

APPENDIX 6 (not yet reviewed by UCCS)
STRUCTURAL ANALYSIS/VIBRATION CRITERIA

GENERAL

The purpose of this standard is to identify structural submittal requirements, as well as identify vibration design criteria for campus buildings.

A. During Schematic Design, the design engineer shall submit:

Code and Loadings:

State the governing code used for design. State the live loading to be used, including floor loads, wind, snow, and seismic, together with data to justify any difference from established criteria. Seismic design shall be in accordance with IBC. State the seismic zone and values used for K and C.

Structural System:

Provide a comparative description of feasible structural systems for the building, i.e., consider wood, steel, concrete, masonry. Give a description of the type of construction proposed and reasons therefore, including the structural framing system. The structural design should be carried only to the point where the total framing systems are determined and a realistic cost estimate can be made.

Foundation Design:

Describe the type of foundation proposed and define the basis for selection. Include bearing capacity, anticipated settlement, alternatives considered, and other pertinent design factors. Also include the depth of excavation, disposition of excavated material, whether in-place foundation material will be compacted, whether imported fill is required, whether compacted backfill will be utilized as foundation, and the frost penetration. State ground water level and method of waterproofing. State needs for drainage or vapor barrier. Describe pertinent corrosion control methods. Refer to the Soils Report included in the supplements.

Vibratory Design:

The structural design engineer shall submit a summary report of the vibration criteria that will be used in the structural design of the building.

Structural drawings should include:

Foundation plan

Floor and roof framing plan

Details are not required

B. During the Design Development phase the following plans shall be submitted:

Structural drawings should include:☐

Foundation plan☐

Floor(s) and roof framing plans: The majority of the framing members and columns shall have sizes indicated.☐

Some typical foundation details. Foundation plan shall show type of foundation proposed, depths, sizes and reinforcing of footings, relationship of walls and floor slab to foundation system, overall dimensions, column spacing, joint pattern in slab-on-grade, tie beams, grade beams, etc.☐

Some typical roof framing details

C. During the Construction and Contract Documents phase, the following shall be submitted:

Full or representative computations (depending on the size of project)

Present complete structural calculations covering all parts of the structure and miscellaneous facilities. Calculations shall be bound and indexed. When a computer is utilized to perform design calculations, the analysis will include, but not be limited to, the following information.☐

Design methods will be described, including assumptions, theories, and technical formulas employed in design solutions.☐

Present copies of computer input data and output summaries in user friendly language, accompanied by diagrams which identify joints, members, areas, etc., according to the notations used in the data listings, will form integral parts of the design analysis in lieu of manual computations otherwise required. Complete listing of all computer output will be provided in a separate binding when it is too voluminous for including in the design analysis. These listings will be augmented with intermediate results where applicable, so that sufficient information is available to permit manual checks of final results.☐

Live loads shall be placed to produce maximum stresses and minimum stresses where there is a possibility of stress reversal.☐

Vibrational criteria and supporting calculations demonstrating compliance with UCCS vibrational criteria.☐

If special methods of solution, tables, etc., are employed, references shall be made in the calculations to the sources of such material.☐

Adequacy of existing structure, where applicable, to account for new functional loads or new criteria.

Drawings

All drawings shall be complete and represent coordination by the architect with all disciplines. Evidence of this coordination shall be provided by the Architect at the Final Design Review.

- A. In order to minimize building construction costs associated with increased vibration control, laboratory areas and areas of sensitive equipment shall be designed to be located at-grade or below in the proposed building or addition.
- B. Facilities Services may require that a vibration consultant be employed to analyze both overall building structure and specific placement and isolation of machinery and equipment with moving parts. The structural engineer, mechanical engineer, electrical engineer, and the architect will be required to coordinate their work with this consultant and to follow Facilities Management direction based upon the recommendations of the vibration consultant.
- C. Vibration analysis shall conform to industry standards, such as American Institute of Steel Construction's *Design Guide 11*.
- D. General office spaces shall be designed to meet a recommended floor vibration velocity limit of 400 micrometers per second (Residential Day Criterion Curve, see Figures 1 & 2).
- E. Classrooms and computer lab spaces shall be designed to meet a recommended floor vibration velocity limit of 200 micrometers per second (Residential Day Criterion Curve, see Figure 1).
- F. General laboratory/research areas, where optical microscopes or other similarly sensitive equipment will be operated, shall be designed to meet a recommended floor vibration velocity limit of 50 micrometers per second (VC-A Criterion Curve). Figure 2 shall be used as a basis for vibration velocity limits when the sensitive equipment manufacturer's recommendations are not available.
- G. Precision instrument spaces shall be designed according to the sensitive equipment manufacturer's recommendations. These areas should be designed considering the effects of adjacent equipment, other sources of vibration, and operations. The use of a consultant specializing in vibration analysis and control is required for both new construction and renovations.
- H. The above criteria may be relaxed on a case-by-case basis provided the relaxed velocity limit will not affect the current and future utility of the space.

1.4 VIBRATION CONTROL ON MECHANICAL EQUIPMENT

- A. Provide vibration isolation devices for limiting transmittance of vibration from vibration-producing equipment to the structure on which it is supported or attached. The type of vibration isolation device is a function of building uses, size of mechanical equipment, and the frequency at which the equipment operates. The mechanical engineer or a vibration consultant shall consider these factors when designing the vibration isolation system.

- B. Provide the types of vibration isolation devices as recommended by the respective mechanical equipment manufacturers or vibration consultant, to isolate vibrations for each particular piece of equipment . Include a schedule of equipment (i.e. pumps and fans) to be isolated.

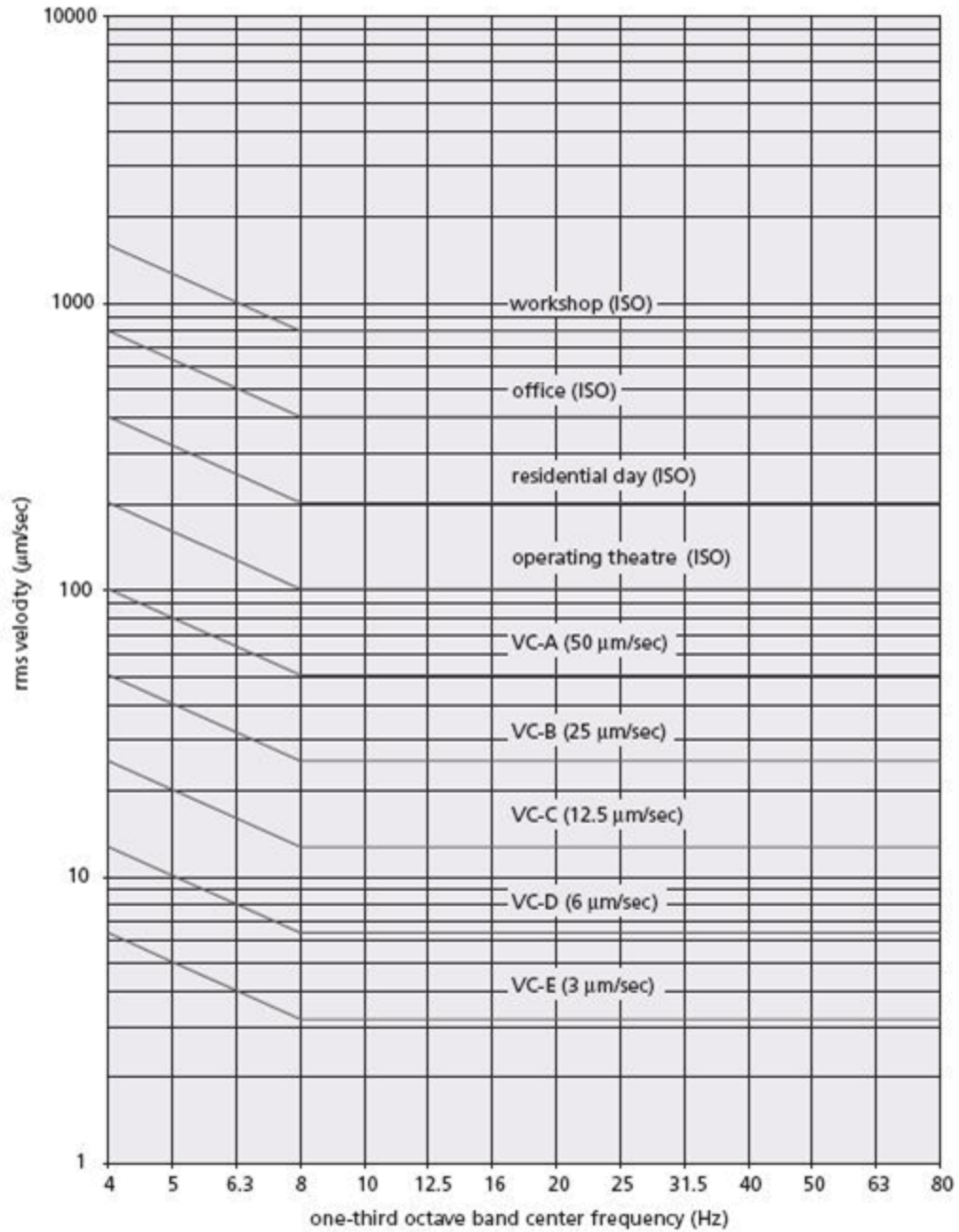


FIGURE 1: Taken from Colin Gordon's *Generic Vibration Criteria for Vibration-Sensitive Equipment*

Table 1: Application and interpretation of the generic vibration criterion (VC) curves (as shown in Figure 1)

Criterion Curve (see Figure 1)	Max Level (1) micrometers/ sec,rms	Detail Size (2) microns	Description of Use
Workshop (ISO)	800	N/A	Distinctly feelable vibration. Appropriate to workshops and nonsensitive areas.
Office (ISO)	400	N/A	Feelable vibration. Appropriate to offices and nonsensitive areas.
Residential Day (ISO)	200	75	Barely feelable vibration. Appropriate to sleep areas in most instances. Probably adequate for computer equipment, probe test equipment and low-power (to 20X) microscopes.
Op. Theatre (ISO)	100	25	Vibration not feelable. Suitable for sensitive sleep areas. Suitable in most instances for microscopes to 100X and for other equipment of low sensitivity.
VC-A	50	8	Adequate in most instances for optical microscopes to 400X, microbalances, optical balances, proximity and projection aligners, etc.
VC-B	25	3	An appropriate standard for optical microscopes to 1000X, inspection and lithography equipment (including steppers) to 3 micron line widths.
VC-C	12.5	1	A good standard for most lithography and inspection equipment to 1 micron detail size.
VC-D	6	0.3	Suitable in most instances for the most demanding equipment including electron microscopes (TEMs and SEMs) and E-Beam systems, operating to the limits of their capability.
VC-E	3	0.1	A difficult criterion to achieve in most instances. Assumed to be adequate for the most demanding of sensitive systems including long path, laser-based, small target systems and other systems requiring extraordinary dynamic stability.

Notes:

(1) As measured in one-third octave bands of frequency over the frequency range 8 to 100 Hz.

(2) The detail size refers to the line widths for microelectronics fabrication, the particle (cell) size for medical and pharmaceutical research, etc. The values given take into account the observation that the vibration requirements of many items depend upon the detail size of the process.

FIGURE 2: Taken from Colin Gordon's *Generic Vibration Criteria for Vibration-Sensitive Equipment*

END OF APPENDIX 6

July 17, 2009