NEBBinar: Sound and Vibration: Maintaining Tenants Spaces and Building Mechanical Systems

October 14, 2014
Jim Huber, NEBB Vice President and President of Complete Commissioning

Jim Huber is the President of Complete Commissioning. He has over 29 years of industry experience, is a Certified Energy Manager, and has extensive experience with BACNET, LON, MODBUS, and other building automation protocols and communication networks. He has programming, tuning, and testing experience with multiple systems and applications, as well as building systems commissioning, sound and vibration measurement, and testing and balancing.
Stuart McGregor, member of NEBB's Sound and Vibration Committee

Stuart is a full partner and senior acoustical engineer at Engineering Dynamics, Inc. He has experience analyzing, designing and measuring noise and vibration from building mechanical systems on projects ranging from residential condominium buildings to commercial and industrial spaces. Stuart has successfully completed over 1000 projects, testified as an expert witness in noise and vibration related cases, and teaches sound and vibration training seminars for NEBB certified professionals and technicians.

Stuart’s professional affiliations include, Acoustical Society of America, Institute of Noise Control Engineering, American Society of Heating, Refrigerating, and Air Conditioning Engineers, and NEBB.
Building owners and design professionals are very familiar with design requirements for

Temperature, Humidity, Odor,
Fresh Air (Make-up air) and Lighting

To have a building that will serve human comfort needs and lead to a productive work environment the Acoustic (Sound) and Vibration environments of the building must also be addressed.

Note: We have all been in building where noise from system diffusers is too high or the spaces echo too much.
Why Should the Building Owner consider Sound & Vibration Commissioning

Cost - the cost to fix sound and vibration related issues can easily be ten or more times the cost to initially install noise mitigation.

Verification - that building design goals and specifications have been achieved and that a quality project has been completed.

Help to Minimize - construction delays and costly issues during building initial occupancy.
When Should the Sound & Vibration Commissioning Begin

Ideally – during the Schematic and Design Phases of a project. During the Schematic Phase non-compatible adjacent spaces can be relocated or other building parameters such as floor thickness or wall thickness’ can be adjusted. This will minimize design changes during CD Phase and minimize change orders during construction.

Less than Ideal (however still valuable) – during the CD Phase or Bidding Phase.

Bottom line is cost - considering the impacts sound and vibration on building occupants and processes during the SD and CD Phases can results in significant cost savings.
What Subtasks are Involved in Commissioning for Sound and Vibration?

Sound – define the appropriate maximum building equipment sound levels for the various space usages within a building. Then Taking sound measurements to verify compliance.

Vibration – define maximum allowable vibration levels for building mechanical equipment and maximum allowable vibration levels of building structure at vibration sensitive areas.

Building Acoustics - Defining appropriate demising walls, floor / ceiling assemblies and acoustical treatments.

NOTE: This task is outside the expertise of a typical NEBB Professional or M&P Design Professional.
The appropriate sound levels in various spaces inside a building depend completely on the usage of the space.

Maximum sound levels are typically defined in terms of the Room Criteria (RC) or Noise Criteria (NC). ASHRAE recommends RC as preferable to NC.

ASHRAE Applications Handbook Chapter 48, Table 1 provides design guidelines for HVAC related background sound in rooms, in terms of RC and NC.

For Example:

Conference Rooms – NC / RC = 30 / 30(N)
Open Offices – NC / RC = 40 / 40(N)
Defining Appropriate Maximum Sound Levels from Building Mechanical Systems (2)

It is critically important to identify noise sensitive spaces within a building during the Schematic Phase of a project when the cost impacts of ‘treating’ the space or moving that usage to another part of the building can be accomplished with minimal impact.

Example #1:

About 25-years ago I worked on a large office complex which had a gymnasium, which was initially supposed to be used as a recreation / basketball area. During the initial construction phase the use was changed to a presentation / recording studio. Two very different acoustical requirements.
Defining Appropriate Maximum Sound Levels from Building Mechanical Systems (3)

Example #2:

Another example an architect and mechanical engineer located a large air handler on the roof (directly in the center) of the sanctuary / worship space at a large church (with a lightweight roof structure).

Cost: In 1995 dollars over $100,000 to relocate.
And some un-happy clients.
Defining Appropriate Maximum Sound Levels from Building Mechanical Systems (4)

The solution is to define the space usages for all areas of the building and use ASHRAE criteria to specify NC / RC design goals for each space.

Then (Most Importantly) review these design goals with the project owner and design team. Then have these design goals put down in writing in the project documents.

This task protects the Owner, the Design Team and the Contractor.
Back to Example #1:

Gymnasium – NC / RC rating is 50 / 50(N)
Large Speech Recording Rooms
  – NC / RC rating is 25 / 25(N)

Very very NC / RC criteria for acceptability and legal costs when the finger pointing started. However, in the end Contract Documents which the Design Team relied on clearly showed the space as a gymnasium. So, in this case the owner had to absorb the costs.
Defining Appropriate Maximum Sound Levels from Building Mechanical Systems (6)

Some basic design guidelines for HVAC systems to minimize HVAC sound levels and lower NC / RC ratings are:

1. Ductliner – this cannot be overstated specially downstream of VAV boxes.
2. Select diffusers with low NC ratings and single deflection pattern controllers.
4. AHU / Fan – selection for low noise levels.
5. Vibration isolation of AHU’s.
In our information age there is no shortage of reliable ways to get good design criteria guidelines.

1. ASHRAE publications are online.
2. There are many qualified acoustical engineers around.
3. There are also many websites where this information can be found. Everyone copies everyone else, who have copied ASHRAE. Acceptable NC / RC ratings for various space usages has not changed in decades.
Defining Acoustical Treatments and Partition Designs for Various Spaces(1)

As noted above this tasks should be contracted to an acoustical engineer. It is discussed here because the acoustics of the room / space is as important as noise from building mechanical systems.

While, the expertise to analyze and address this issue is or maybe outside the expertise of most NEBB Professional or M&P Design Professional, they should have sufficient knowledge to at least recognize when a noise issue may arise, and bring the issue to light.
Example #3:

A mechanical room located adjacent to private offices or conference rooms. The mechanical equipment may be completely within spec. however, a demising partition between the spaces may not provide sufficient mechanical noise isolation. The problem is not the mechanical engineer’s or contractor’s, it is the architect’s.
The levels of sound isolation between two spaces is defined in terms of the Sound Transmission Class (STC). The higher the STC rating the greater the level of sound attenuation / isolation between the spaces.

Sound attenuation between spaces is very important for Speech Privacy,

In office / business environments, and Medical Offices

Health Insurance Portability and Accountability Act (HIPAA) Privacy Rule
It is important for all Mechanical Design Professionals and Mechanical Contractors to minimally do the following,

a. Identify if the mechanical equipment room is adjacent to (above, below or beside) a noise sensitive area?

b. If it is, in writing, contact the architect, to verify that the demising partitions have been adequately designed.

c. Has ductwork between noise sensitive spaces been designed properly?
Item ‘c’ on the previous slide is important for Mechanical Design Professionals and Mechanical Contractors. “And the solution is, in concept easy.”

a. Lined ductwork, minimum 1” thick standard ductliner.

b. At least TWO 90 degree elbows.

c. And a bit of duct attenuation analysis.
Acoustical treatments on walls of rooms – carpeting and acoustical ceiling tiles. One cannot overstate how much benefit carpeting and Acoustical Ceiling Tiles provide.

This task is outside the expertise of a typical NEBB Professional or M&P Design Professional.
Vibration commissioning is the process of designing and specifying appropriate vibration isolation of building rotating equipment or vibration isolation of sensitive building areas, and specifying maximum vibration levels (out of balance) for rotating equipment.

For Example: Maximum floor vibration limits for a cafeteria are much higher than for an area with Medical Imaging Devices (CAT Scans, MRI’s, etc.)

The degree of vibration isolation of rotating equipment and maximum out of balance is crucial.
Vibration commissioning is the process of designing and specifying appropriate vibration isolation of building rotating equipment or vibration isolation of sensitive building areas, and specifying maximum vibration levels (out of balance) for rotating equipment.

Insuring good vibration isolation design is straightforward:

a. Appropriate vibration isolation design
b. Correct installation
c. Post installation conformity
An Important Aside:

NEBB’s Procedural Standards for Sound and Vibration specify that vibration measurements (Vibration Commissioning) MUST happen before sound measurements (Sound Commissioning). The reason is that poor vibration isolation, improperly adjusted vibration isolation or out-of-balance machines can cause significant sound issues in occupied spaces.

As counter intuitive as it is, a small input of vibration to building structure can cause audible and annoying Sounds.
Appropriate vibration isolation design: it may seem obvious; it is overlooked more than it should be. This oversight occurs when there are vibration sensitive areas or during the Value Engineering (VE) process.

It is vitally important during the Schematic Design Phase of a project that vibration sensitive areas in a building are identified.

There is no more important place for this than in Hospitals and Electronics and Optical Manufacturing Facilities.
What are appropriate vibration limits?

Vibration limits for what? The rotating equipment or the building structure.

Vibration Severity Ratings for Rotating Equipment – are specified in ASHRAE Section 48, Table 46 and Figure 42.

Vibration Limits on Building Structures – are specified in ASHRAE Section 48, Table 46 and Figure 42.
Vibration Severity Ratings for Rotating Equipment – are specified in ASHRAE Section 48, Table 46 and Figure 42.

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Allowable rms Velocity, mm/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pumps</td>
<td>3.3</td>
</tr>
<tr>
<td>Centrifugal compressors</td>
<td>3.3</td>
</tr>
<tr>
<td>Fans (vent sets, centrifugal, axial)</td>
<td>2.3</td>
</tr>
</tbody>
</table>

Table 46 Maximum Allowable RMS Velocity Levels

Fig. 42 Equipment Vibration Severity Rating for Vibration Measured on Equipment Structure or Bearing Caps
Defining Maximum Allowable Vibration Limits (7)

Building Structural Vibration Criteria—are specified in ASHRAE Section 48, Figure 41.

Fig. 41 Building Vibration Criteria for Vibration Measured on Building Structure
Some basic design guidelines for vibration isolation are presented in ASHRAE Handbook Applications, Section 48.

1. The benefit of spring isolators and inertia bases cannot be overstated.

2. Beyond isolation proper alignment and equipment balancing is a must.

3. For large air handling systems 30,000 CFM Fan walls will significantly reduce vibration input to building structures.
Some General Information Regarding Sound and Vibration Commissioning (1)

While, there is a cost associated with hiring individuals and firms to do an acoustical (sound and vibration) commissioning review, inspection and measurements on a project.

The cost savings can be significant.

Good mechanical system design, which ASHRAE and NEBB have promoted can go along way to achieving a successful project.
Some General Information Regarding Sound and Vibration Commissioning (2)

1. Sound levels in occupied spaces are never or almost never loud enough to cause hearing loss or damage. Tonal noise may be very annoying; however it will not damage hearing.

2. Vibration in building structures is almost always insufficient to cause any long term structural fatigue / failure issues. The equipment will self destruct long before structural issues arise.
The old adage about being less expensive to do the job right the first time is really true.
What does the NEBB S and / or V Certification provide?

The knowledge base to measure sound in building spaces and determine if the sound levels exceed building design criteria.

The knowledge base to measure vibration on rotating equipment and on building structural members and assess if vibration levels exceed vibration criteria or limits.
Question and Answers
Contact information

Jim Huber, NEBB Vice President and President of Complete Commissioning
Tel: +1.301.877.2260
Email: JHuber@completecx.com

Stuart McGregor
Tel: +1.720.341.7767
Email: stuart@engdynamics.com
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