VALIDATION OF A SOUND INTENSITY IMAGING SYSTEM FOR WALL ISTC CALCULATION, WITH LEAK DETECTION

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1 Introduction

ASTM E2249-2016 [1] establishes two methods (Discrete Point and Scanning) for the laboratory measurement of airborne intensity transmission loss (ITL) of building partition and elements using sound intensity. No difference in precision for these two methods is given. This airborne transmission loss can then be used to calculate an Intensity Sound Transmission Classification (ISTC) for the partition of element using ASTM E413-2016 [2]. This paper presents a 3rd method ("Imagery" method) which allows for the ISTC calculation through the novel use of an acoustical imaging system, that allows for automated leak/weakness detection.

2 Methodology

2.1 Measurement location and sample partition

A comparison of the three intensity methods can be between any two spaces where the dominant sound transmission is via the separating partition being measured, with an understanding that the calculated ISTCs do not conform to E2249 or E90-2009 [3]. In this study, we used a standard office partition (2.4 m x 4.0 m) with a steel stud gypsum board wall, wood door with no seals, and two single-pane windows. A dodecahedron loudspeaker generated a broadband-noise within the source room and the sound pressure level in the source room was measured.

2.2 Sound intensity measurements

In each method, certain field indicators criteria must be satisfied for results to be valid (See E2249). The time required for each intensity method (including set-up and post processing) was recorded for comparison. For each of the three methods the same Class 1 intensity probe, frequency range, 25 mm spacer, distance to surface of 150 mm, and sampling rate of 0.1 seconds were used.

Sound intensity – discrete point method

The sound intensity is measured at fixed positions over a period of 10 seconds in each of 240 square segments (200mm x 200mm) of a computer projected grid totally enclosing the separating partition (See Figure 1, left, for grid measurement points). In post-processing; (i) the average sound intensity for the whole surface are calculated; (ii) Field Indicators are compared against two criteria (adequate dynamic range, and adequate measurement array), (iii) the sound power is calculated; (iv) the ITL is calculated; (iv) the STC is calculated, and finally (vi) a basic coloured grid is created using Excel/PowerPoint to create a sound intensity map over the surface used for weakness detection.

Figure 1: Grid with discrete points (left) and scanning path (right)

Sound intensity – scanning method

The sound intensity probe is swept through the same grid the geometrical centre of each segment by hand at a constant speed of 0.2 ms^{-1} (Figure 1, right), and the sound intensity level continuously averaged through each 4-minute scan. The scan was then repeated, and then a twice more with the scan path rotated 90º (vertical scan), with approximately 1 minute between scans to stop-process-start. In post-processing, the process has slightly different Field Indicators and Criteria (for example, a limit on negative partial power and a partial-power repeatability check), with significantly less data to process, but no imagery.

Sound intensity – imagery method

The *I-track* digital camera optically tracks the sound intensity probe as it is swept across the wall surface at both an irregular speed and an irregular pattern (Figure 2, left). The optical tracking allows for real-time averaging and colour rendering of the sound intensity across an image of the surface using an averaging radius of 100 mm, equivalent to a segment of 200 mm by 200 mm (Figure 2, right). The integrated sound intensity and sound power for the scanned surface is automatically calculated by the *Mezzo* software. To adequately scan the surface takes between 4 and 6 minutes, depending on the non-uniformity of the partition and the desired precision of weakness localisation.

3 Results

3.1 Sound Intensity, ITL and STC

The integrated A-weighted surface intensity measured in each method is presented in Table 1, along with the

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difference between the discrete and scanning methods, and the difference between the discrete and imaging methods.

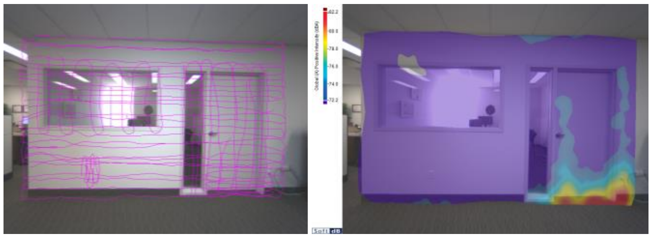

Figure 2: Imagery method. Actual irregular scan path taken (left) and overall A-weighted sound intensity map (right).

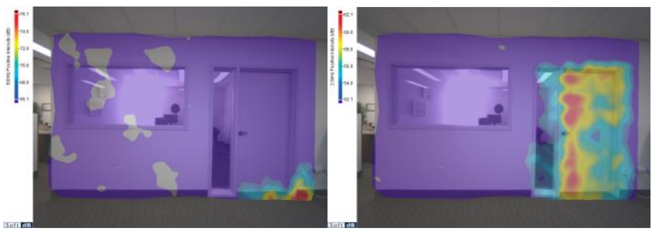

Figure 3: Imagery method. 500 Hz (left) and 2500 Hz (right) A-weighted intensity imagery. Note colour scale for each is different.

Table 1: Average surface A-weighted sound intensity per 1/3rd octave band by measurement method

Freq.(Hz)	Discr. Point (DP)	Scan. (S)	Imag. (I)	DP - S	DP - I
125	56.1	55.3	55.3	0.8	0.8
160	59.5	59.7	59.6	-0.1	-0.1
200	62.3	62.2	62.4	0.1	-0.1
250	64.9	64.0	64.1	0.9	0.8
315	62.4	62.2	62.4	0.2	0.0
400	61.6	61.2	61.7	0.4	-0.1
500	60.3	59.6	60.1	0.7	0.2
630	56.9	56.9	57.1	0.1	-0.2
800	54.7	54.7	55.1	0.0	-0.4
1000	52.3	52.8	53.1	-0.4	-0.8
1250	49.8	50.3	50.5	-0.5	-0.7
1600	50.1	49.9	49.8	0.2	0.3
2000	53.3	52.7	52.6	0.6	0.7
2500	52.2	51.6	52.0	0.6	0.2
3150	46.2	46.0	46.3	0.1	-0.1
4000	41.7	41.6	41.8	0.1	-0.1
Total	**70.8**	**70.4**	**70.6**	0.4	0.2

Table 2: Time taken (in minutes) for each phase of intensity measurement (not including source room set-up or measurement)

Method	Discrete Point	Scanning	Imagery
Set-up grid, camera	5	5	2
Calibration, settings.	5	5	5
Measurement	120	20	6
Post-processing	15*	10*	1
Calculation of L_W, ITL, and STC	7*	7*	5*
Colour intensity map (overall intensity)	30*	N/A	Instant
Colour intensity map (additional per frequency band)	3*	N/A	Instant
Total time (minutes)	**185***	**47****	**19**

*This time may be reduced when using template calculation spreadsheets.
**Does not include any weakness detection

Using the methodology of E2249 and E413, the ITL and STC can be calculated for each method. Minor differences between the methods in integrated sound intensity levels (Table 1) causes minor differences in the ITL, but as the STC calculated for each method is the result of the sum of deficiencies from the STC curve exceeding 32 dB for each method, there is no difference in calculated ISTC level in this example (STC 21). Figure 3 presents leakages causing these deficiencies; the door bottom (500Hz); and the unsealed door perimeter (peaking at 2500Hz). Whilst the scanning method does not allow for mapping of the intensity, a basic cartography can be made in Excel/PowerPoint from the Discrete Point results. The ability of the Imagery method to sweep at variable speed in an irregular pattern reduces the risk of imprecision associated with the Scanning method.

3.2 Comparison of time required

The time required for each method (excluding enforced repetition arising from non-valid measurements based on Field Indicator Criteria), from establishing a grid or setting up the digital camera, to having a final STC and imagery for weakness localisation is presented in Table 2.

4 Discussion

The difference between the Discrete Point and (i) Imagery and (ii) Scanning methods for overall sound intensity levels was 0.2 and 0.4 dB respectively (standard deviation across frequency bands was 0.5 and 0.4 dB respectively). The Discrete Point method allows for the basic mapping of the scanned surface in post-processing by frequency band, to detect “hotspots” of leakages or weaknesses in the partition; the faster scanning method does not. In contrast to both traditional methods, the Imaging method is clearly much faster than both the Discrete Point method (90% faster) and the scanning method (60% faster, despite scanning having no weakness detection). Additionally, the automated probe tracking of the Imagery method maps the intensity distribution in real-time and a high resolution at each 1/3rd octave band frequency, resulting in faster weakness detection than the traditional Discrete Point method.

5 Conclusion

The Imagery method of sound intensity measurement has been shown to be comparable in precision to the traditional Discrete Point and Scanning methods of ASTM E2249. After repeating this study on a more uniform laboratory sample, the Imagery method will be proposed for inclusion in the ASTM E2249 standard as an acceptable alternative.

References

[1] ASTM E2249-16 Airborne Transmission Loss of Building Partitions and Elements Using Sound Intensity.

[2] ASTM E413-16 Classification for Rating Sound Insulation.

[3] ASTM E90-09 Airborne Sound Transmission Loss of Building Partitions and Elements.