Sound Isolation – Building Partition Performance Case Studies

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Case studies are presented that involve both modeling the sound transmission loss of a building partition and subsequent measurements in the field to determine the actual performance. Modeled sound transmission class ratings and measured noise isolation class results are presented along with a discussion of the specific details and problems associated with each case.

Often, an acoustic consultant is brought in on a project where sound from one space is intruding on an adjacent space and the consultant is tasked with finding a solution. Both modeling transmission loss (TL) of sound through the partition and measuring the sound levels on both sides of the partition can provide valuable information about potential sound isolation problems and solutions. This article presents case studies that involve both the modeling of the partition sound TL and subsequent measurements in the field to determine actual performance.

The ASTM E336[1] standard details the standard test method for measuring airborne sound attenuation between rooms in buildings. Several sound isolation metrics are available for specific uses. The sound transmission class (STC) metric is commonly used as a single-number rating of how well a partition attenuates airborne sound.

Since room dimensions did not meet the standard's requirements for reporting of the apparent sound transmission class (ASTC) rating of the partition in all but one case presented in this article, noise isolation class (NIC) results were used instead. The ASTC and NIC metrics usually only differ by a few rating points, with NIC typically being lower. Construction details provided by the clients were used with INSUL Sound Insulation Prediction software[2] to model the STC rating of each partition.

Adult and Children's Worship Spaces

Background. A local church requested assistance with some last-minute decisions about the floor-ceiling construction between an upstairs children's worship space and downstairs adult classrooms. The children's worship space uses recorded and live music along with children singing and dancing. The downstairs space houses adult teaching classrooms using the lecturer/discussion format. We modeled the floor-ceiling construction, provided recommendations, and later conducted measurements to quantify the noise reduction and impact isolation. Impact isolation class (IIC) results are not presented in this article.

INSUL Model. The floor-ceiling partition consisted of 4-inches of concrete, 8 inches of mineral wool in a 48-inch airspace, and a drop ceiling with mineral fiber acoustical tiles with a surface weight of 1.1 lbs/ft^2. INSUL calculated an STC rating of 72.

Field Measurements. Using a pink noise source that fed signal into the sound system in the upstairs children's worship space, we conducted our measurements. Measurements were conducted using the moving-microphone method described in the standard, achieving a space- and-time average of the sound pressure levels in both the source and receiving spaces.

The NIC rating for the floor-ceiling partition was 55. Figure 1 shows the NR curve from the test data plotted against the NIC 55 curve.[3]

Discussion. The modeled STC result was 17 points higher than the NIC rating from the measurements. This discrepancy is likely due to small air gaps around doors in each room that are connected by a common stairwell and flanking paths through walls. Little or no sound could be heard from the actual ceiling. Both the modeled and measured results indicate that the floor/ceiling partition provides good sound isolation.

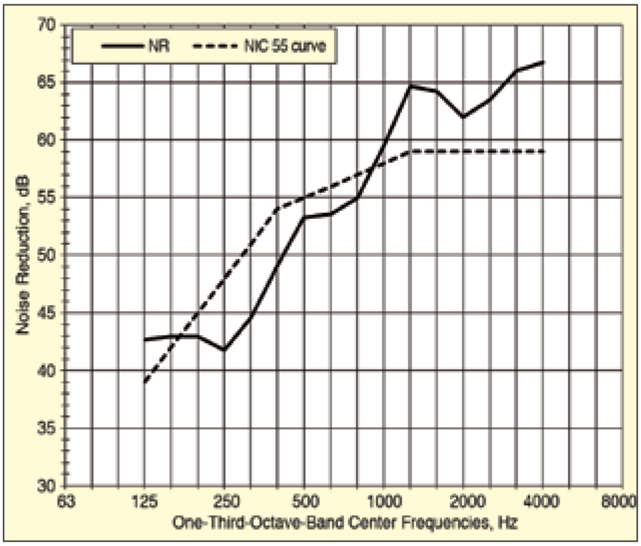

Figure 1. NR curve for floor-ceiling partition separating worship spaces.

The main reason the intrusive sound was annoying in the adult space was due to the extremely low ambient sound level in the adult teaching classrooms. With the HVAC off, the ambient sound level was measured at 18.5 dBA and the sound level meter used had an inherent noise level of 17 dBA.

With HVAC noise as masking and with reasonable limits on the sound level upstairs, the space can be usable for classrooms.

Fitness Studio and Adjacent Post Office Space

Background. This project involved a fitness studio that occupies a rental space in a commercial strip center with tenants on each side. The music played in the fitness studio was clearly audible in both adjacent spaces, leading to complaints (mainly from the shipping tenant, which is the space we focused on). We were contracted to conduct a study and recommend treatments to improve the sound isolation. Our recommended treatments included a separate stud wall and a window mullion treatment. The owner of the fitness studio implemented our recommended treatments and we were able to make noise reduction measurements for both pre- and post-treatments.

INSUL Model. The original demising wall consisted of 3-1/2-inch steel studs, insulation in the cavity, three layers of 5/8-inch gypsum board on the sid of the fitness studio, and one layer of 5/8-inch gypsum board on the side of the shipping tenant (INSUL STC 50). The wall dimensions were about 20 feet high (extending to the deck) and 60 feet long. The fitness studio had a suspended gypsum board ceiling, and the shipping tenant had a suspended acoustical tile ceiling.

Field Measurements. We conducted our measurements using a pink noise source that fed signal into the fitness studio's sound system. Measurements were made at three locations along both sides of the wall each at about 3 feet away from the wall. The first

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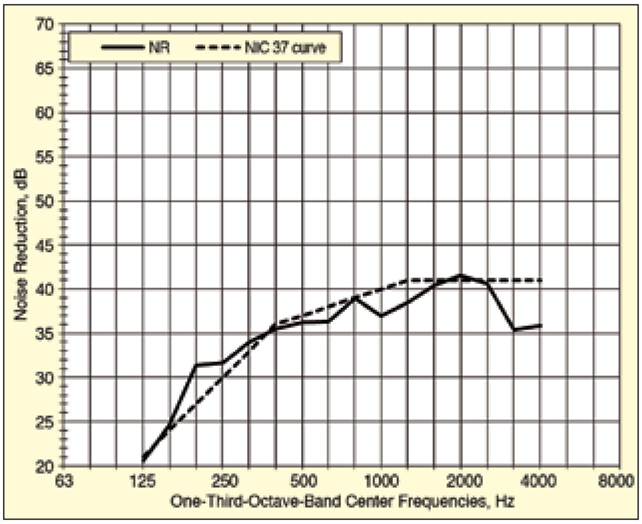

Figure 2. NR curve for fitness studio and post office; near window (pre-treatments).

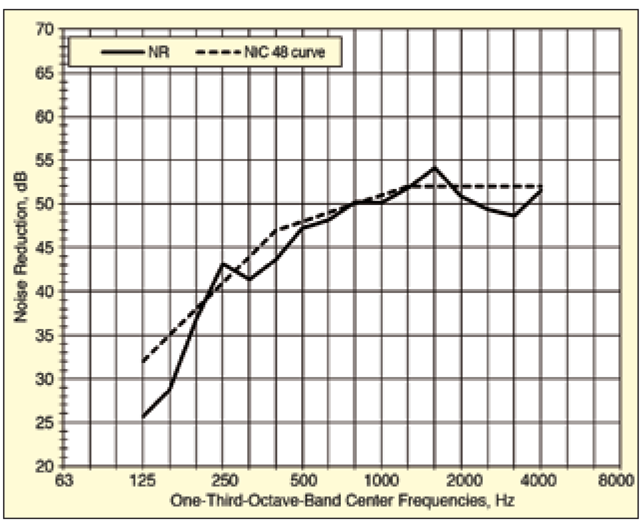

Figure 3. NR curve for fitness studio and post office; far from window (pre-treatments).

location was near the window, the next in the center of a wall, and the last near the back of the space.

We noticed that sound levels from the fitness space were much higher (about 6 dBA higher) near the window of the shipping tenant. This was because of sound leaks where the demising wall butts into the window mullion. There were some small gaps between the wall and the mullion, but even if there were no gaps, the mullion provides much less sound isolation than the wall.

The NIC rating for the pre-treatment wall near the window was 37 and away from the window (locations at center of wall and near the back of the space averaged together) was 48. The difference in sound isolation near and far from the window is illustrated in Figures 2 and 3.

INSUL Model. In accordance with our recommendations, a separate stud wall on the fitness studio side was constructed that consisted of 3-1/2-inch metal studs spaced 2 inches away from the existing wall, 5-1/2 inches of fiberglass insulation filling the cavity, and two layers of 5/8-inch gypsum. This new wall extended the entire length of the existing wall and from the floor to the gypsum-board ceiling (about 10 feet above the floor). The new double stud wall modeled with INSUL had a rating of STC 68.

Field Measurements. The same three measurement locations along both sides of the wall were used, again using a pink noise source that fed signal into the fitness studio's sound system.

The NIC rating for the post-treatments wall near the window was 55 and away from the window (locations at center of wall and near the back of the space averaged together) was 61. Figures 4 and 5 present the NR curves plotted against the NIC curves.

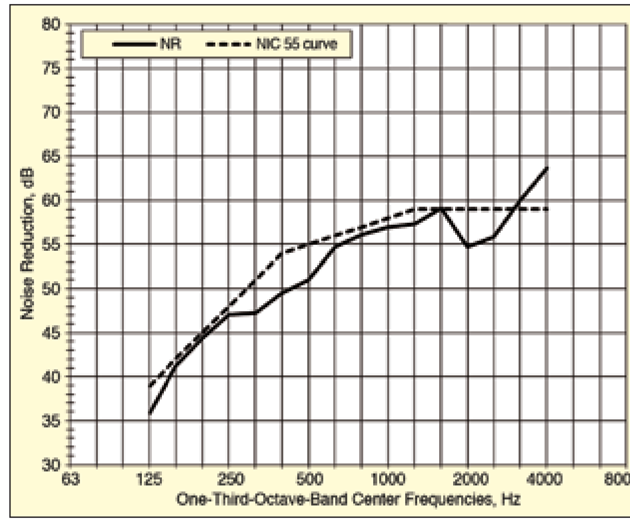

Figure 4. NR curve for fitness studio and post office; near window (post-treatments).

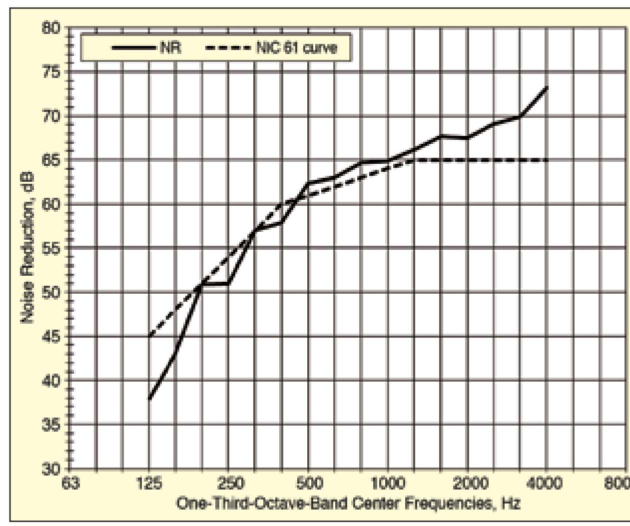

Figure 5. NR curve for fitness studio and post office; far from window (post-treatments).

Discussion. During the first round of measurements (pre-treatments), measurements were also made above the ceilings of both the fitness and post office spaces. It was determined at the time that sound traveling from above the fitness space into the post office space was not a major problem and that the wall and the mullion were the major weak links.

Once the treatments were implemented, it was clear (from both measurements and observations) that the greatest improvement in sound isolation was near the window mullion, because the isolation was previously very poor at that location. The window mullion treatment consisted of sealing the gaps between the existing wall and the mullion, stuffing fiberglass insulation against the mullion (from floor to ceiling) and extending the gypsum board layers of the new wall all the way to the window so that the mullion is covered, sealing any gaps between the gypsum board and the window.

Even though the wall treatments greatly improved the sound isolation, the improvement was not as dramatic as modeled with INSUL. We suspect that there was some vibration transmission from the fitness studio ceiling into the original wall, which then transmitted some sound into the post office space. Although the new wall is structurally separated from the original wall, the fitness studio ceiling is structurally connected to both walls; this results in some vibration transmission that can only be eliminated by cutting the ceiling structure all around the perimeter of the room between the existing wall and the new wall.

Fitness Studio and Adjacent Office Space

Background. Another project involved a fitness studio and an

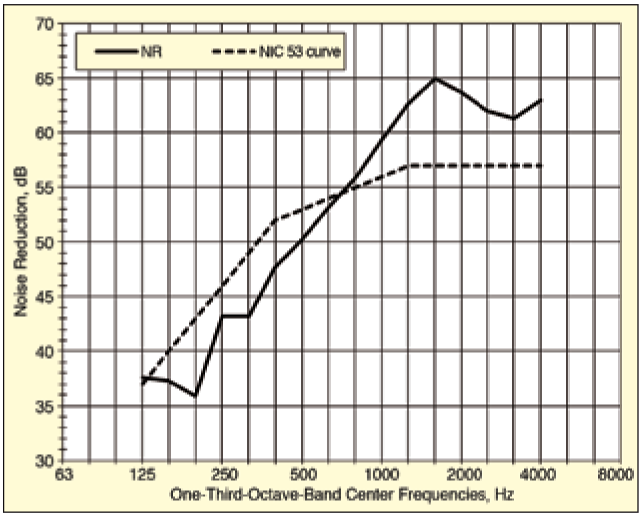

Figure 6. NR curve for wall partition separating fitness studio from offices.

office on opposite sides of a shared wall. One common area and two offices shared a long wall with the fitness studio. The fitness studio plays high-energy music with instructors leading the class using a microphone. The office occupants complained about thuds from the music and the instructor's voice being clearly audible. The fitness space was large (greater than 150 m^3) with mostly hard surfaces and no ceiling beneath the roof structure.

INSUL Model. A series of construction documents showed a number of revisions to the design of the wall made before and during construction. The initial design was a double-stud wall with a 6-inch air cavity, insulation, and three layers of gypsum on each side (INSUL STC 76). However, to gain more space in the offices, the construction was changed to a single-stud wall, 3-1/2-inch insulation in a 4- to 5-inch cavity, a resilient clip attached to 7/8-inch 25Ga drywall furring channels, and two layers of 5/8-inch gypsum board on each side (INSUL STC 62).

Field Measurements. Access was granted to the studio to play pink noise over their sound system. With that noise level set, measurements were made in the offices. Our experience while in the offices during normal fitness classes was that a large amount of the sound was coming from the ceiling into the offices. We measured the noise above the ceiling to confirm this suspicion. The ceiling was acoustical tile with batts and a layer of gypsum board laid on top, but with gaps between the gypsum board panels. Table 1 summarizes the NIC results.

The NIC rating of the wall between the fitness studio and the office spaces was 53. Figure 6 shows the NR curve from the test data plotted against the NIC 53 curve.

Discussion. The plenum above Office A was 11 NIC points lower than in the office. Upon further investigation, two major issues above the ceiling were discovered. The metal roof deck was made of a lightweight material and was susceptible to vibration that could propagate over the top of the wall. There was also a furred-out portion of the wall above the ceiling to accommodate a joist that prevented the wall from going directly to the deck. Photographs taken during construction showed that no resilient clips or mounting devices were used in this section.

Table 1. NIC results for wall separating fitness studio from office spaces and plenum space.

Area	NIC Rating
Office spaces	53
Plenum space above Office A	42

The rigid attachment of gypsum to a joist at the furred-out section and the lightweight metal deck provided a short-circuit path for sound and vibration to propagate from the fitness studio into the plenum above the office space. This flanking path was not included in the model. It was recommended that an isolated dropped ceiling be put in the gym space to reduce the incident sound on the upper wall and roof deck. No follow-up measurements have been made.

Conclusions

We have outlined the modeling and measurement of the sound attenuation provided by various building partitions. One of the first things that is noticed is the discrepancy between the modeled STC rating of a partition and the NIC rating from the field measurements. This is partly due to limitations of the model (INSUL margin of error is generally within STC ±3 dB), the fact that NIC ratings are generally lower than STC ratings, and flanking paths. Flanking paths were identified in all three cases presented in this article.

The cases of the fitness studio sound intruding into adjacent spaces is a reminder for compatible-use planning and strong consideration before reducing wall thickness to gain floor space. The case of the children's worship space intruding on the adult worship space below might best be rectified with limiters on the upstairs sound system and increased masking downstairs. Most importantly, even if everything is done correctly with a partition but flanking paths are not considered, then the partition can be short-circuited by another common construction element to the spaces. To achieve a desired STC performance, great attention to detail is required. And even with attention to detail, it is recommended that walls be designed with an STC value that is at least five points higher than theoretically required.

References

1. ASTM E336-05, Standard Test Method for Measurement of Airborne Sound Attenuation Between Rooms in Buildings, ASTM International, West Conshohocken, PA, 2005, www.astm.org.
2. Insul Sound Insulation Prediction (V8.0.9), Marshall Day Acoustics, 2015.
3. Joe Bridger, Stewart Acoustical Consultants; Graphs in this article were created using a modified template from a spreadsheet developed by Joe Bridger of Stewart Acoustical Consultants. Calculations were performed in a spreadsheet developed by Isaac Harwell of CSTI Acoustics. SV

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