Construction Noise and Vibration Monitoring for Hospitals

By Benjamin Davenny and Marc Newmark

The advancement of existing hospital facilities often involves significant renovation plans or completely new construction and expansion. As with any critical service, healthcare settings present a unique challenge for conducting work that will not compromise the patient experience or quality of care. Over the past few years, the advent of real-time monitoring systems has helped bridge this gap, creating more informed projects on both sides of the construction wall. Rather than simply document them, real-time systems enable projects to happen compatibly for MRIs, inpatients and doctors alike.

Before each construction project, The Joint Commission requires a preconstruction risk assessment (PCRA) per its EC.02.06.05 standard. The PCRA addresses air quality, infection control, utility disruptions, and noise and vibration. A hospital can improve its PCRA by anticipating the noise and vibration impacts that may occur and planning to monitor them during construction.

Not just annoying

The impact of noise and vibration extends far beyond interrupted conversations and right into the functional aspects of any hospital. From a vibration perspective, the floors in a healthcare environment are designed so that when people are walking, the vibrations are below the average threshold of human perception.[1] Standard operating rooms are designed to move even less than the level considered the threshold of the most sensitive humans.

The concern for vibration is not just about waking up patients but also for the correct performance of laboratory and imaging equipment used around the clock. Equipment can have limits up to 100 times lower than perception, required for the use of specialized microscopes, MRI machines and CT scanners. Excessive vibration can lead to blurry images and the need to repeat scans. Often, highly sensitive equipment requires not only a low vibration level but also specifically a certain limit at each frequency of the vibration. For example, the specifications of a leading manufacturer's CT scanner require a floor vibration level six times lower for vibrations at 10 Hz than at 20 Hz in frequency.[2]

Noise is transmitted from a construction site to the building occupants through two paths: the air and the structure. Airborne noise transmission occurs when noise from construction activity is radiated into the air and passes through building wall or floor-ceiling constructions to the building occupant. Structure-borne noise occurs when the construction activity produces vibration in the ground or building structure, and the vibration travels through the building structure and is radiated as noise in the occupied spaces.

Airborne noise can be mitigated with temporary walls, ceilings or other barriers. Structure-borne noise is much harder to moderate, because construction activities necessitate vibrating or impacting the structure and the structure transmits the resulting sound very efficiently. Vibrations can sometimes be reduced through tool selection and methods, and at other times through the use of careful scheduling. If the nearby occupied spaces are active only during typical working hours, the noisier activities could be scheduled during off hours. However, if the nearby occupants are patients with continuous occupancy, then the noisier activities should be during the day, when the ambient activity noise level is higher.

Bridging the gap

The use of real-time monitoring systems provides a project with continuous feedback and insight on the conditions in potentially affected spaces. Once criteria are in place, monitoring systems provide automatic email or text notifications to project staff when levels exceed the preset limits. For occupied spaces, limits often utilize statistical metrics and frequency band variations in order to separate out acceptable nonconstruction activity. For example, the vibrations generated by walking in a nearby corridor or the sounds of a patient monitor have a different signature than those generated by a drill or jackhammer. Immediate feedback enables the contractor and hospital project manager to respond and minimize incompatible work, receive advance notice to address any complaints, and adjust efforts or schedule in an optimal and informed manner. The result is a reduction in downtime and unnecessary impacts on cost and schedule, as well as the preservation of conditions expected in the hospital. From the facility

perspective, staff and departmental managers can also rest assured that there are systems watching out for their interests. As one hospital project manager expressed it, “When I’m not getting notifications, I can rest assured that everything is running fine.”

Planning for compatibility

Depending on the nature of the project, the expectation of impact due to noise and vibration can usually be established early in the process. For a building addition, the focus is typically on the closest occupied areas and vibration-sensitive uses of the worksite. In a renovation, the work is often located in, over/under and around several areas, with periodic change possible through various stages of the project. The first step in either case is to develop an inventory of noise- and vibration-sensitive concerns where environments need protection. The second step is to determine both the noise and/or vibration limits that will be acceptable during construction. This is done using a combination of baseline measurements, functional design criteria, manufacturers’ specifications and/or other acceptable industry standards based on the purpose of each space. Often, however, these items form a picture of an idealized environment that lacks the subjective and practical needs of the staff, managers and technicians in their respective spaces. To complete this picture, a project can utilize construction simulation exercises during planning or even during construction.

Using a plan of expected methods and equipment, a simulation means conducting sample activities at sample locations (often starting farther from sensitive areas and moving closer). This provides a live test of the noise and vibration transmission from work areas to sensitive spaces. If done prior to actual work, the process can help inform the methods, equipment choices, schedule, cost, potential impact and compatibility with ongoing hospital activities. It also provides an opportunity to solicit feedback in determining proper limits and for affected parties to participate in the process, improving acceptance and tolerance of the program. After work begins, construction tests performed in conjunction with real-time monitoring give the contractor and facility manager a live understanding of how noise and vibration levels compare directly with the limits.

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[1] According to the Guidelines for Design and Construction of Hospitals and Outpatient Facilities (Facility Guidelines Institute, 2014), patient rooms should be designed to not exceed a floor vibration level of 6,000 micro-inches per second (min/s), measured in 1/3-octave frequency bands. For reference, this is below the average threshold of human perception at 8,000 min/s.

[2] Hz is a unit of frequency and stands for cycles per second. For example, a 10 Hz vibration means that a surface is vibrating at a rate that completes 10 back-and-forth cycles every second.

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