[research / education] [vibration / acoustics] [construction research / education] [architecture & engineering]

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Vibrations …
Should I worry?
What about?

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Vibrations – Should I worry?

Technical Spaces

- Metrology – YES
- High-end imaging – YES
- Low-end imaging – Maybe not
- Optical microscopy – Some
- Mass spectroscopy – Some
- Other characterization – Perhaps not
- Photolithography – Yes
- Probe development – VERY MUCH SO
- Theory and modeling – No

Non-Technical Spaces

- Probably not

Acoustics – Should I worry?

Technical Spaces
- High-end imaging – YES
- Metrology – YES
- Low-end microscopy (SEMs) - Perhaps
- E-Beam Lithography – Perhaps
- Optical Microscopy – No
- Animal spaces – YES

Non-Technical Spaces
- Auditoriums
- Conference rooms, especially with teleconferencing
- Offices

Cleanrooms
- If Class 100 or less, cannot be made extremely quiet!
- If Class 1000 or greater, requires special measures

What should I worry about?

- Facility's Goals
- Facility Requirements, cost of
  - Now
  - Future
- Future Flexibility, cost of
  - How important?
  - Cost of flexibility
- Conservatism, cost of
  - Required by equipment and/or process
  - For its own sake

What should I worry about?

- Selecting the design Team
  - Designers
  - Vibration / Acoustics consultant
- Facility Planning Issues
  - Criteria
  - Designing for specific equipment
  - Designing for processes
  - Communicating with design team
- Design Issues
  - How important are looks?
  - All at once or phased?
  - Internal or external mechanical systems

Get the most economical design

Define your needs clearly
- Now
- Several years from now

Know what will limit your environment
- From outside the building
- Layout and interior issues

Set a realistic design target
- Don't overdesign – get your money's worth
- Don't underdesign – will cost to fix

Be wary of "anecdotal design"
- Joe Scientist did such-and-such in Germany and likes his facility. Therefore, copy exact.
- Semiconductor facilities and copying exact

Use an experienced vibration and acoustics consultant

Q: What does a consultant do?

- Interpreter
  - Your needs
  - Your equipment's needs
  - Technical communication between design team members
- Prepares workable design criteria
- Coordinator of his/her technical information flow within team
- Body of knowledge, experience
- Designs a few specific parts of your building
  - Vibration isolation hardware
  - Floors
  - Prediction of room noise; design of mitigation

Select Vibration Criteria

Assemble equipment- and process-specific criteria

- Sensitivity based on internal distortion of beam path
- Criteria based on needs of individual tools

Assign generic criterion that meets "common denominator" requirements

- Well known in design and construction industry
- Clarify "level of effort"

Relevant "Generic" Vibration Criteria

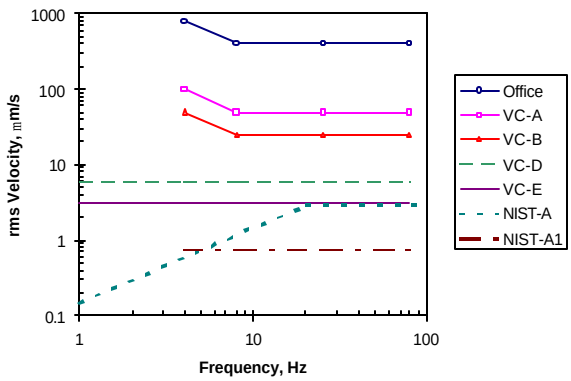
VC-A/B
- 50 or 25 μm/s (2000 or 1000 μin/s)

VC-D/E
- 6 or 3 μm/s (250 or 125 μin/s)

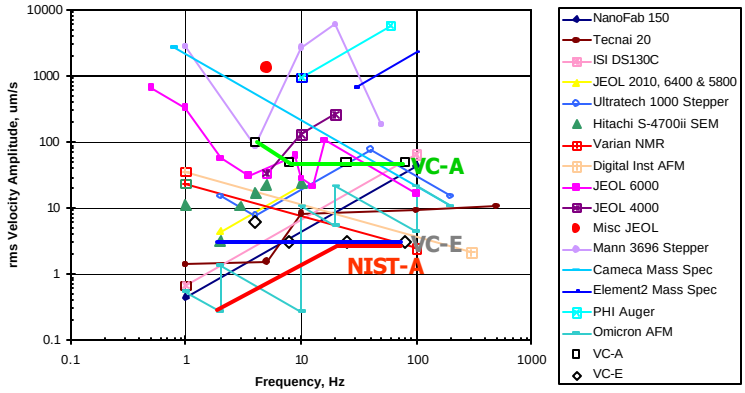
NIST A
- 0.025 μm (1 μin) displacement for $1 \le f \le 20$ Hz; 3 μm (125 μin/s, or VC-E) velocity for $20 < f \le 100$ Hz

NIST A1
- 6 μm/s (250 μin/s) for $f \le 5$ Hz; 0.75 μm/s (30 μin/s) for $5 < f \le 100$ Hz

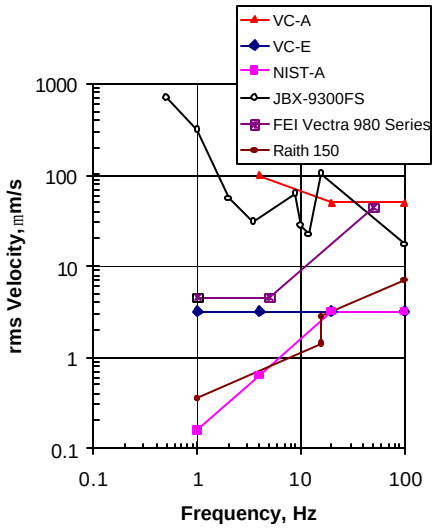
Relevant "Generic" Vibration Criteria



Representative Tool Criteria



Example of Specific Tool Criteria



Select Vibration Criteria

From a typical project ...

Space Category	Criterion, μm/s
Offices, Theory and Modeling	400 to 800
General Labs	50 to 100 (VC-A ±)
Class 1000 Cleanrooms	25 (VC-B)
Class 100 Cleanrooms	6 (VC-D)
Class 10 Cleanrooms	3 (VC-E)
Metrology	3 to 6
Nanostructures AFM / Atom Pushing	3 (VC-E or NIST-A)
Nanostructures Instrument Development	< 1.25

Additional Reading

"Facility Vibration Issues for Nanotechnology Research," Hal Amick, Michael Gendreau and Colin G. Gordon, Proceedings of Symposium on Nano Device Technology 2002, May 2-3, 2002, National Chiao-Tung University, Hsinchu, Taiwan.

"Dynamics of Stiff Floors for Advanced Technology Facilities," Hal Amick and Ahmad Bayat, Proceedings of 12th ASCE Engineering Mechanics Conference, La Jolla, California, May 17-20, 1998, pp. 318-321

"Dynamic Characteristics of Structures Extracted from In-situ Testing," Hal Amick, Michael Gendreau, and Ahmad Bayat, SPIE Proceedings Vol. 3786A , Denver, CO (July 1999), pp. 40-63.

"Design of Stiff, Low-Vibration Floor Structures," Hal Amick, Steve Hardash, Paul Gillett, and Ronald J. Reaveley , Proceedings of International Society for Optical Engineering (SPIE), Vol. 1619, San Jose, CA (November, 1991), pp. 180-191

"Vibration Data Representation for Advanced Technology Facilities," Hal Amick, Proceedings of 12th ASCE Engineering Mechanics Conference, La Jolla, California, May 17-20, 1998, pp. 306-309

"Analytical / Experimental Study of Vibration of a Room-Sized Airspring-Supported Slab," Hal Amick, Bea Sennewald, Norman C. Pardue, Clayton Teague, and Brian Scace, Noise Control Engineering Journal, March/April 1998, v. 46, no. 2, pp. 39-47

"The Effects of Ground Vibrations on Nanotechnology Research Facilities," Michael Gendreau, Hal Amick and Tao Xu, Proceedings of 11th Intl. Conf. on Soil Dyn. & Earthquake Engng. (11th ICSDEE) & the 3rd Intl. Conf. on Earthquake Geotech. Engng. (3rd ICEGE), 7-9 January, 2004, Berkeley, CA.

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