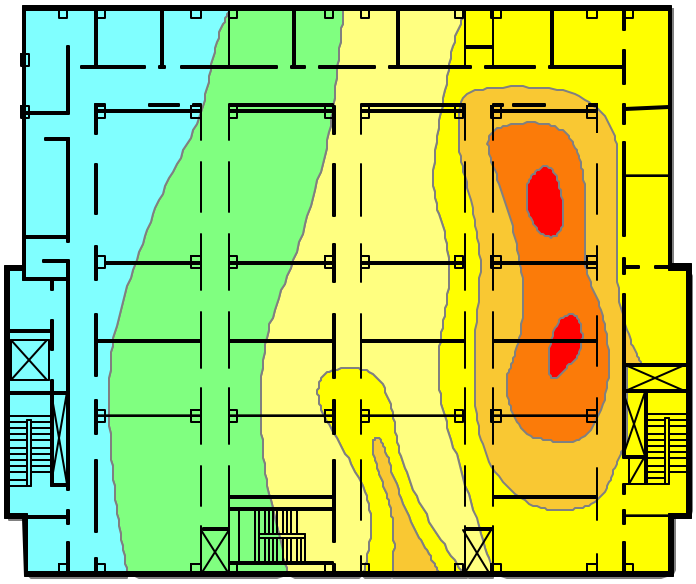
VIBRATION MAPPING FOR QUIET PLACES

Could we take the 'pulse' of the laboratory? Not just one or two rooms, but the whole building! That was our goal at the University of Minnesota: find high and low vibration areas of the building.

Shepard Laboratory was built in the late 60's and has housed laboratories for many research projects including study of some of the first moon rocks. In a university environment a facility such as this is constantly changing. As new grant money and research projects come in new equipment is created and installed. A space used for offices or high energy physics may be needed for the study of thin films or laser optics.

Many of the experiments are very sensitive to vibration. The resolution of microscopes and other precision equipment depends on limited movement of the equipment and the specimen. At the same time, equipment such as vacuum pumps and compressors create unwanted vibration.



Plan View -- Shephard Laboratory -- Vibration Contour Plot

FLOOR VIBRATION

Some of the mechanical equipment for the building needed maintenance and repair so there was another dimension to the equation.

Walter Carlson, Administrative Director, for the laboratory, was in a position to decide what projects would go into each area of the facility. He wanted to know where the quietest areas were as well as the areas of high vibration. Permission was granted to describe this study.

After discussing the project with Carlson and settling on some goals, the task of testing and collecting data was begun.

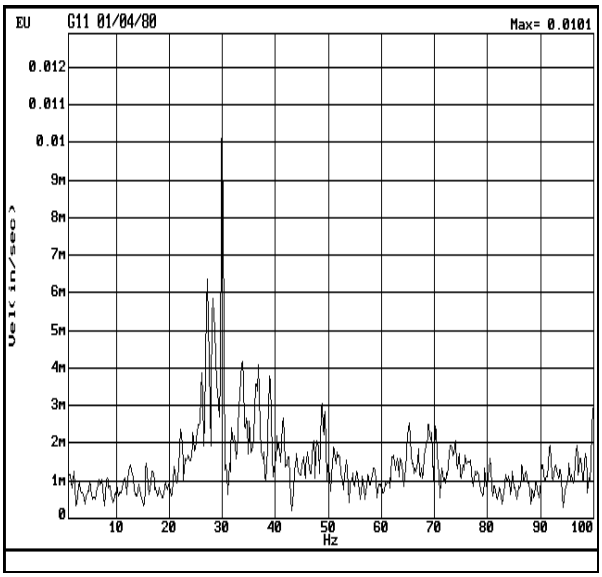
Armed with our spectrum analyzer, computer and accelerometers, we measured floor motion on each of the five stories of the facility. On each floor approximately 40 points were selected.

The equipment used is sensitive enough to measure displacements to 1 μ" (one millionth of an inch) over a wide frequency range of 1 to 100 Hz. While humans can feel vibrations in the range of 200 μ" at 10 Hz, some electron microscopes require vibration levels below 5 μ" at that frequency.

The equipment picked up floor motions due to cooling tower fans on the roof along with motion from pumps and compressors in the basement. Traffic on nearby streets could be seen as well as people walking down the hall. Each motion produced its own unique signature on the monitor.

VIBRATION CONTOURS

The study produced some interesting information. But how could the huge amount of data be summarized? Where were the patterns? Could it be mapped? It did not help to simply write down the peak displacements on the floor plan because each movement had an associated frequency. The frequency information associated a vibration with the cause.



FFT Spectrum Plot

In the frequency range from approximately 8 to 100 Hz, acceptance levels for machine balancing and for human sensitivity follow constant velocity lines. This allows one to judge the severity of a vibration by stating the particle velocity only rather than the displacement and frequency of the peak.

When the data was expressed in terms of a single variable at each point we could make a map; a vibration contour map of the building stated in peak velocity.

With this approach patterns could be seen. The northeast corner of the building was vibrating more than the rest of the structure. The vibration increased as we went higher in the building. With maps and spectra, the sources of significant vibration could then be easily identified.

IDENTIFYING SOURCES OF VIBRATION

Some problems were obvious such as fans with bad bearings. Others were more subtle. There were corridors with more foot traffic. Piping in need of isolators and small vacuum pumps that needed to be placed on pads. The cooling tower on the roof was badly in need of repair and there were pumps with improperly installed isolation systems.

Each source of excessive vibration could be located and identified by examining the velocity spectra. It was also possible to see how large an area a particular piece of equipment affected.

REDUCING VIBRATIONS

ESI produced a list of the problem areas along with suggested modifications and repairs. Each piece of offending equipment was identified and a suggested remedy was given.

The University acted on these recommendations and repaired or replaced equipment where possible. In some cases isolators were installed or replaced.

After repairs were completed, additional testing was done to evaluate the results and update the vibration contour maps.

Some of the problems could be solved, and others could not. But, now the building can be understood and managed for vibration. Critical work areas can be chosen and protected. The productivity of the staff and the quality of research can, no doubt, be improved.

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