

“Vibration Kills” and other Lessons from the Trenches

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Overview

- Criteria used by acousticians are usually upon parameters such as comfort, privacy, intelligibility, productivity, or machine precision.
 - Use of these criteria can involve a somewhat dispassionate attitude.
- With biological and medical research communities
 - Much of their work ultimately deals with life-and-death issues
 - patients for whom a drug, procedure or medical device is intended
 - organisms used in test protocols

Typical Effects of Vibrations

- Optical Devices
 - "Jiggle" or blurring of images* – Impairment of visual observation
 - Misalignment of sequential photographic images
 - Misinterpretation by visual processing software
- Electron Beam Devices
 - Straight lines become wavy* – Assessment errors, measurement errors
- Probe-Type Devices
 - Vibratory forces in sensor misinterpreted*
- Long-beam-path Devices
 - Beams deflected*, often causing energy loss or misalignment

Cases for Discussion

- Serendipitous discovery of life-saving medical device
- A surgeon's vibration-induced nausea (during spine surgery ... ouch!)
- Lab mice and vibration-induced startle
- Cell death during electrophysiology

Serendipitous discovery
of life-saving medical device

Arterial Stents

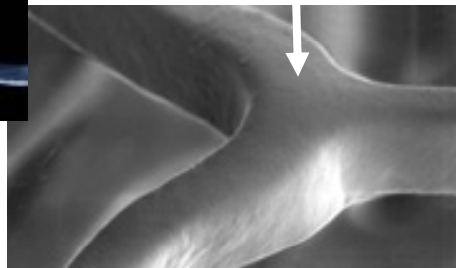
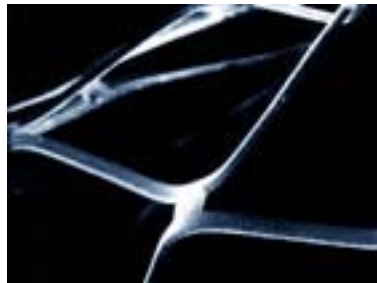
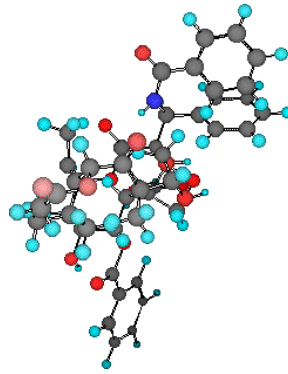
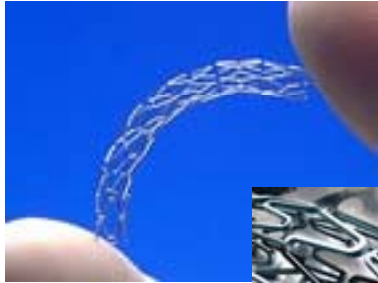


- **Stent:** A slender catheter inserted into a blood vessel, to provide support after balloon angioplasty or to facilitate expansion of the vessel diameter
- **Stenosis:** The constriction or narrowing or collapse of blood vessel after angioplasty or insertion of stent

Stenosis is a Big Problem

- Balloon angioplasty developed to unclog coronary arteries
- A certain fraction of them collapsed or grew inward to close again
- Stents introduced to keep them open
- Artery grew through the “cage” of the stent and inward from there
- Several drugs have been developed to fight this
- *A researcher discovered that one of them could be delivered directly to the artery by coating the stent*

Drug-eluting Stents



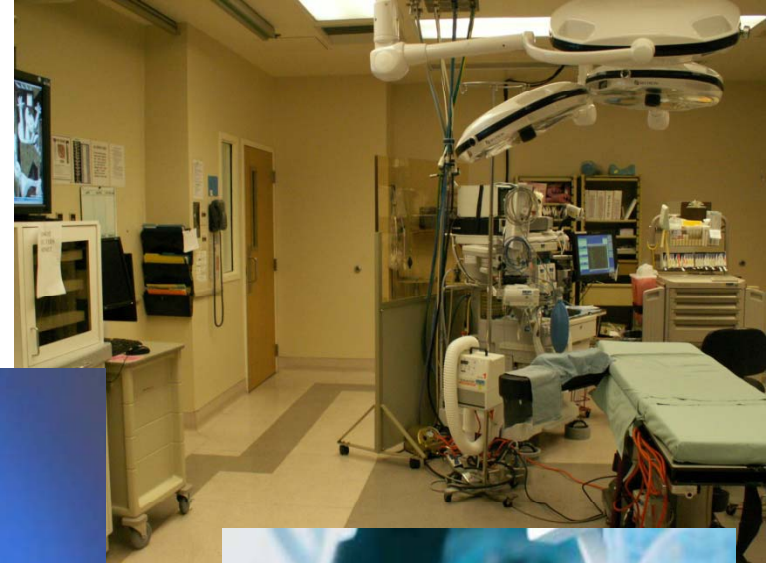
- *Several million* drug-eluting stents have been “installed”
- The drug is applied to the stent skeleton
- A chemical “trick” is employed to release the drug over time
- The “trick” is the result of a serendipitous observation of a chemical gradient that could be exploited to deliver the drug
- The researcher repeated the experiment a few months ago, artificially increasing the floor vibration to “generic lab” levels (VC-A)
 - The chemical gradient did not form. He would not have made his discovery!

A surgeon's
vibration-induced nausea
(during spine surgery)

oops!

Microscopic Surgery

- Some types of surgery require microscopy (10x to 50x)
 - Ophthalmic
 - Spine



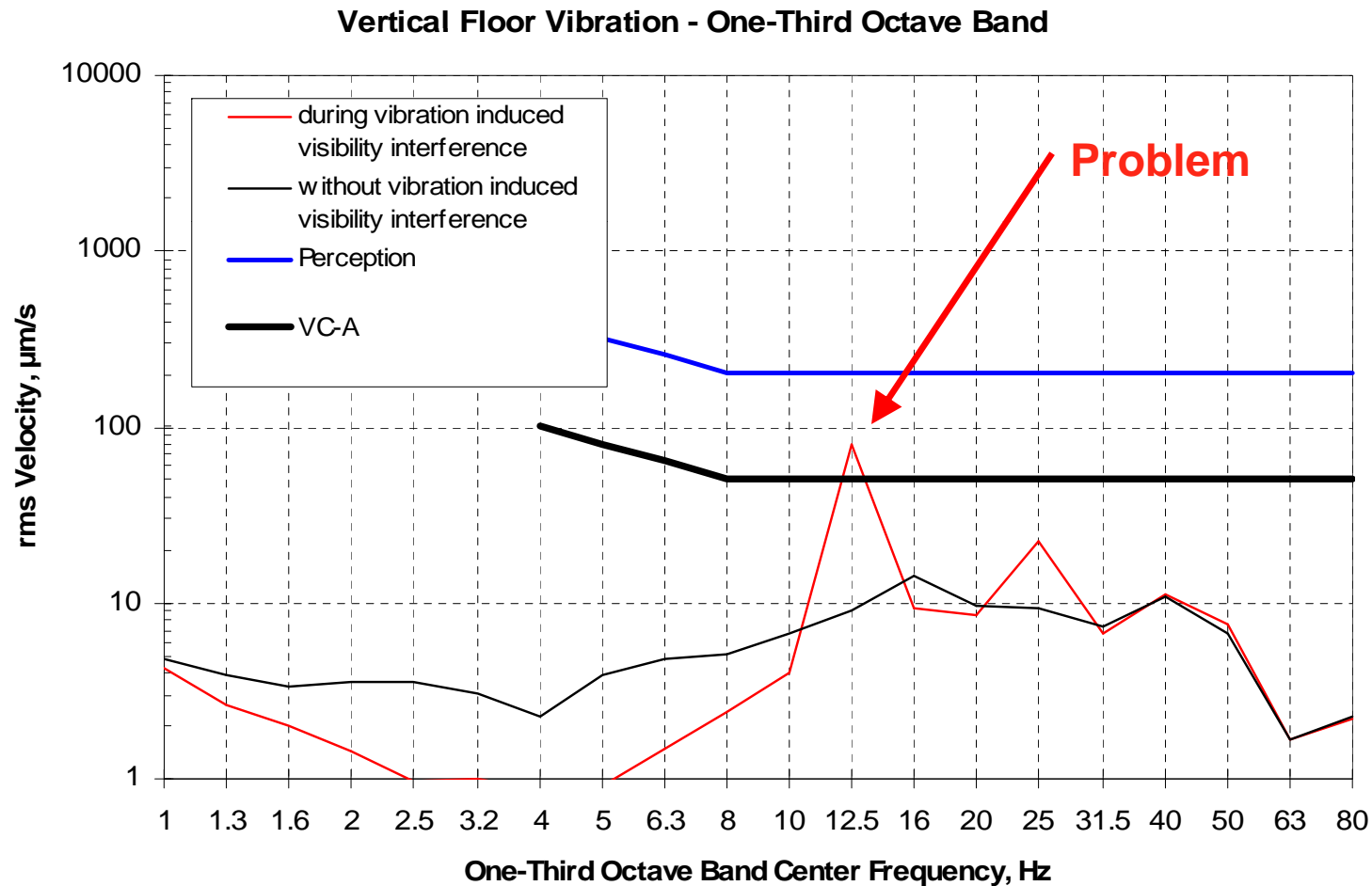
Our Assignment

- Our client: A regional medical center with four operating rooms, two dedicated to microsurgery, using floor-mounted microscopes
 - One Leica, one Zeiss
- “Occasionally” there are vibrations which cause the image to jiggle
- One of the surgeons is about to start refusing patients.

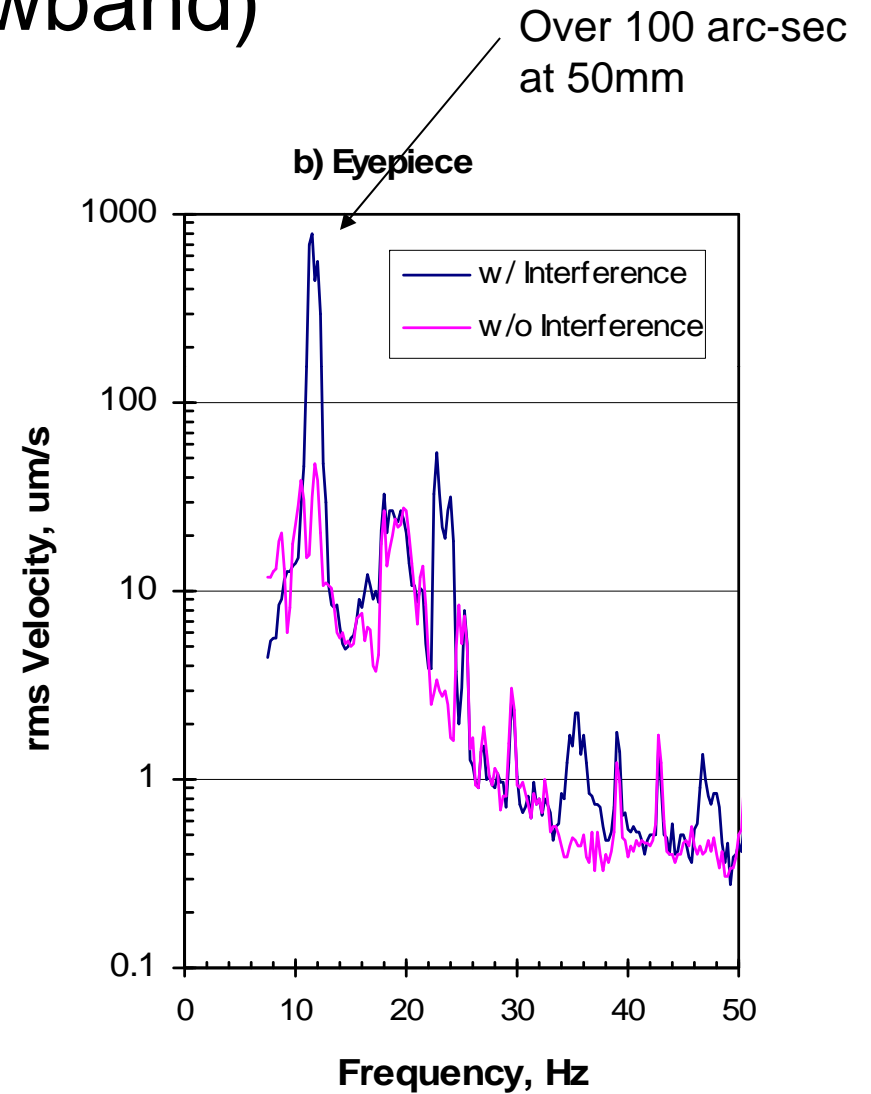
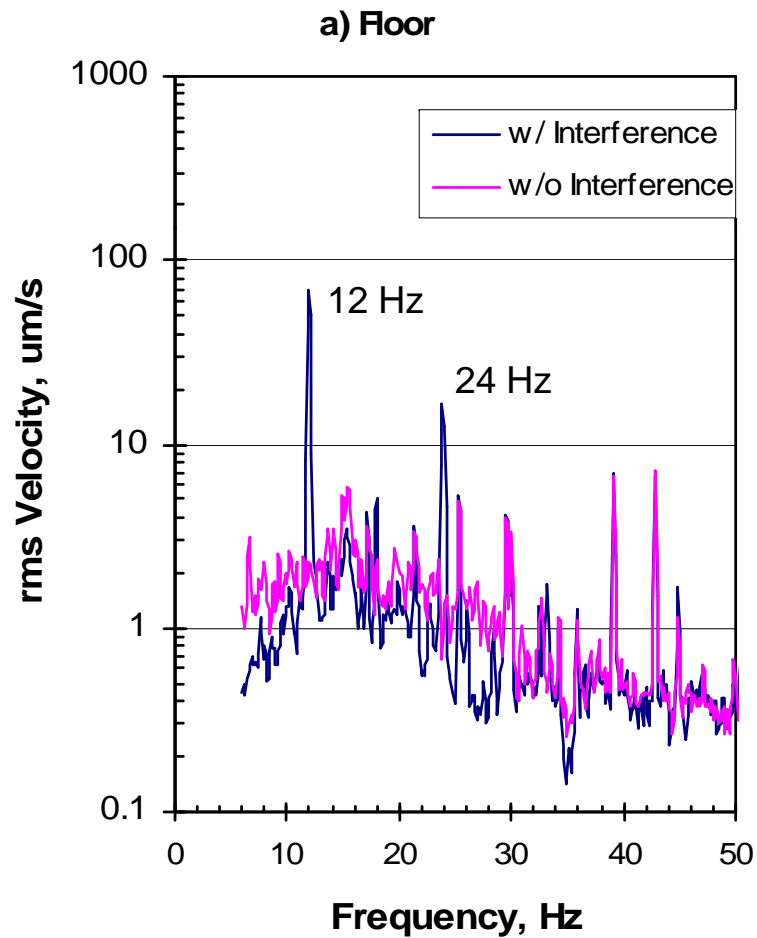
What we found ...

- Nice, stiff, concrete structure
- The “typical” vibration environment in these OR’s is below VC-A (OR criterion is $2*VC-A$)
- Footfall below VC-A
- Steady-state has some jiggle
- “Problem” occurs a few minutes at a time, a few times a day
- One surgeon routinely experiences nausea during the “problem”

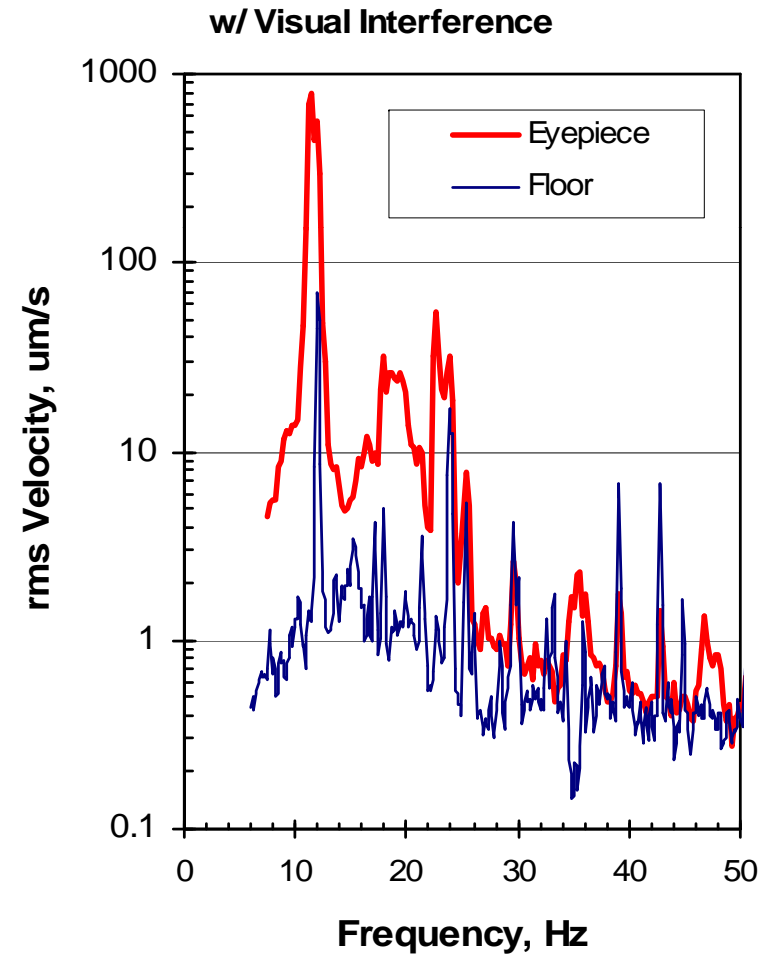
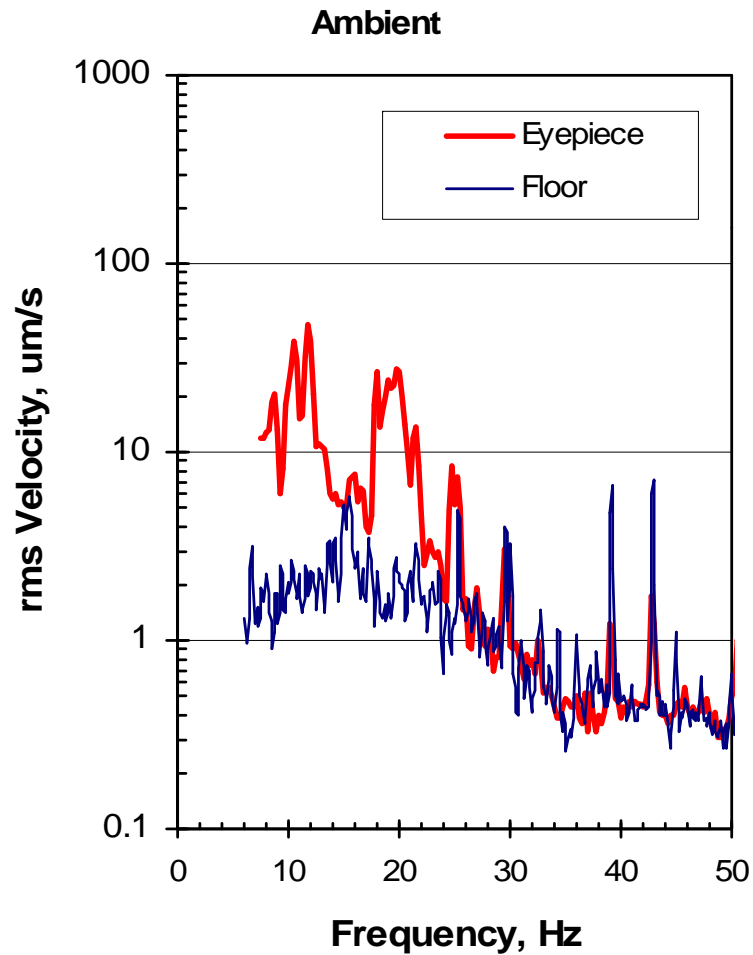
Routine Floor Measurements (why such a problem?)



Compare Floor and Eyepiece (in Narrowband)



Compare Floor and Eyepiece (in Narrowband)



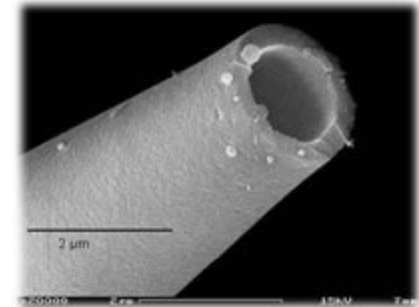
The Problem ...

- Resonance amplification is a fact of life
 - 8-12 Hz, 18-21 Hz, in this configuration
- Intermittent vibration from mechanical equipment (12.0 Hz and harmonics) only slightly exceeded VC-A
- Improve the vibration isolation on the mechanical equipment
- Was VC-A adequate?

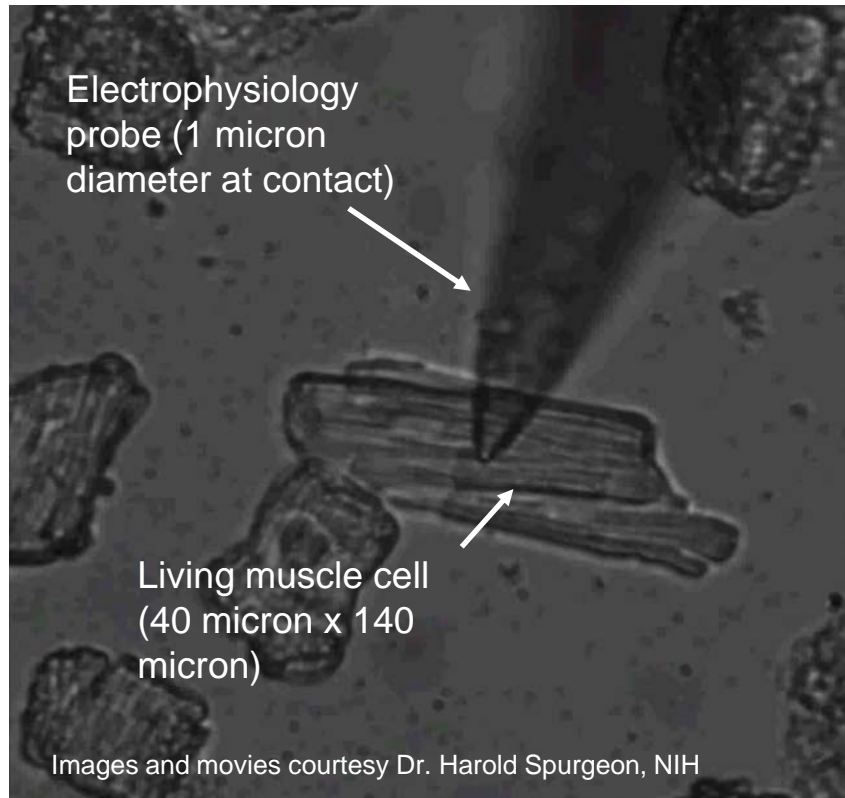
Cell Death
during
Patch-Clamp Experimentation

Whole-Cell Patch Clamp Work (e.g., Electrophysiology)

- Patch pipette (photo) of diameter 1 μm is electrostatically “attached” to a cell
 - Can inject material into cell
 - Can remove material
 - Can monitor cell
 - Can stimulate cell
- Excessive vibration can damage the attachment, causing leakage and cell death



Vibration can Kill – (literally)



- Excessive vibration can damage (and thus kill) cells during electrophysiology experiments.
 - Image at left shows a typical setup. Movie shows cell death after nearby “heel drop” on floor
- Excessive vibration can prevent important discoveries from happening
 - Researchers may assume a process “just doesn’t work” and not realize it didn’t work because of vibration

Conclusion

- Most criteria used by acousticians and vibration consultants are based upon “dispassionate” parameters
- Some criteria associated with biological and medical research communities deal with life-and-death issues
 - Test specimens
 - Ultimate beneficiaries of research
- In some cases, we know conceptually what to avoid, but don't have a criterion
 - The “easy out” is to be conservative—use VC-A
 - Value Engineering (VE) is challenging uses of conservatism

Thank you

Questions?