ISO3382 Reverberation Time Measurement in ET308

Abstract

Students of the Coventry University's 200EPA Acoustics module measured the reverberation time in an audio mixing room in accordance with ISO 3382 testing protocol. Reverberation time was discovered to vary significantly from the mix position to the rear of the room; however, the average reverberation time is as expected for an audio mixing and mastering room.

Introduction

Reverberation time was once considered the most significant acoustic quality of a room (Everest 2009: 151). For this reason, many testing procedures have been proposed to evaluate the reverberation time in rooms. In performing such tests, procedures outlined by the standards should be followed precisely so that the results may be compared with the results of tests performed elsewhere and conclusions may be drawn about the opportunities for acoustical improvement that are available. Further, testing is essential because calculations used to predict reverberation time, such as the Sabine equation, may not necessarily be accurate.

Method

Reverberation time measurements were made by students of Coventry University in conformity with ISO 3382, as defined by the British Standards document BS3382-2:2008 *Acoustics – Measurement of Room Acoustics Parameters.* Measurements were made on 15 March 2013 at Coventry University in room ET308 of the Ellen Terry Building, located on Jordan Well Street in Coventry, West Midlands, CV1 5RW. Scale dimensions of the room are illustrated in Appendix F. The volume of the room is approximately 74.67 m^3. Of the three methods described in ISO 3382, tests were conducted in accordance with the 'standard' measurement protocol. Accordingly, the relative temperature and humidity of the room were not measured, clutter was not removed prior to measuring, and two people were present. The permanent furniture and clutter present at the time of measuring are as follows: 7 plastic chairs, two large wooden desks, an SSL audio mixing desk, a variety of electronic components mounted on racks, loose cables wired into the components, 1 music stand, 5 microphone stands (collapsed), a large bag of cables, a boxed microphone, and a boxed set of cymbals. Sound was played through a 5.1 surround sound system featuring Dynaudio Acoustic monitor speakers. The sound source may be described as omnidirectional because the speakers projected the sound in 5 directions and the room is small. Broadband, unfiltered pink noise was generated using the signal generator that is built into Protools. The approximate measurement locations are marked in figure F.1 with the letters A, B, C, and D. The height of the microphone was approximately 0.8 meters and was consistent for all measurements. Photographs of the microphone in the four measurement positions are shown in figures F.3 through F.6. As is permitted by the standard method, a single noise reading was made at each location, and the results from the four locations were averaged.   The measurement positions were approximately one meter apart from one another and one meter apart from walls and room surfaces.   A Phonic PAA3 recorder was used for the measurement. ISO 3382 recommends the use of an omnidirectional condenser microphone with a diaphragm that is 16mm in diameter or smaller. According to the PAA3 specification, a 'miniature' omnidirectional condenser microphone is built in. The PAA3 is a 31-band real-time spectra analyser with 0.5dB resolution at center frequencies. BS3382 requires that the measurement device be capable of correcting against overflow. The PAA3 has a dynamic range of 30 to ~130dB and a maximum level peak hold display.   Further, the PAA3 is advertised as ISO standard from 20Hz to 20KHz.

After the reverberation time measurements were made, the room's dimensions were measured. A three-dimensional model of the room was created in Google SketchUp, and the surface area and volume of the room were calculated using SketchUp's built in area and volume functions. Estimates were made about the materials used in the room's construction and appropriate absorption coefficients were assigned to the materials. The surface areas and absorption coefficients are presented in figure F.7, and images of the three dimensional renderings are displayed in figure F.2.

Results

The measured reverberation times of the four measurement positions, as labelled in Figure F.1, are as follows:

A) Mix Position	C) Mix Left	B) Mix Right	D) Rear
0.31 seconds	0.34 seconds	0.36 seconds	0.42 seconds

The average reverberation time shall be the mean of the four measurements:

$$T_{60} = \frac{T_A + T_B + T_C + T_D}{4}$$

$$T_{60} = \frac{0.31 + 0.34 + 0.36 + 0.42}{4}$$

$$T_{60} \approx 0.36$$

From the Sabine calculation, the calculated reverberation times are as follows:

150	250	500	1000	2000	4000	Average
0.45 seconds	0.39 seconds	0.2 seconds	0.32 seconds	0.2 seconds	0.22 seconds	0.3 seconds

Discussion

In review of the procedures followed, ISO3382 advised the use of an omnidirectional source and microphone. An omnidirectional source and microphone are important because sound may become trapped in a portion of the room that a more directional microphone might not be directed towards and therefore, might not detect the slowly escaping sound of the coupled space. Similarly, a directional source might not bring all portions of the room to steady state equally, resulting in a reverberation time that only reflects a portion of the room. According to Howard, the mean time between reflections and the number of reflections can be calculated with the following formulas:

$$t = \frac{4V}{Sc} = \frac{4(74.67\ \mathrm{m}^3)}{(125.83\ \mathrm{m}^2)(340\,\frac{\mathrm{m}}{\mathrm{s}})} = 6.98ms$$

$$N_{reflections} = \frac{T_{60}}{t} = \frac{0.36}{6.98 * 10^{-3}} = 51.6$$

In the case of this room, 51.6 reflections occurred, but if the total number of reflections was very low, it would be even more difficult to obtain accurate and consistent measurements with non-omnidirectional equipment (Howard 2006: 285).

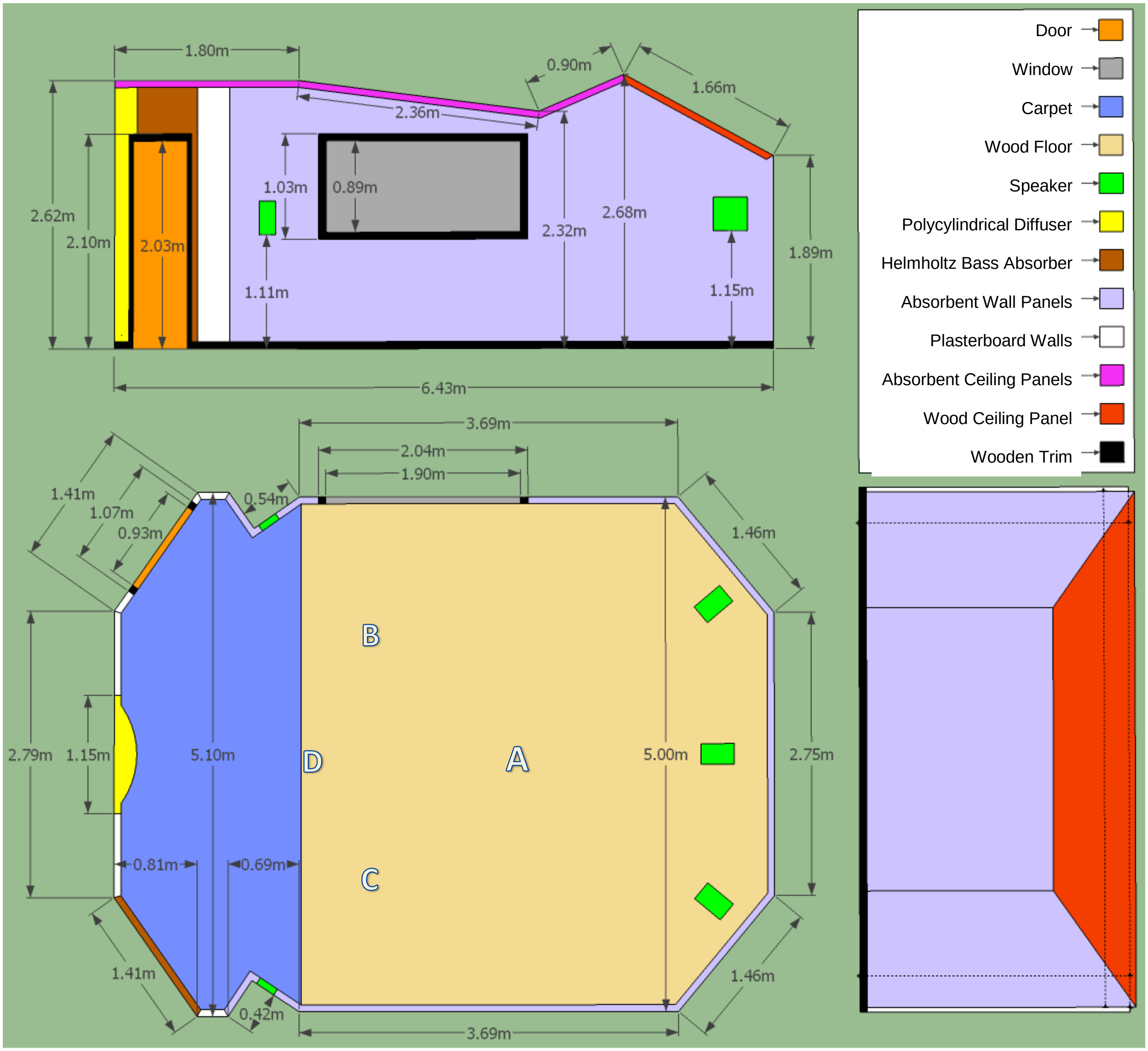
The strength of the noise signal used is also significant because background noise readings are an average over time and do not necessarily reflect the noise conditions at all times. A signal 35 dB above background noise must be offered for the measurement so that an additional margin of error is available for inevitable increases and decreases in background noise level.

A broadband pink noise signal accurately represents all frequencies within a specified bandwidth. The use of pink noise ensures that all resonant frequencies of the space and absorption deficiencies of the materials that compose it are accounted for.

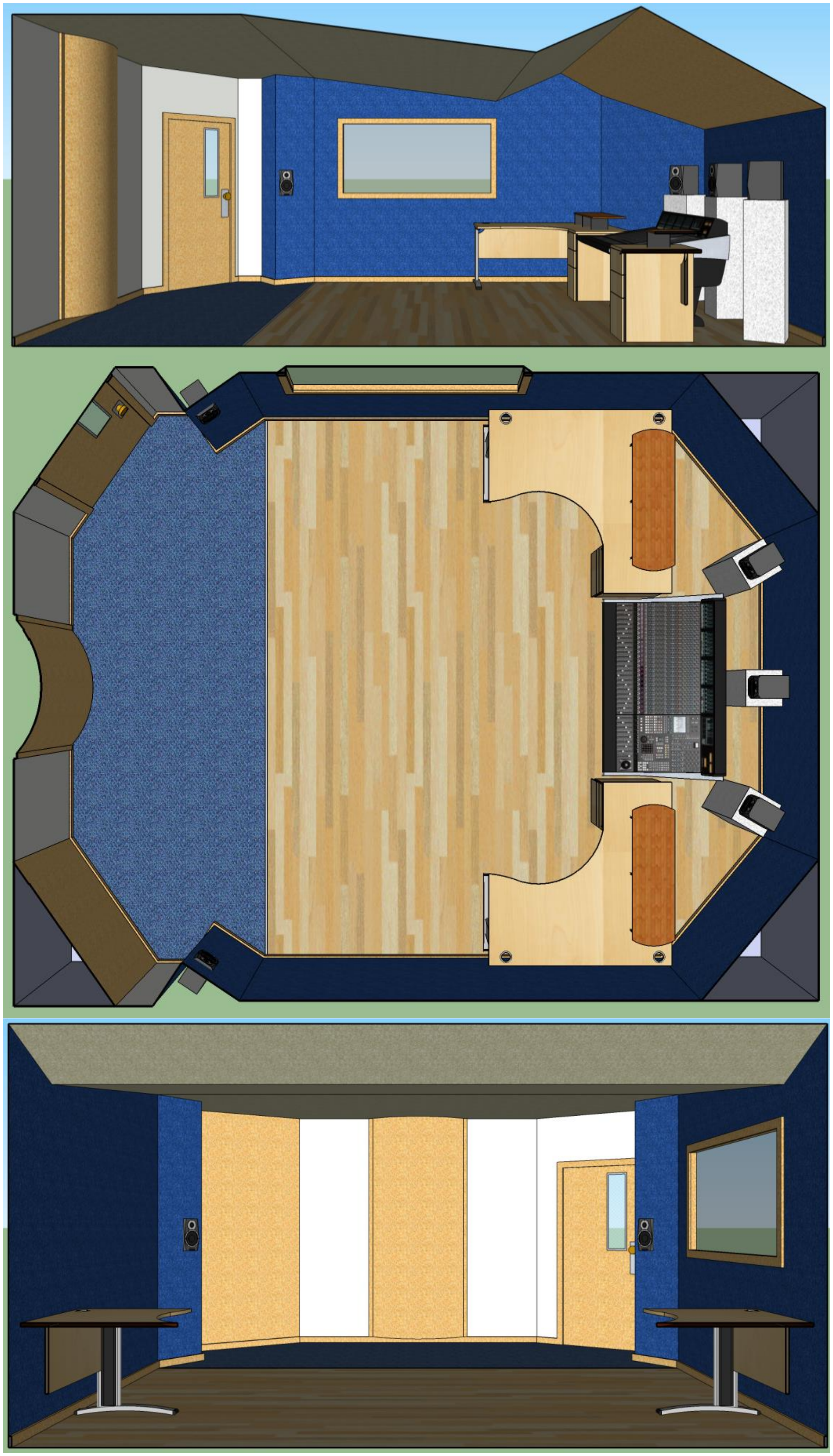
This method of reverberation time testing utilizes a single measurement, whereas other reverberation time measurements might perform separate tests at 6 octave frequencies. The benefit of testing octaves individually is that more information about the room is available. In the predictive calculations that were performed using the Sabine formula, the reverberation at 150 Hz was over twice as long as at 500 Hz, yet this disparity is hidden in the averaged measurement. If measurements are being performed to assess for improvement, a six octave method would provide more meaningful information about the room.

The room that was measured is a hybrid between live end dead end design and reflection free zone design. Measurements in the rear position of the room were attempted multiple times and the results were consistently longer than measurements made in the other room positions. This suggests that the live end (in the rear, D) has a longer reverberation time than the dead end (surrounding the mix position, A). Accordingly, measurements made in multiple locations are more meaningful than in a single location because they alert the tester to the presence of a competing reverberant decay, which may be problematic.

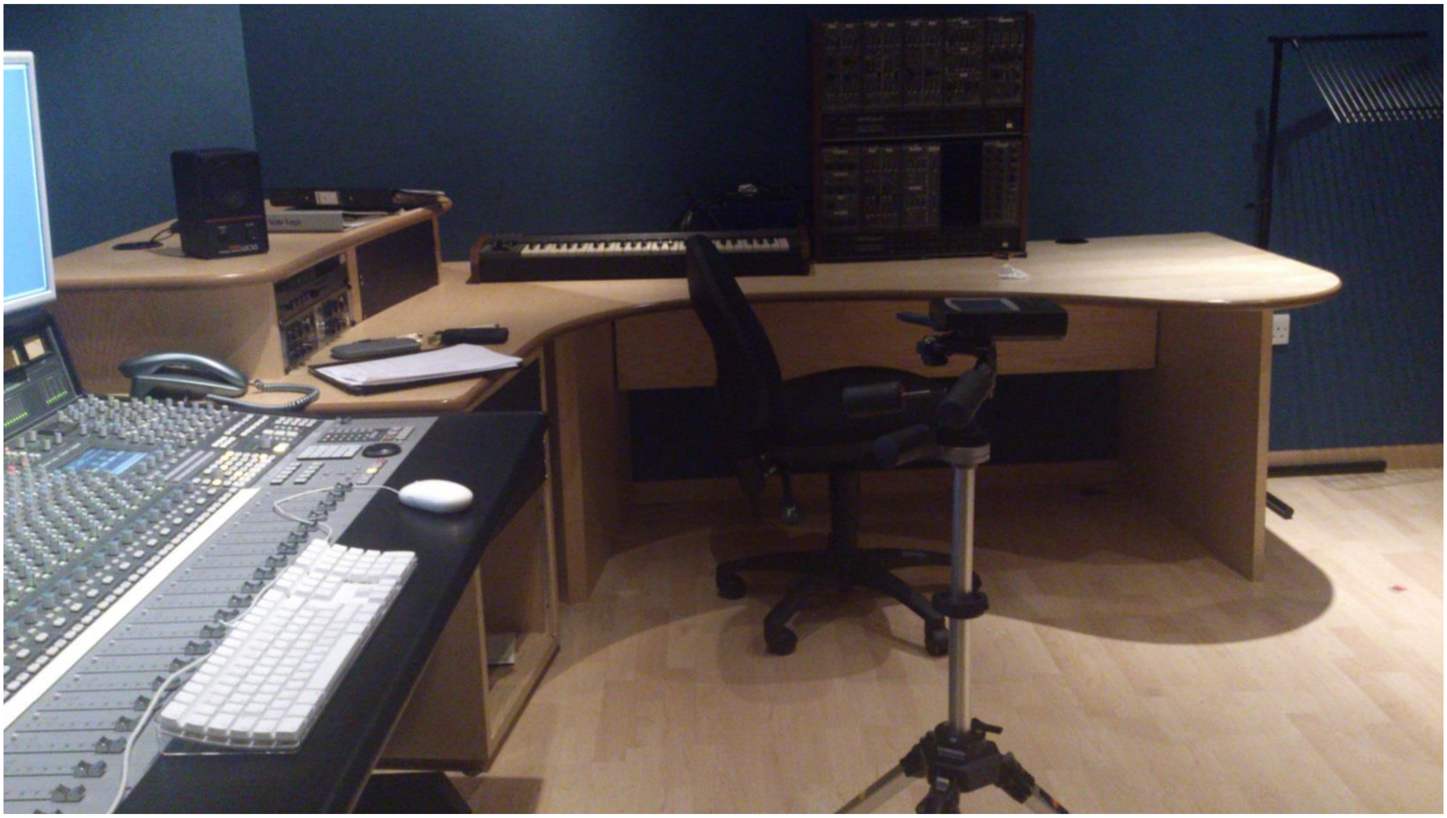
In conclusion, ET308 is a suitable environment for mixing. The dry acoustic provides the clarity of sound that is required for sensitive listening. Furth, the variation in reverb time at the rear of the room is of no concern to the mixing engineer because the positions to the left and right of mix position yielded measurements that were consistent with the mix position’s measurements. The very slight difference of 0.06 seconds between the calculated and measured reverberation times of the space suggests that the Sabine formula remains an accurate method for predicting reverberation time, even in small rooms with containing highly absorbent materials.



F.1: Side profile, floor plan, and rear profile of the ET308 located in the Ellen Terry Building of Coventry University. The proportions of the illustration are accurate. The letters 'A,' B,' 'C,' and 'D' on the floor plan indicate the *approximate* locations of the PAA3 reverb time measurement positions: A is mix center, B is mix left, C is mix right, and D is rear. Room components are labelled according to the colour coded legend in the upper right. Please see the 3D renderings in figure F.2 for a more clear representation of material distribution.



F.2: A 3D rendering of the 2D profiles in F.1 (made with Google SketchUp).



F.3: PAA3 measurement position A: mix center.

F.4: PAA3 measurement position B: mix left.

F.5: PAA3 measurement position C: mix right.

F.6: PAA3 measurement position D: rear.

F.7: ET308 Reverberation Time Calculations

COMPONENT	METERS$^{2/3}$	MATERIAL	125	250	500	1000	2000	4000	SRC.
Door	1.9	Solid timber door	0.14	0.10	0.06	0.08	0.10	0.10	3
Window	3.38	Double glazing, 2-3mm glass, 10mm air gap	0.15	0.05	0.03	0.03	0.02	0.02	1
Carpet	7.86	Carpet, thin, over thin felt on wood floor	0.20	0.25	0.30	0.30	0.30	0.30	1
Wood Floor	21.42	Raised computer floor, steel-faced 45mm chipboard 800mm above concrete floor, no carpet	0.08	0.07	0.06	0.07	0.08	0.08	4
Polycylindrical Diffuser	3.44	3-4mm plywood, 75mm cavity containing mineral wool	0.5	0.3	0.1	0.05	0.05	0.05	2
Helmholtz Bass Absorber	3.59	Plywood 12mm thick perforated 5mm diameter holes 6200 m2 11% open area backed with 60mm thick fibreglass between mounting battens	0.40	0.90	0.80	0.50	0.40	0.30	1
Absorbent Wall Panels	31.72	Rock wool 50mm, 33 kg/m3 direct to masonry	0.15	0.60	0.90	0.90	0.90	0.85	2
Plasterboard Walls	7.14	2 x 13mm plasterboard on frame, 50mm airspace with mineral wool	0.15	0.10	0.06	0.04	0.04	0.05	1
Absorbent Ceiling Panels	24.14	25mm Glass wool/mineral wool over air space	0.40	0.00	0.80	0.00	0.90	0.80	1
Wood Ceiling Panel	7.1	Plywood, hardwood panels over 25mm airspace on solid backing with absorbent material in air space	0.40	0.25	0.15	0.10	0.10	0.05	1
Wooden Trim	3.14	Woodblock/linoleum/rubber/cork tiles (thin) on solid floor (or wall)	0.02	0.04	0.05	0.05	0.10	0.05	1
Desk	2	Adult office furniture per desk	0.50	0.40	0.45	0.45	0.60	0.70	1
Hard Chairs	7	Empty plastic or metal chairs (per chair) in m2 units	0.07	0.00	0.14	0.00	0.14	0.14	1
People	2	Adults per person standing	0.15	0.38	0.42	0.43	0.45	0.45	1
Miscellaneous Clutter	N/A	1 Music stand, 5 microphone stands (collapsed), large bag of cables, boxed microphone, boxed cymbals, loose cables/papers			N/A				
ROOM VOLUME	74.67	**TOTAL SABINES**	26.6	30.9	59.1	37.3	60.3	55.7	
									AVERAGE↓
SOURCE		**REVERBERATION TIME (SECONDS)**	0.45	0.39	0.2	0.32	0.2	0.22	0.3

1	Original figures from Building Bulletin 51 published in 1976
2	web.arch.usyd.edu.au
3	Bobran, H.W., "Handbuch der Bauphysik" Verlag Ilstein Berlin 1973
4	Hewetson floors Ltd lab data

References

Everest, F. A. and Pohlmann, K. C. (2009) *Master Handbook of Acoustics.* 5th edn. New York: McGraw-Hill

Howard, D., M. and Angus, J. (2006) *Acoustics and Psychoacoustics.* 3rd edn. Amsterdam: Elsevier