EXPLORING VARIATIONS TO ASTM E336 DIRECTIONAL SOUND SOURCE POSITIONING

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1 Introduction

Noise isolation tests of secure office perimeters often require measurements across all four office walls. Per ASTM Test Standard E336 [1], sound sources must be located at least 5 m from the test partition, or in the corners opposite of the test partition when the room dimensions do not allow this. Given the typical dimensions of office spaces, at least two loudspeaker positions are required for measurements across all four office walls. This paper explores the feasibility of using alternative (non-conforming) loudspeaker positioning when noise isolation test results are needed across all four partitions of the source room, to enable a single source room setup to be used for all horizontal tests. This would reduce the time required for measurements and post-processing.

2 Method

2.1 Overview

Noise Reduction (NR) and Noise Isolation Class (NIC) testing was completed across office partitions, firstly following the requirements of ASTM E336, and then repeated with alternative loudspeaker positions intended to achieve a similar result. A total of four source rooms were tested, each with receiving measurements in four to five adjacent rooms on the same floor. Three of the source rooms were orthogonal, one was L-shaped. Most of the test partitions were designed with the same wall type (steel studs with insulated cavities and drywall over). Some of the test partitions included standard office doors without acoustic seals, while others included STC-rated door and door frame assemblies. All measurements were completed using the manually scanned microphone technique. Directional sound sources were used: self-powered Yorkville loudspeakers, model NX520P.

2.2 ASTM-Compliant Loudspeaker Positioning

The loudspeaker was initial placed near one corner of the source room, and aimed into the corner, as per ASTM E336 requirements. Measurements of the source room and receiving room sound levels were then completed for the two walls opposite to the loudspeaker. The loudspeaker was then moved to the opposite corner, so that source and receiving room sound levels could be measured for the remaining walls. Background sound levels were also measured in each receiving room.

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2.3 Alternative Loudspeaker Positioning

The alternative approach was to use two loudspeakers simultaneously within the source room, using un-correlated pink noise signals. Each loudspeaker was positioned approximately 1 m from diagonally opposed corners of the source room. The loudspeakers were aimed towards the centre of the room rather than into the corners, so that most of the direct sound energy was aimed away from the nearest test partitions. This single source setup was used for all receiving measurements across the test partitions.

3 Results

3.1 NR Measurements

The measurement data were used to calculate separate NR values for loudspeakers positioned in compliance with ASTM E336, and for the alternative loudspeaker positioning. A total of 17 partitions were tested using both methods. Charted below are the NR values per one-third octave band obtained from the alternative loudspeaker positioning, relative to the NR value for the ASTM-compliant loudspeaker positioning for the same partition. Also shown are the mean and standard deviations, as well as the repeatability and reproducibility standard deviations referenced in ASTM E336 [2].

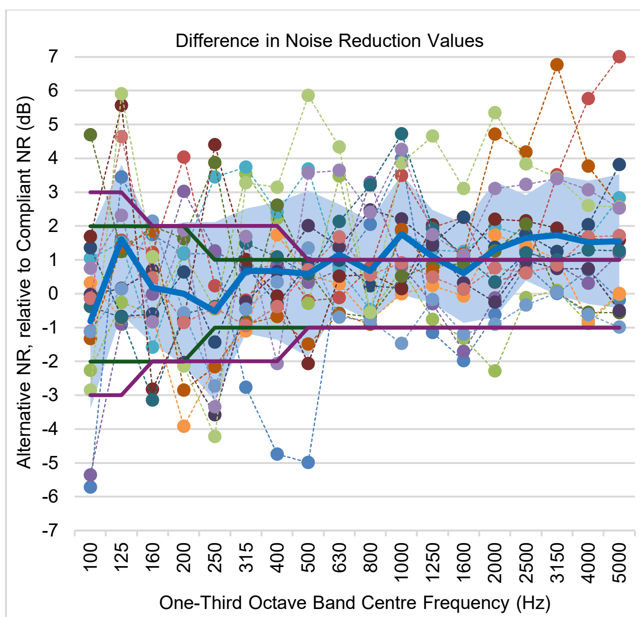

Figure 1: Difference in measured NR values using both loudspeaker positioning methods. The mean values are shown as a blue line, with the shaded blue area showing one standard deviation above and below the mean. The solid green and purple lines are the repeatability and reproducibility standard deviations, respectively, as referenced in ASTM E336 [2].

3.2 NIC Results

The NR values were used to calculate NIC ratings following ASTM E413 [3]. The results are listed in Table 1. On average, the alternative result was 0.94 dB higher, with a standard deviation of 1.09 dB. For reference, the repeatability and reproducibility standard deviations of single-number ratings referenced in ASTM E336 [2] are 1.3 dB and 1.9 dB, respectively.

Table 1: Comparison of NIC Ratings

Test	Compliant	Alternative	Difference
A	46	46	0
B	64	65	+1
C	42	42	0
D	52	53	+1
E	38	40	+2
F	40	40	0
G	61	62	+1
H	32	33	+1
I	46	48	+2
J	37	38	+1
K	61	61	0
L	47	47	0
M	31	31	0
N	44	44	0
O	22	26	+4
P	34	36	+2
Q	44	45	+1

3.3 Time Saved

The sound level meter measurement timestamps were reviewed following the testing. From this data, the alternative loudspeaker positioning allowed the testing to be completed approximately 21 minutes faster than the ASTM-compliant tests, or about 5 minutes faster per secure office (source room), on average.

In relative terms, the tests using alternative loudspeaker positions took approximately 30% less time to complete than the ASTM-compliant tests. This includes the time to complete all sound level measurements (source room, receiving room, background noise) and loudspeaker repositioning (for ASTM-compliant tests), but excludes the initial sound source setup and final teardown time in each source room.

4 Discussion

If the alternative loudspeaker positioning resulted in similar test results as compared to the ASTM-compliant positioning, the mean NR difference would be close to 0 across the test frequency bands, with standard deviations similar to the repeatability or reproducibility standard deviations referenced in ASTM E336 [2]. Figure 1 shows that this was not the case. Mean values tended to be greater than 0, with high variability in the data (individual NR differences range from approximately -6 to +7 dB).

Of note, background noise levels in the offices were low for these measurements, and so the higher NR measurements are not likely attributable to differences in the signal-to-noise ratio in receiving rooms. With few exceptions involving only the 4 kHz and 5 kHz bands for NIC results above 60 (Tests B and G), receiving levels were always more than 6 dB above background levels in each one-third octave band.

Despite relatively poor agreement in NR values, the NIC ratings are much more consistent. Accounting for the bias of about +1 dB, the standard deviations in NIC results were less than the standard deviations for repeatability and reproducibility per ASTM E336 [3]. This result is not expected to be reliable, given the above-noted variability in NR differences.

5 Conclusion

Overall, the alternative loudspeaker positioning does not appear to be a suitable substitute for following ASTM E336 requirements. Rather, our results highlight the importance of following the Test Procedure with respect to loudspeaker positioning, as alternative positioning may lead to artificially higher noise isolation test results.

Alternative loudspeaker positioning may be useful only for a survey-level analysis of NIC ratings, which our results suggest would need to factor in a bias of +1 dB (for similar test conditions). The time saved using alternative loudspeaker positions may not justify the increased uncertainty in the results.

6 Future Work

Further experimentation could be done to determine whether there are other directional loudspeaker positions that can provide better agreement with the Test Standard while enabling a single source setup for measurements in all horizontal directions within typically sized and furnished closed office spaces.

The directivity across frequencies will vary between individual directional loudspeaker models. The impact of this variability on the reproducibility of ASTM E336 measurements (and comparisons to omni-directional sources) is a topic worthy of further study.

References

[1] ASTM E336-23, Standard Test Method for Measurement of Airborne Sound Attenuation between Rooms in Buildings, 2023

[2] The repeatability and reproducibility limits in ASTM E336-23 (section 14) originate from Higginson, R.F., “A Study of Measuring Techniques for Airborne Sound Insulation in Buildings,” Journal of Sound and Vibration, Vol 21, 1972, p.405.

[3] ASTM E413-22, Classification for Rating Sound Insulation, 2022