Vibration Sensitivity of a Laboratory Bench Microscope

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Presented at the First Pan-American/Iberian Meeting on Acoustics; 144th Meeting of the Acoustical Society of America, 2-6 December 2002, Cancun, Mexico

Overview

- Definition of Problem
- Tests of Microscope Base Sensitivity
- Floor Vibrations
- Microscope Support
  - Common Types
    - Laboratory Benches
    - Optical
  - Vibrations at Base of Microscope
- Vibration Criteria as a Function of Magnification and Support

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Definition of Problem

- Vibration degrades image observed in microscope
  - Low frequency: Jiggle
  - Higher frequency: Blurring
- Not much information regarding vibration sensitivity of optical microscopes
- How does sensitivity vary with magnification?
- How the bench contribute?
- How much does an isolation table help?

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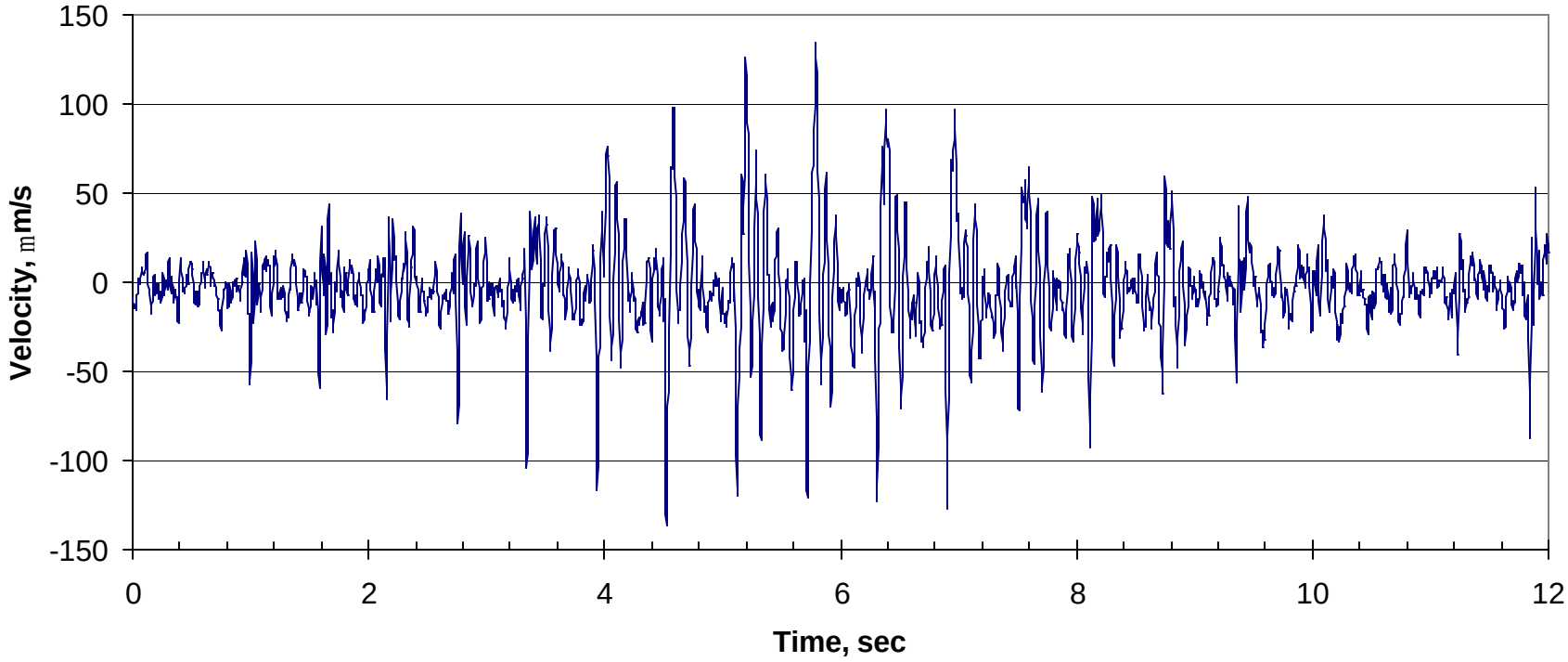
Typical Walker-Generated Floor Vibration (Vertical)



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Tests of Microscope Base Sensitivity

- Benchtop represents interface between the microscope and “the rest of the world”
- Document the sensitivity at the microscope’s base
- Document the modification to floor motion provided by the support bench
- “Back out” the limits of floor vibration

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Microscopes Used in Study

- Nikon Eclipse E400
  - 40x, 100x, 400x
- Nikon Optiphot
  - 1000x

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Basic Test Configuration

- Microscope and shaker on “springy” table
- Graduated Calibration Standard for gauging motion
- Tested in three directions:
  - ***Vertical*** – Microscope placed midspan, shaker placed behind it, vertical force
  - ***Fore-and-aft*** – Microscope placed at one end on centerline, shaker placed on table behind it with force axis through microscope
  - ***Side-to-side*** – Microscope placed at middle of edge on long side, shaker on table behind it above long’l axis of table

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Test a Given Direction's Sensitivity

1. Select a frequency
2. Set at lowest amplitude, turn on shaker
3. Watch through eyepiece
4. Increase amplitude until motion first visible
5. Record frequency and amplitude
6. Change frequency, repeat

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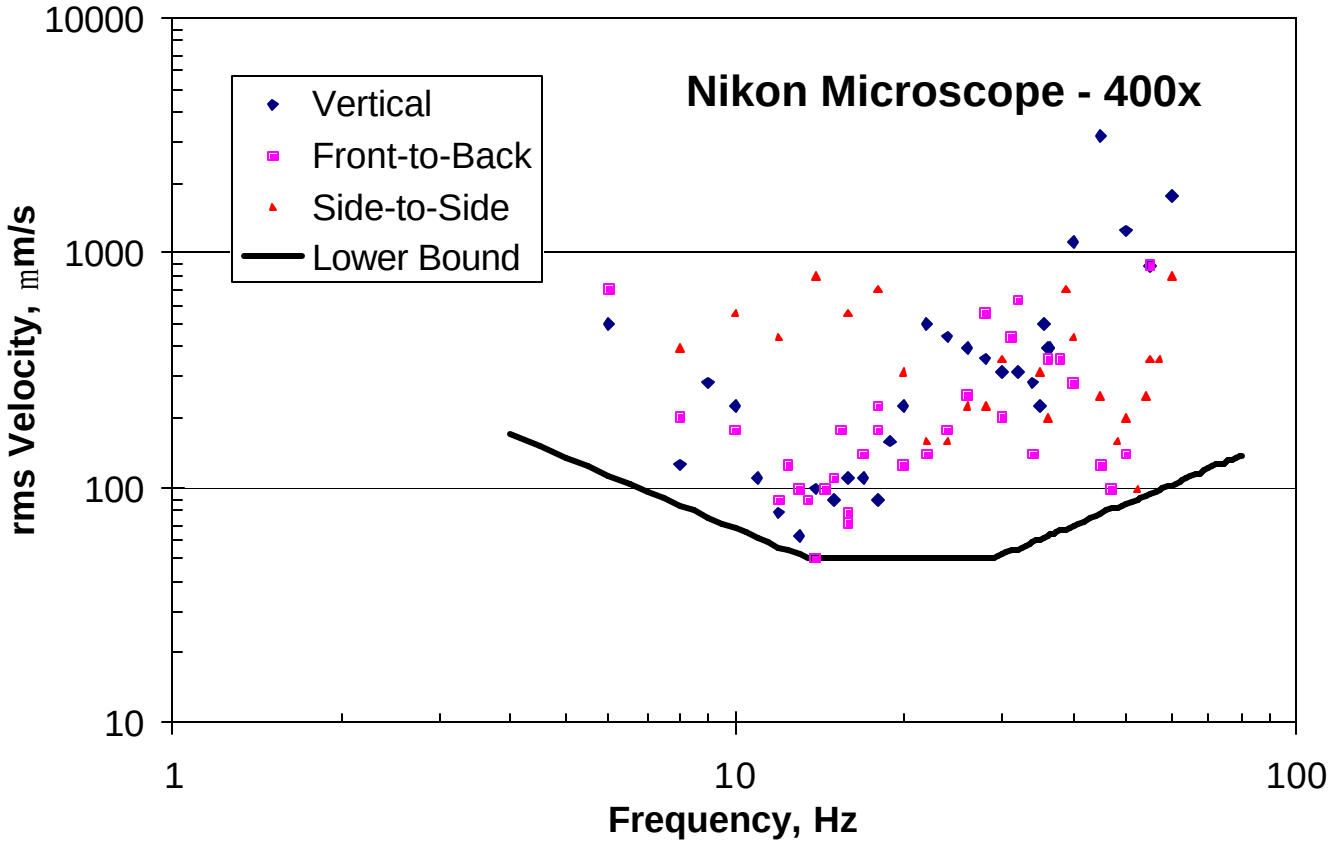
Lower Bounds – 1

(Omnidirectional)



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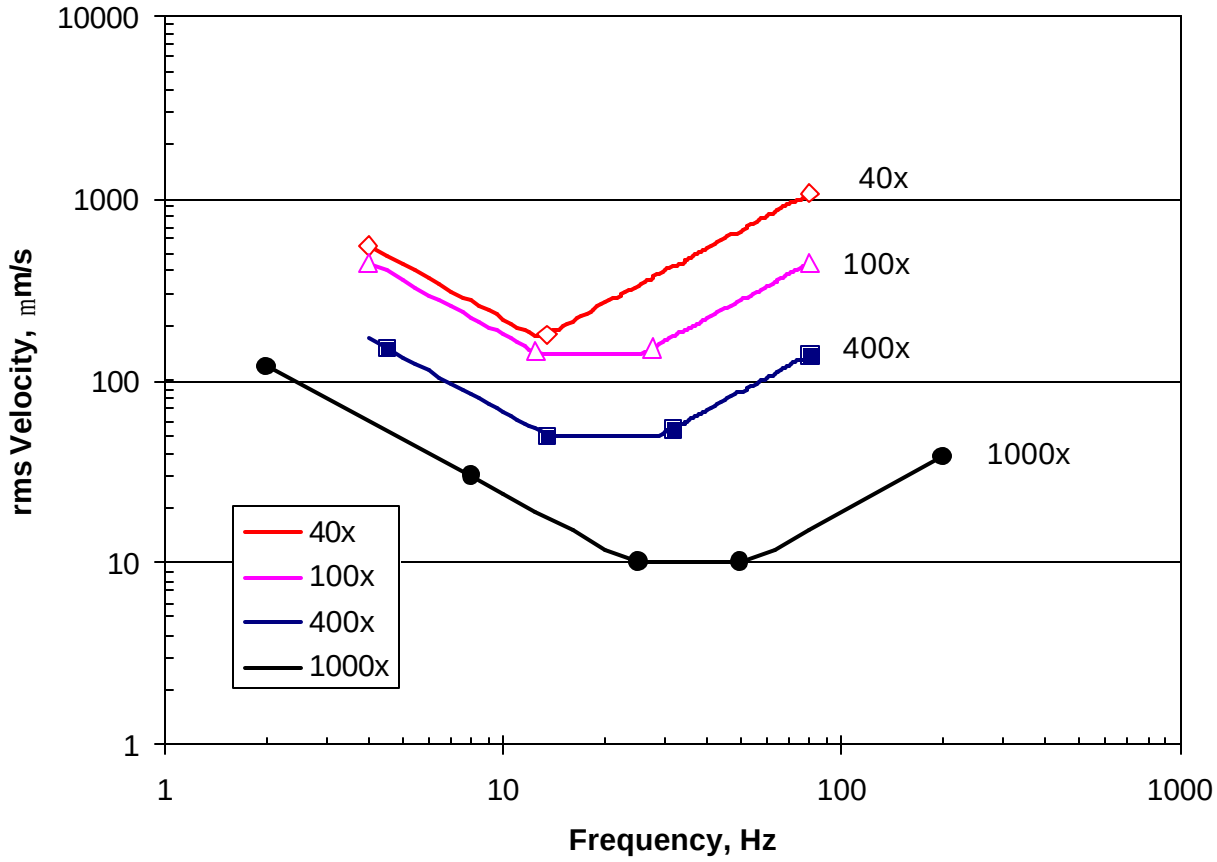
Lower Bounds – 2

(Omnidirectional)



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Microscope Support

- Primary excitation is floor motion due to people walking
  - Laboratory – Predominantly vertical
  - Raised access floor – Predominantly horizontal
- On laboratory bench
  - Bench amplifies vertical motion; “stiff” horizontally
- On cleanroom bench
  - Bench amplifies both horizontal and vertical motion
- On pneumatically isolated bench or benchtop support, such as those from Newport Corporation
  - Bench amplifies at very low frequencies and attenuates at higher frequencies

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Field Tests

- Performed at UCSF Genetech Hall, biotechnology research lab under construction
  - Built-in laboratory bench
  - Newport microscope isolation bench
- Measurement of walker-generated vertical vibrations on floor and benchtops
- Measurement of transmissibility of lab bench and Newport bench

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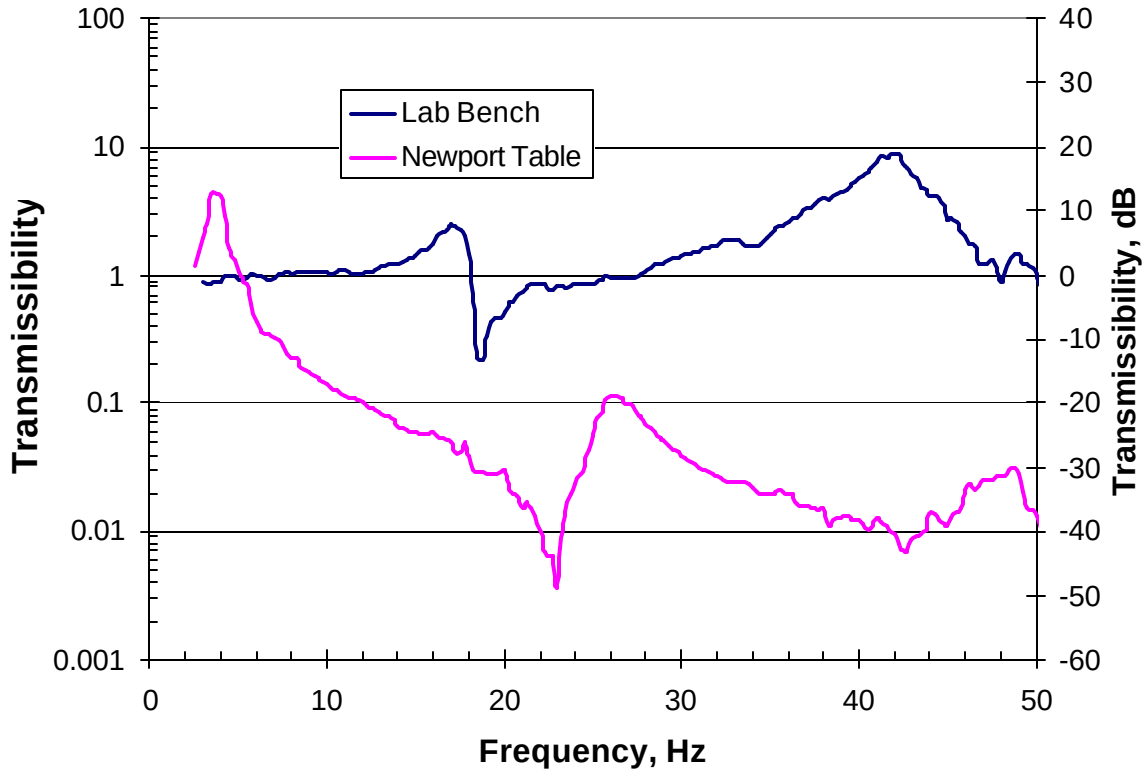
Compare Transmissibility

(Vertical Only)



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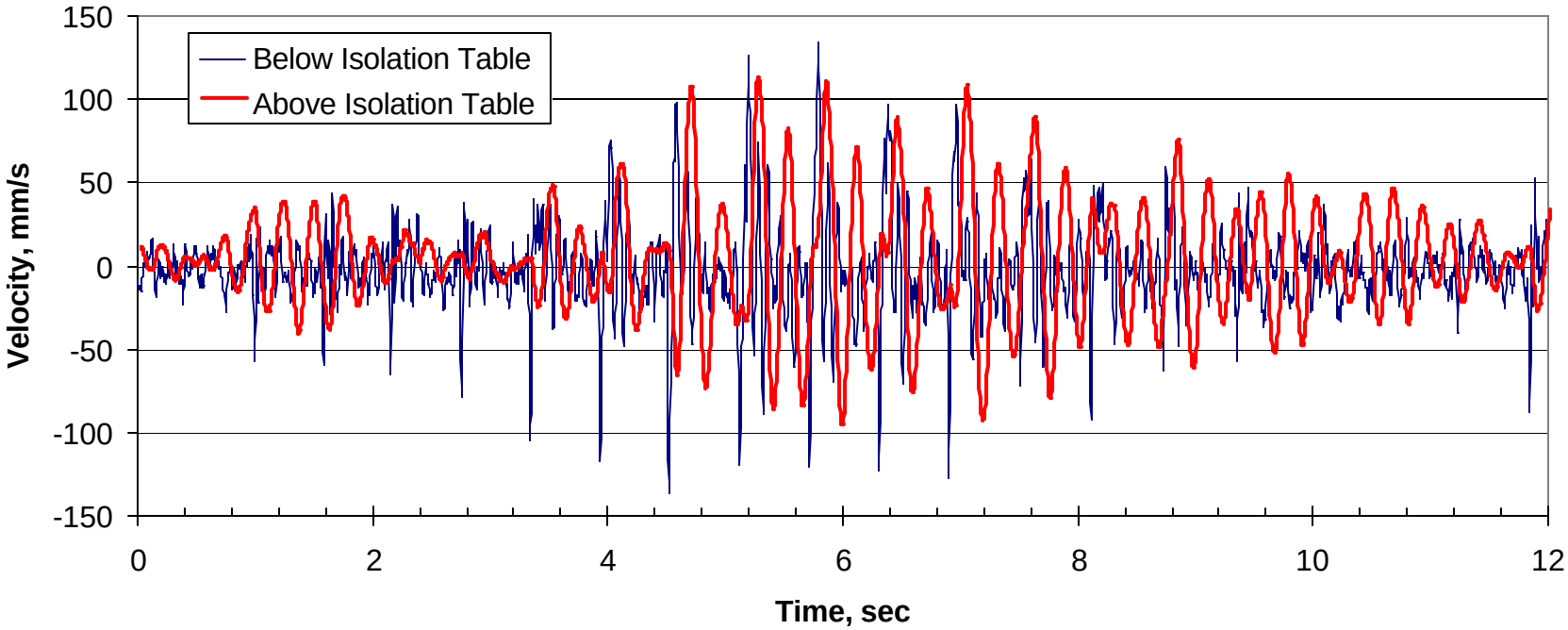
Time Histories
Floor & Newport Table



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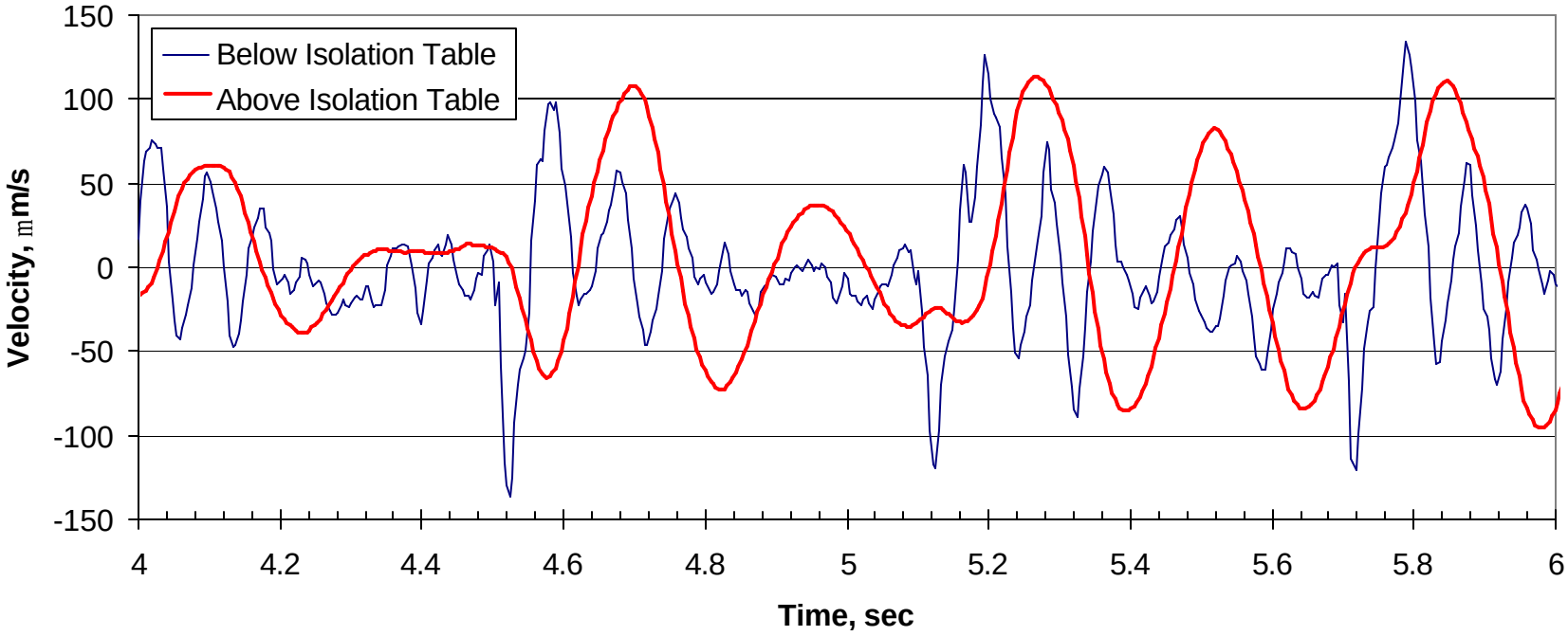

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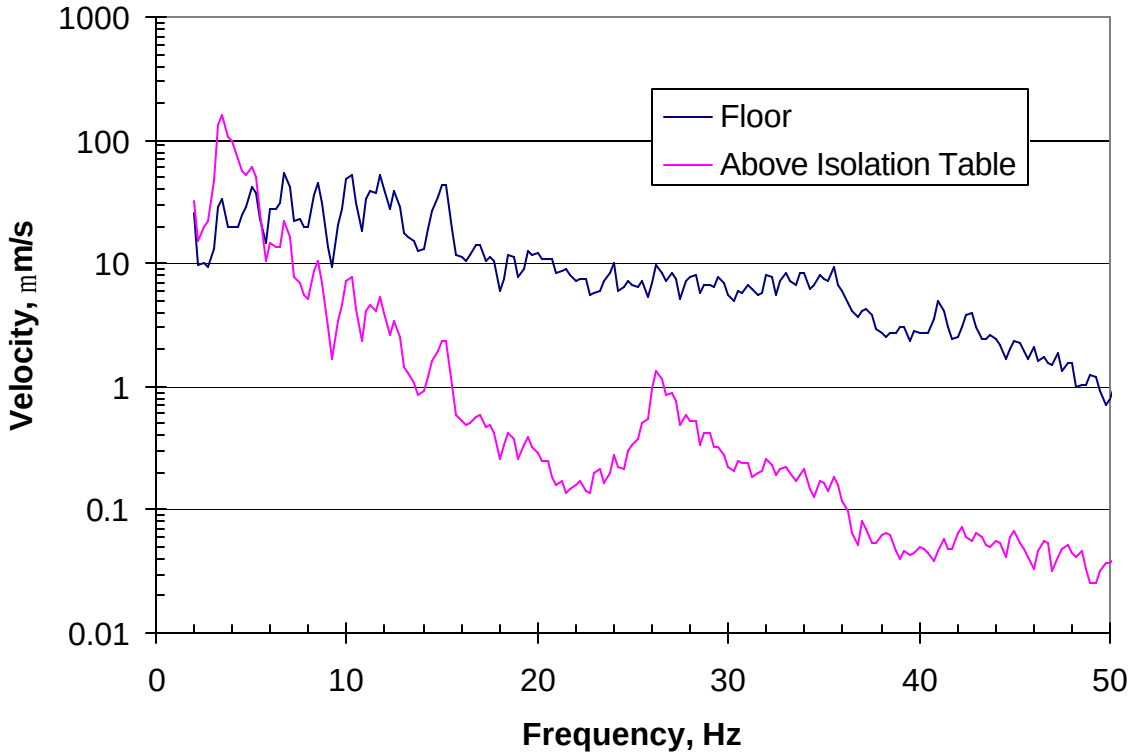
Walker-Generated Spectra Floor & Newport Table



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Vibration Criteria

1/3 O.B. Amplitude, μm/s (μin/s)	Old BBN designation	IEST designation	ASHRAE designation	Typical Application
100 (4000)			Curve F	Surgical suites
50 (2000)	BBN-A	VC-A	Curve E	"Generic" lab
25 (1000)	BBN-B	VC-B	Curve D	Non-Photo Semiconductor
12.5 (500)	BBN-C	VC-C	Curve C	
6.3 (250)	BBN-D	VC-D	Curve B	Semiconductor Photolithography
3.1 (125)	BBN-E	VC-E	Curve A	Nanotechnology

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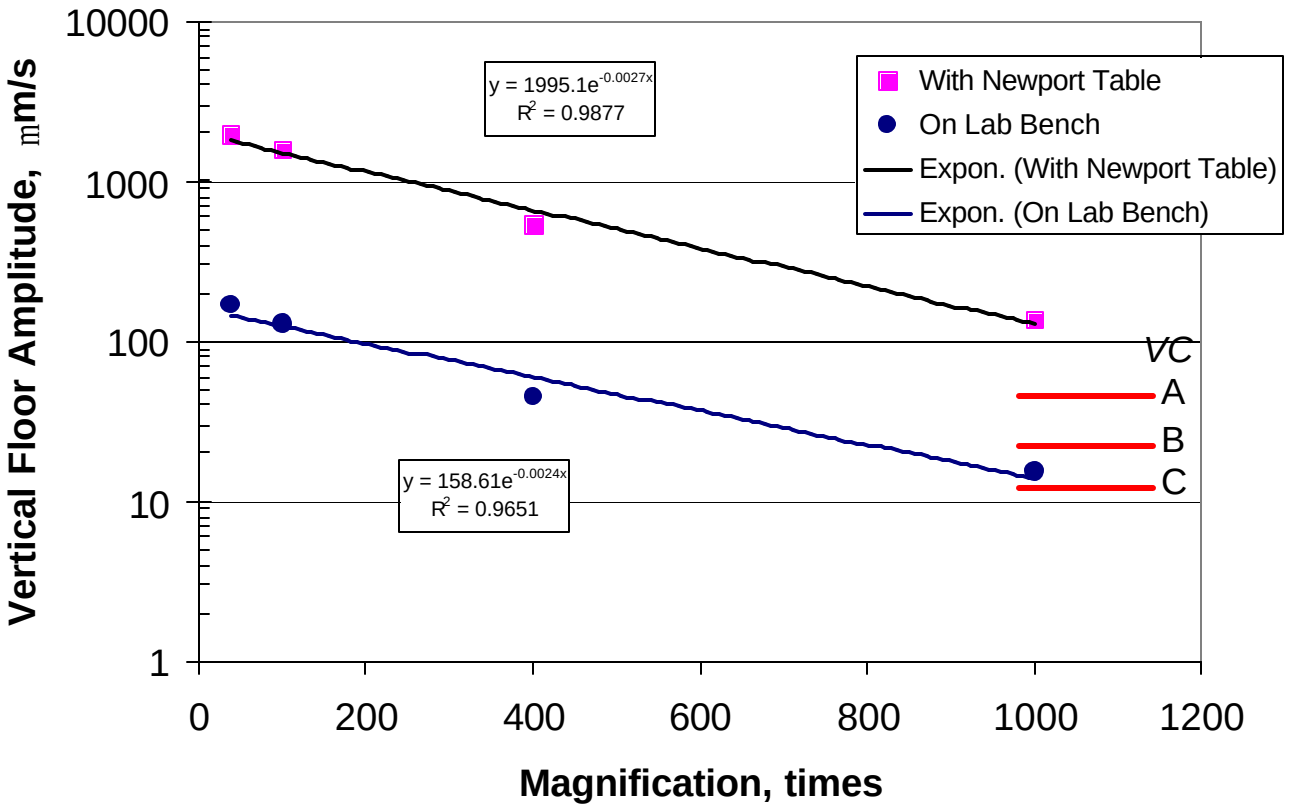
Variation of Sensitivity



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Floor Criteria for Microscopes

Magnification	Benchtop	Newport Table
40x – 100x	100 μm/s (4000 μin/s)	1000 μm/s (40,000 μin/s)
400x	VC-A 50 μm/s (2000 μin/s)	500 μm/s (20,000 μin/s)
1000x	VC-C 12.5 μm/s (500 μin/s)	125 μm/s (5000 μin/s)

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Conclusions

- Microscope equally sensitive in all directions
- Greatest sensitivity between 10 and 50 Hz
- Sensitivity increases with magnification
  - Relatively insensitive at 40x
  - Order of magnitude increase in sensitivity between 40x and 1000x
- Optical bench has major effect (~20 dB)

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