Controlling vibration

labdesignnews.com/articles/2015/04/controlling-vibration

Laboratory Design News

Articles

Thu, 04/16/2015 - 4:25pm

Lindsay Hock, Editor

Proper vibration/EMI control in lab environments furthers research by isolating state-of-the-art vibration-sensitive equipment.

Much equipment used in nanotech, physical and biological sciences can’t function properly if subjected to vibrations that exceed small threshold values. As a result, lab designers are faced with the challenge of developing designs where vibration disturbances are within acceptable limits to further science.

With the high costs and technical difficulties associated with the design of high-tech facilities and labs, potential disturbances must be discussed early in the design process. Implementation of vibration control measures must be well-planned and verified as the design and construction process progresses, and electromagnetics specialists are critical to this success.

The effectiveness of a vibration control solution is governed by the laws of physics. And, while physics hasn’t changed, isolation requirements have. Modern lab equipment is becoming more sensitive, placing tighter constraints on allowable levels of vibration.

“Fifteen years ago it was possible to design an affordable building floor that was sufficiently stiff to accommodate all lab equipment in the building,” says Jeffrey Zapfe, President, Acentech. “It’s simply not possible to do that now; equipment vibration limits are too restrictive.”

The current trend to accommodate this equipment is to design local “low-vibration” islands within a building, which incorporate some form of isolation system to protect the sensitive equipment.

The costs of amending a building design to accommodate stringent vibration criteria is proportional—the higher the floorplate above grade, the greater the cost to achieve the criteria. “Given this, vibration-sensitive equipment and research functions are driven down to lower levels in buildings to better spend available funds," says Mark Tinsley, LEED AP, Associate, Lord Aeck Sargent.

However, increasingly architects and engineers are tasked with integrating vibration-sensitive equipment and research functions on upper floors. To address this trend, designers rely on point-of-use solutions, such as air tables, which require the end-users to provide their own, process-driven solutions.

Yet, vibration control isn't just about vibration sensitivity. Some equipment can be adversely affected by acoustic noise. As a result, effective acoustic enclosures and low-noise HVAC systems can be important in the design process, according to Zapfe.

The importance of site

Site selection is one of the most important factors in designing a low-vibration lab or building. The baseline level at the foundation is largely determined by the environmental vibrations at the site. These sources of vibrations include ambient microseismic activity, street and rail traffic, aircraft overflights, machinery operating nearby and construction work.

Site planning involves disturbances from within the building—elevators, vehicles, MEP systems—and outside the building—Earth's natural magnetic flux. "Importantly, shielded, or unshielded, tools can 'feel' interference from a host of sources, such as wireless networks and variable-frequency drives, as well as negatively impact other components within or outside the building," says Davidson Scott, Director of Engineering of Field Management Services, FMS, Ontario, Canada. As a result, lab planners must consider siting the tool area—gaining distance from a potential source—as well as the various strategies to defeat or lessen the EM field—traditional shielding.

Selecting an inherently quiet site for a facility with critical vibration requirements is a primary consideration, particularly in regard to those sources beyond the control of a facility developer or designer.

Some of the most common in-facility sources of vibration are generated from staff walking, interior dollies or vehicles such as forklifts. However, significant vibration can also be generated by the facility's equipment—such as vacuum pumps, materials handling systems and production tools such as scanners and robots.

These disturbances can be addressed in the layout and planning of the facility, with strategies that locate sensitive equipment far away from internal and external sources of vibration. As a rule of thumb, elevators, fans, cooling towers, compressors and other heavy electrical equipment should be situated in areas that are well-separated from those where sensitive equipment is located.

Vibration on ground-supported slabs is less severe than higher floors, so it's wise to reserve the on-ground floor for sensitive equipment and/or critical labs. If the sensitive equipment is planned for implementation on a higher floor, it should be placed near cores or columns or atop heavy girders, where supported floors tend to vibrate less than near the middle of structural bays.

Effective vibration control design

Vibration and shielding controls are often associated with core lab spaces—the spaces at the heart of a given facility. These spaces must be functional to ensure work can be conducted free from the confounding effects of vibrations and electromagnetic fields. In the end, high-quality research yields top-notch research staffs.

"In most facilities we work on there's a desire to design flexible spaces that can accommodate future evolutions in research and tool technology," says Brad Pridham, Vibration Specialist, Novus Environmental Inc. "In such cases, control strategies must target not only the receiver space, but also the source spaces (service spaces, loading bays) and transmission paths (shielding of feeder line, structural members)." The details associated with these strategies impact many facets of the base building design and require careful integration. And successful integration results in lab spaces adaptive to future science needs.

Designers are often asked to accommodate a specific piece of either existing or new equipment. This equipment can include NMR systems, electron microscopes, telescopes or certain nano-electrical or opto-electrical systems.

“In the case of accommodating a specific piece of existing equipment, we must work closely with the end-user and tool manufacturer to establish the requirements, and work with the end-user to define what may come next in the evolution of their research,” says Tinsley.

“In the case of accommodating new equipment, it’s largely a matter of defining, during programming, the type of research the building is designed to accommodate, and the equipment requirements likely to support those research needs,” continues Tinsley.

The type of vibration isolation a piece of sensitive equipment needs is dependent on the equipment’s vibration sensitivity and on the vibration environment at its location. Many isolation systems are currently available from a number of vendors, such as Kinetic Systems, Minus K and Grainger. These systems include small isolation platforms for desktop equipment and optical tables consisting of very stiff tops supported on air-spring legs. Some equipment—NMRs and electron microscopes—can be obtained with isolation systems provided by their suppliers.

For most large pieces of equipment, simple isolation systems consisting of rubber pads or other resilient materials, such as steel coil springs and other vibration isolators, suffice.

A well-designed isolation system can reduce floor vibrations by a factor of 10 or more. However, the tricky part, according to Zapfe, is the sensitive equipment probably has its own isolation system which needs to be taken into account. “The most common way to do this is to employ a massive platform to support the equipment,” says Zapfe. The mass separates the isolation systems, allowing them both to work effectively.

If low-vibration islands are used, designers must plan on more space. “For example, the isolators and massive platform will likely be housed in a pit to maintain the floor height,” says Zapfe. And, if acoustical isolation is needed, this requires special construction like double grout-filled concrete masonry walls.

Overall, active vibration-isolation systems have matured over the past five years. “Active systems are attractive because they obviate the need for the massive platform,” says Zapfe. Active systems are suitably stiff, with little chance of adverse reaction with the equipment’s isolation system.

Challenges of vibration control

Essentially, the greatest challenge in vibration control design is providing lower vibration environments. Some researchers use two, three or more stages of isolation. The question then becomes: How can this be done economically?

According to Zapfe, the locations of building systems are important to answer this question. “The farther sensitive areas are from mechanical rooms, the better,” says Zapfe. And, properly designed supplement isolation for sensitive equipment can make a difference in the base vibration levels. With a strong plan, both cost and space can be viewed economically.

Another challenge in vibration control design of labs and facilities is the schedule. Programming may begin for a project years before the equipment is eventually purchased, installed and validated, making equipment integration during the duration “a moving target”, according to Tinsley, requiring that lab planning presumptions made during programming be retested during each phase of the project.

To alleviate this issue, a ground rule, according to Tinsley, is to establish a stakeholders committee and make sound decisions with everyone onboard from programming through equipment validation. Having an experienced estimating group onboard early to guide the process of defining requirements and costs is essential to project success.

Yet another key challenge on most vibration control facility projects is the integration of control strategies with structural, architectural and MEP elements. “Some of the vibration and EMI controls are seemingly small construction details that are critical to performance,” says Pridham. “Diligent management of quality control during construction is essential to as-built performance.”

The desire for some owners to “future proof” facilities against future unknown sources is another challenge, as well as the availability and quality of information on vibration and EMI sources and technology implemented in facilities.

“The best way for designers to face these challenges is accept there are EMI/vibration challenges in every facility and resolve to incorporate controls and resiliency into the design to address challenges foreseen and unforeseen,” says Pridham.

In the end, the most successful projects are those where experienced consultants are brought onboard early.

With tooling increasing in complexity, the lab or facility is required to keep pace. Consulting in this area is an evolutionary process, says Tinsley, with new ideas coming to the forefront to challenge old ways of thinking and old strategies.

Future of vibration control design
More data will essentially lead to more definition of the market; and time will prove some strategies better than others, or more economical or easier to construct.

From a design perspective, Novus Environmental envisions the assembly of a library of cataloged low-vibration/low-EMI components, materials and design elements that can be referenced for implementation on projects. “Further improvements to integration of these elements with BIM lead to optimization and value engineering to control costs, better visualization of the vibration and EMI environments and for planning of shelled spaces,” says Pridham.

In the future there will also likely come a time when low-vibration islands are designed with two stages of isolation, according to Zapfe. However, that’s a ways off. “Such a design will be challenging because the low-acoustical noise requirements that would presumably come along with it,” says Zapfe.

From a vendor and end-user perspective, FMS envisions the integration of active controls into toolsets to address both vibration and EMI becoming more popular. “With increasingly collaborative research environments we foresee tool sharing becoming more prevalent, enabling the best tools in the best environments to be shared amongst several research organizations,” says Scott. This, in turn, will lead to the development of remote research and toolset operational capabilities though virtual research environments.

Topics

Share This Story

You may login with either your assigned username or your e-mail address.

- Create new account
- Request new password