MEASUREMENT OF LATERAL IMPACT NOISE ISOLATION

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Impact noise isolation measurements and evaluation are traditionally defined for vertical adjacencies, where the impact source is located in the space above the receiving room. ASTM standards currently allow for the measurement, but provide no guidance for a method of performing a lateral impact noise isolation measurement. ISO 16283-2 describes protocol, procedures and methods for the measurements and analysis of the data collected. In the absence of the ASTM method, the authors have developed modified methods prior to ISO 16238-2 and practices for performing this measurement. The various measurement methods are compared, and preliminary categorization of lateral impact isolation is developed.

Keywords: lateral impact, impact isolation

1. Introduction

Lateral (or horizontal) impact noise isolation is measured in the field (*in situ*) in conditions where the source and receiving spaces are adjacent and on the same level. Lateral impact isolation has had little study compared to vertical impact noise isolation. ASTM E1007 [1], which defines field measurement of impact noise isolation, explicitly allows lateral impact measurements, but the procedure is clearly designed for vertical measurements. ISO 16283-2 [2] does not explicitly mention lateral impact testing in the body of the standard, but provides guidance for the measurement in Annexes D and E (informative). The authors have also developed a measurement procedure, which is a modification of the ASTM procedure. In this paper, the various measurement methods are compared in several different structural types. A preliminary categorization of lateral impact isolation is also presented.

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2. Existing standards

2.1 ASTM E1007

ASTM E1007 [1] is commonly used in North America to measure impact noise isolation. It states in section 3.2.7.2 that “The receiving room is usually the room below the floor-ceiling assembly being excited by the tapping machine but, depending on the metric being measured, it may be on the same level, diagonally below, or, in some cases, above the source room.”

However, there are no adjustments to the procedure or guidance for how to perform a lateral impact test. Specifically, the standard requires measurement of the sound level from four positions of the tapping machine, and these positions are explicitly defined and are all near the center of the floor. These positions are shown in Fig. 1. Section 9.4 specifying the tapping machine position is clearly written for vertical adjacencies, with references to the spaces “above” and “below” as well as “separating floor-ceiling.” Further, the ASTM standard clearly defines that tapping position 1 is in the middle of the floor (specimen) when the rooms are the same above and below, but is mute in the description of this location in horizontal measurement applications.

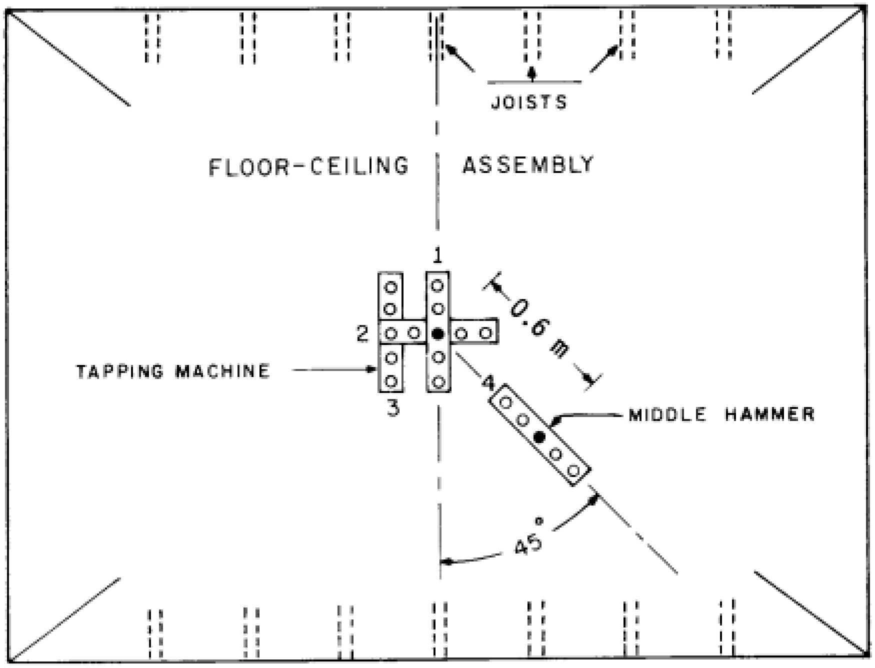

Figure 1: Tapping machine positions in ASTM E1007

2.2 ISO 16283-2

The relevant ISO standard is 16283-2 [2] which does not refer explicitly to lateral measurements in the body of the standard, but only generically to "source" and "receiving" spaces. The tapping machine is required to be placed in "at least four different positions randomly distributed on the floor under test."

Annex D (informative) in Ref. 2 provides guidance for horizontal measurements in section D.3, along with example diagrams in Annex E. It states that four tapping machine positions shall be used (per usual) for sources rooms with a floor area less than 20 m^2. If the source room is larger than 20 m^2, then the tapping machine positions should be limited to the 20 m^2 nearest the partition with the receiving room. However, the area including the tapping machine must be the full width of the partition to the receiving space, and no less than half of the source room in the direction away from the receiving room. Therefore, in rooms such as that in Fig. 2 [which is Fig. E.1a) in Annex E of Ref. 2], the resulting area can be much larger than 20 m^2.

Under ISO 16283-2, therefore, the distance from the farthest tapping machine location to the partition separating the source and receiving rooms can be up to half the dimension of the source room. For large spaces, some tapping machine locations will be far from the horizontal intersection (e.g. junction between the source and receiving rooms).

3. Development of a modified method

To the authors knowledge, the exact rationale for the tapping machine locations specified in the two standards in Section 2 has not been published. However, both concepts have an apparent justification in the context of vertical measurements where source and receiving rooms have similar floor plans. The ASTM method uses four positions apparently designed to average over any variation due to joist layout. These are clustered near the center of the space, where they would radiate evenly within the receiving room. The ISO method distributes the impacts across the floor, again providing an apparent uniform radiation into the receiving space.

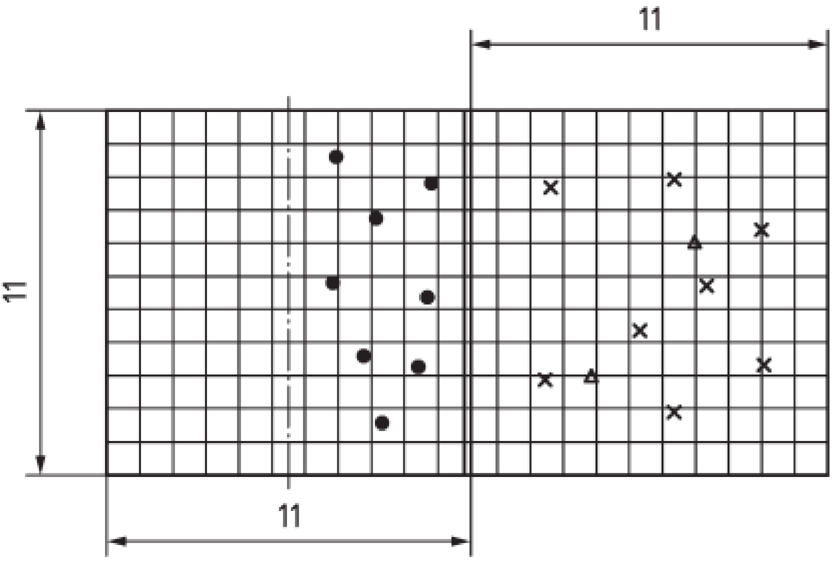

Figure 2: Example lateral impact noise measurements from ISO 16283-2. Dots are tapping machine locations. Crosses and triangles are receiving room positions which are not discussed here.

The ASTM method would result in all four tapping machine locations at some distance from the wall, and that distance would vary depending on the size of the source room. This seems problematic, and to the authors, it makes more sense to measure at a fixed distance from the receiving room (i.e. lateral junction). Some time ago (prior to the publication of the ISO standard), a measurement protocol was developed for impact isolation using a modified ASTM method. Three tapping machine positions were defined and used, corresponding to the first three positions described in Ref. 1, with the middle hammer of the tapping machine on a line parallel to and 1.5 m (5 feet) from the separating wall, and centered on the wall. See Fig. 3. The distance between the tapping machine in Positions 1 and 3 remained as half the distance between the joists or 0.6 m for homogenous floors, the same as in the ASTM standard.

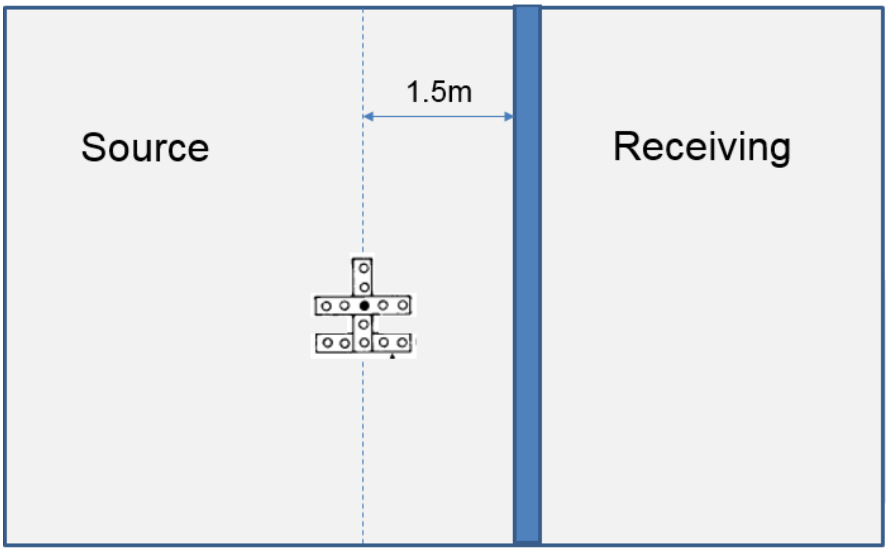

Figure 3: Modified ASTM tapping machine positions for lateral impact noise measurements

4. Comparison testing

To investigate the differences between the two methods, lateral impact noise testing was performed in three different buildings. For each test, the measurement was repeated using tapping machine locations from both the ISO and the modified ASTM method. In order to restrict the scope of the study to the tapping machine locations only, the measurement procedure on the receiving side were identical and following the ASTM procedure. (The ISO procedure is substantially similar but not identical.)

Test 1 was a poured concrete slab on grade. The thickness was unknown but believed to be approximately 150 mm (6 inches). There was no finish floor in the source room. Test 2 was a high-rise hotel with an approximately 200 mm (8 inches) structural concrete slab, with vinyl finish flooring over a rubber mat. Three different rooms were included in the testing in this building. Test 3 was on a wood-joist structure with continuous plywood sheathing and a 35mm (1.5 inch) gypsum concrete topping, and an engineered wood finish floor.

The test results are summarized in Table 1, which shows both the ASTM Impact Sound Rating (ISR) [1] used in North American and the ISO $L'_{nT,w}$ [3] which may be more familiar to some readers.

Table 1: Comparison testing results

Test	Assembly	Finish floor	ISR		$L'_{nT,w}$	
			Mod. ASTM	ISO	Mod. ASTM	ISO
Test 1	Concrete slab on grade	None	43	48	60	55
Test 2	Concrete slab	Vinyl over rubber mat	65	67	45	43
			62	62	48	48
			58	58	52	52
Test 3	Wood joist with gypsum concrete topping	Engineered wood	68	68	42	42

5. Discussion

5.1 Variation in level with distance

For some of the tests, there were only small differences between the tapping positions using the two methods. However, for other tests the noise level from the operation of the tapping machine varied significantly. Fig. 3 shows the impact sound pressure level (ISPL) spectra of Test 3 for each tapping machine location of each of the two methods. To investigate whether the differences in spectra can be attributed primarily to distance, the distance between the tapping machine and the common wall was measured. The spectra were then normalized to a distance of 1.5 m by assuming that the level would vary as

$$20 \log \frac{d}{1.5} \tag{1}$$

with d the distance between the tapping machine and the common wall in m. (Bands above 1000 Hz were controlled by background noise level and were therefore not normalized for distance.)

There is no particular theoretical justification for Eq. 1, except for the general principle of geometrical divergence. A different coefficient (instead of 20) may be appropriate for other conditions. In this case, however, Eq. 1 appears suitable. When applied to the spectra (see Fig. 4), the results are consistent with the hypothesis that the ISPL for a given floor and receiving room varies only as the distance between the tapping machine and the wall.

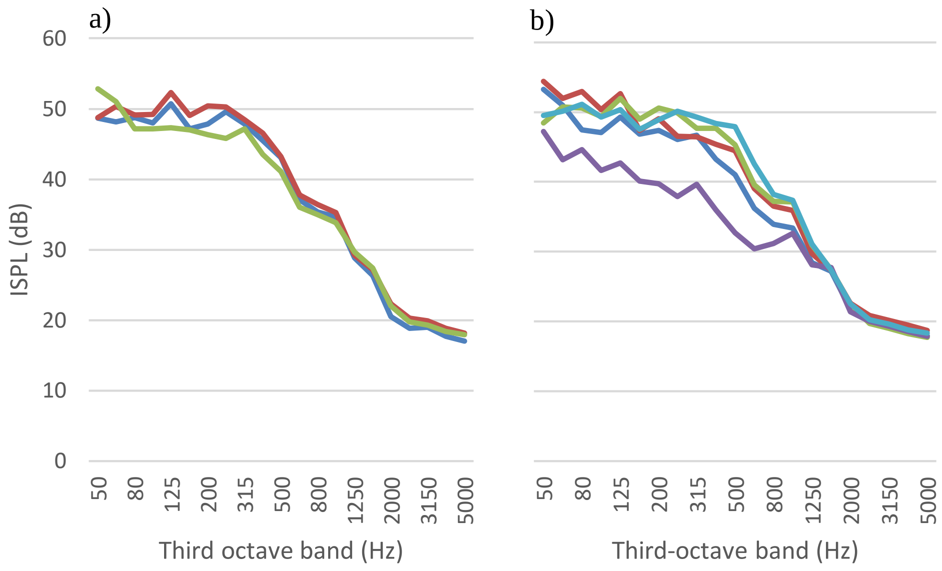

Figure 3: Lateral ISPL spectra for each tapping machine position for a) proposed modified ASTM positions and b) ISO positions.

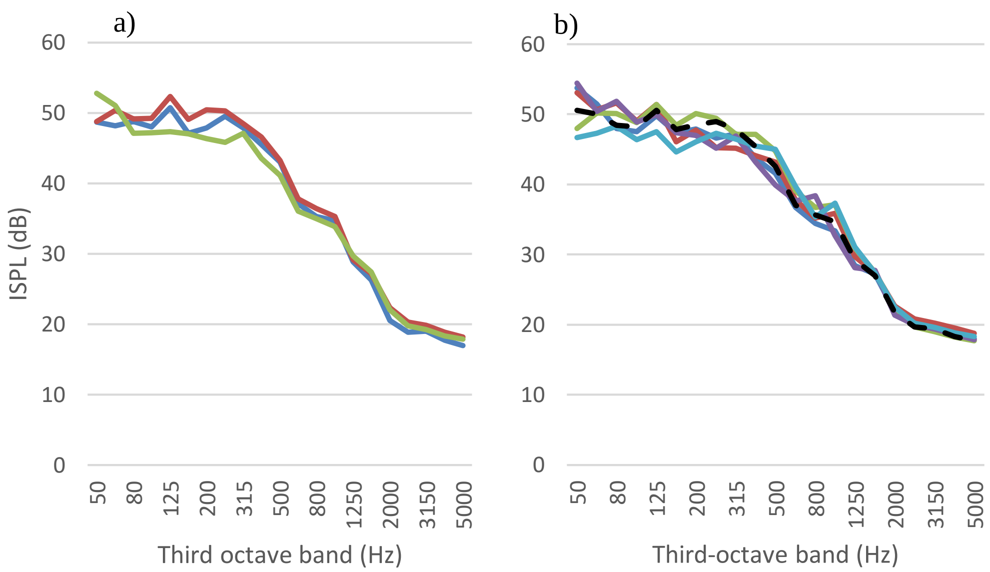

Figure 4: Lateral ISPL spectra for each tapping machine position for a) proposed modified ASTM positions and b) ISO positions normalized according to Eq. 1. The dashed line in b) is the average of the three positions in a).

5.2 Comparison of methods

In most conditions, the difference between the two methods is small. The ratings when using the ISO method are always the same or better than the modified ASTM method. This is attributable to the simple fact that some of the tapping machine locations are farther away.

A justification for the ISO positions might be that the impact source may occur at any location in the room. However, the standard already restricts the sources to the closer half of the room, apparently recognizing that distant tapping machine locations are not appropriate. Compared to the modified ASTM method, the ISO method results in either the same results (if the closer positions dominate) or slightly better results (if the average ISPL is reduced because of more distant positions). Averaging the levels in this manner does not seem to provide any additional information, but merely increases the variance in the measurement.

Therefore, a method that maintains a constant distance to the receiving room is preferred for evaluating the lateral impact noise isolation between two spaces. The modified ASTM method would be considered superior for the reasons indicated above.

6. Classification

Figure 5 shows the average ISPL spectra (using the modified ASTM positions) for the three assembly types tested in Section 4. In many ways, the lateral ISPL spectra are similar to the expected vertical spectra. The bare concrete floor spectrum has a slight positive slope, with level increasing with frequency. The presence of a finish floor or sound mat dramatically reduces the high frequency levels but has little effect at lower frequencies.

The wood joist floor does not demonstrate the elevated low-frequency impact noise that is characteristically exhibited by such assemblies. More colloquially, there is no low frequency thudding in the horizontal direction.

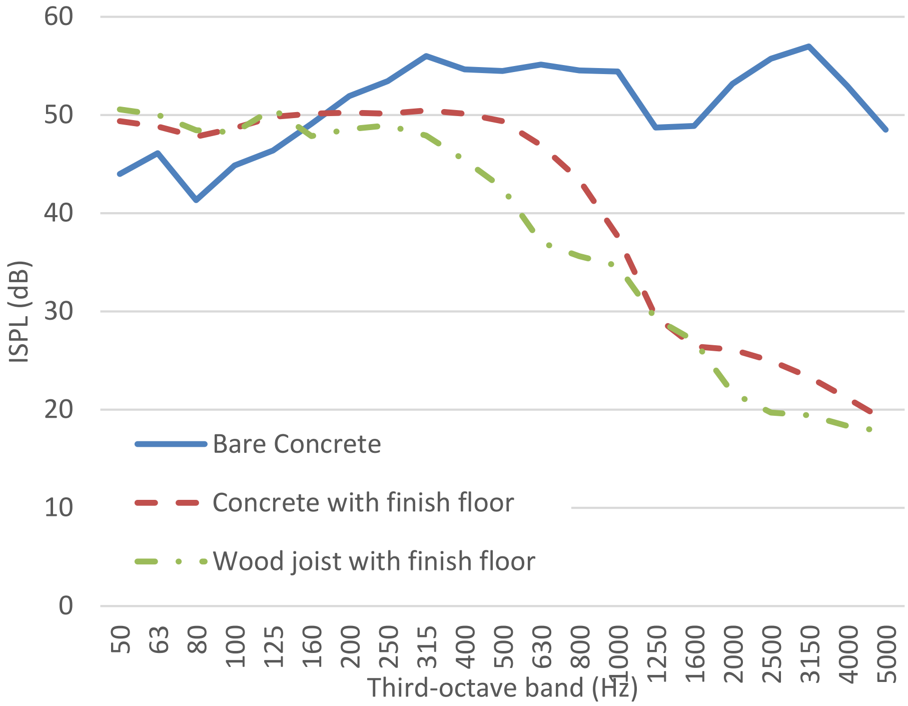

Figure 5: Average ISPL spectra of the three building types tested.

Table 2 shows the single number ratings of the three average spectra in Fig. 5. In addition to ISR, the recently-introduced [4] Low-frequency Impact Rating (LIR) and High-frequency Impact Rating (HIR) are shown. The ratings indicate that evaluation of lateral impact noise can be performed using the same ratings and possibly the same classification scheme as vertical testing. If the ISR is evaluated according to the ICC-G2 Guidelines for Acoustics [5], the bare concrete assembly (ISR 43) is unacceptable, while the assemblies with finish floor exceed the Preferred (Grade A) level of performance. Based on a recent tentative classification of LIR and HIR [6], the LIR for all floors exceed the Preferred (Grade A) level, quantifying that low-frequency thudding is not a concern. The HIR for the bare concrete floor is below minimum standards (and would be considered unacceptable), while both of the finish floors exceed the Preferred (Grade A) level of performance.

Table 2: Single Number Ratings of the spectra in Fig. 6.

Assembly	**ISR**	**LIR**	**HIR**
Bare concrete	43	92	46
Concrete with flooring	65	83	67
Wood joist with flooring	68	81	73

7. Summary

Lateral impact transmission is less studied than the vertical condition, but is important in the evaluation of some lateral adjacencies. With the exception of tapping machine location, the measurement method, calculation methods, and single number ratings for vertical impact noise isolation appear to apply equally well to lateral as to vertical measurements. The classification schemes developed for vertical measurements function suitably for the evaluation of lateral isolation. The recently introduced LIR and HIR also show to translate the lateral impact into reasonable classification indexes for evaluation. Based on our analysis, restricting tapping machine locations at a fixed distance from the common wall improves the repeatability of the test, and therefore the modified ASTM method is suggested for adoption into the measurement standards.

REFERENCES

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