Ozone Panel Pty Ltd

Ozone Panel 120

Acoustic Assessment and Optimization

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EXECUTIVE SUMMARY

Vipac Engineers & Scientists was commissioned by Ozone Panels Pty Ltd in April 2012 to conduct an optimization exercise for the “Ozone Panel 120”, a structural insulated panel (SIP) construction system.

Initial laboratory tests of the product as a base panel were carried out in June 2012.

Using the results of this initial laboratory testing, an optimization exercise was undertaken using a mathematical model to investigate constructions, which could be utilised to improve the sound insulation performance of the product. The target of this exercise was that the proposed constructions should meet, as a minimum, the current National Construction Code (NCC) requirements for the sound insulation performance of inter-tenancy partitions.

Subsequent laboratory tests using the product as a basis for other constructions were carried out in July 2012.

A construction, which meets the design objectives, was identified.

1. INTRODUCTION

This report details the assessment methodology and results as well as outlining recommended additions to enhance the acoustic performance of the Ozone Panel 120 system.

1.1. Scope

The optimization program comprised the following steps:

1. Laboratory testing of the Ozone Panel, as supplied by the manufacturer, was carried out in accordance with the procedures outlined in **AS 1191: 2002** was undertaken to establish the sound insulation performance of the panel as a stand-alone system;
2. A mathematical model was developed to predict the performance of the panel and alternate constructions. The model was calibrated using the results of the laboratory testing of the base panel; and
3. Laboratory testing of an enhanced panel was carried out in accordance with the procedures outlined in **AS 1191: 2002.** The specifications of the panel were based on predictions of a construction, which would be expected to satisfy NCC sound insulation requirements for inter-tenancy partitions.

1.2. Optimization Procedure

The process of optimizing the sound insulation performance of a product can be summarised in the flow chart shown below in **Figure 1**.

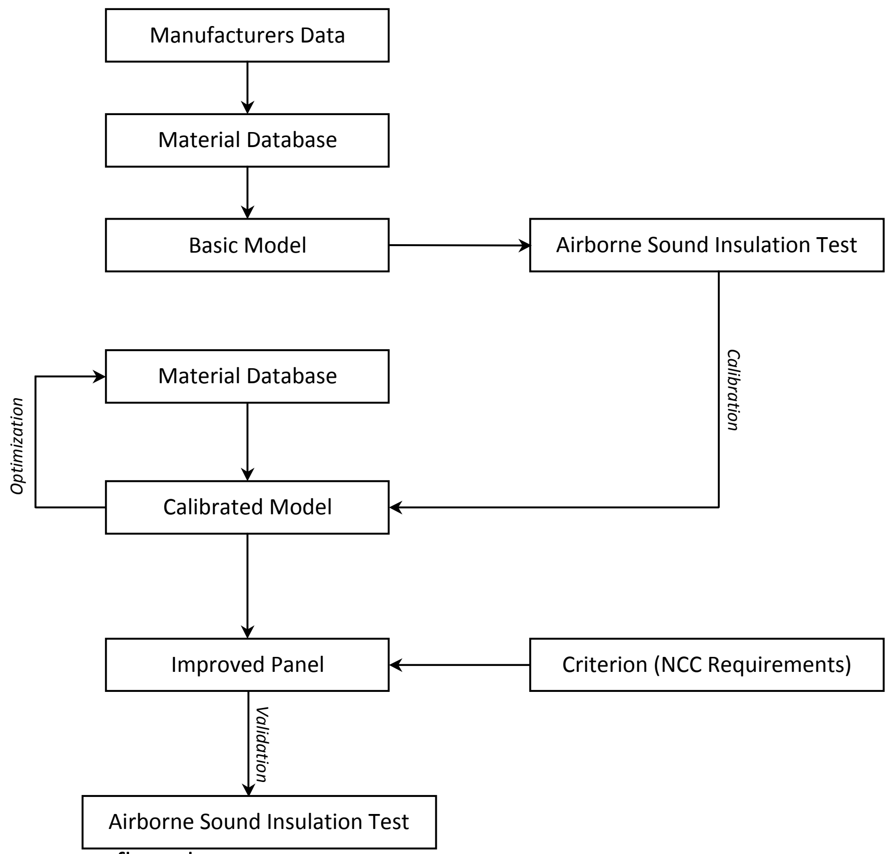


Figure 1 – Optimization process flow chart

2. NCC REQUIREMENTS FOR INTER-TENANCY PARTITIONS

For apartments, the intent of the acoustic design is to achieve conditions of privacy and levels of noise and vibration that would cause minimal disturbance to most people. The corresponding design criteria are defined by NCC requirements and these translate into the need for specific (or minimum) constructions, details, treatments, and materials.

Required airborne sound insulation performance is expressed in terms of the weighted standardized level difference ($D_{nT,\,w}$) and the weighted standardized level difference with spectrum adaptation term ($D_{nT,\,w} + C_{tr}$). These rating indices are determined in accordance with **AS/NZS 1276.1: 1999** or **ISO 717.1: 2004** using results from in-situ measurements.

Deemed-to-satisfy provisions are expressed in terms of the weighted sound reduction index (R_w) and the weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}). These rating indices are determined in accordance with **AS/NZS 1276.1: 1999** or **ISO 717.1: 2004** using results from laboratory measurements carried out in accordance with the procedures outlined in **AS 1191: 2002**.

2.1. *NCC Criteria – Inter-tenancy Walls*

The NCC airborne sound insulation performance requirements for walls are summarised in **Table 1**. Certain walls require impact sound insulation rating and these must be of a discontinuous construction. This is summarised in **Table 2**.

Partition	In-situ performance requirement	Deemed to satisfy provision
Wall separating two sole occupancy units	$D_{nT,\,w}+C_{tr} \geq 45$ dB	**$R_w + C_{tr} \geq 50$ dB**
Wall separating a unit from common areas or buildings of other classification	$D_{nT,\,w} \geq 45$ dB	**$R_w \geq 50$ dB**

Table 1: NCC requirements for airborne sound insulation by walls

Partition	Discontinuous construction
Wall separating a wet area[1] in one unit from a habitable room (other than kitchen) in an adjacent unit	○ for masonry walls, where wall ties are required to connect leaves, wall ties are of the resilient type ○ for walls other than masonry, there is no mechanical linkage between the leaves except at the periphery
Wall separating a unit from a plant room or a lift shaft	

Table 2: NCC requirements for impact sound insulation by walls

Note: Because they share the same space as living room areas, open kitchen areas are technically habitable rooms when they are receiving rooms. They are wet areas when they are source rooms.

[1] *a bathroom, a sanitary compartment, a laundry or a kitchen*

3. LABORATORY TESTING (PHASE 1)

The purpose of the first phase of the laboratory testing is to establish the sound insulation performance of the Ozone Panel 120 System as a stand-alone product.

3.1. Testing Arrangement

Initial tests of the product were carried out at the Commonwealth Scientific and Industrial Research Organisation (CSIRO) testing facility in Highett, Australia 3190 on 19th June 2012. Details of the testing facility and conditions are included as **Appendix 2**.

The Ozone Panel 120 installed in the test chamber is shown below in **Figure 2**.

Figure 2: Ozone Panel 120 in situ - as viewed from the receiving room side

3.2. Tested Specimen – Ozone Panel 120

As the manufacturer supplies them, an Ozone Panel 120 is described as a load bearing precast panel made up of two faces of 15mm Oriented Strand Board (OSB/3) bonded to either side of a 90mm core of closed cell polyester foam (Polyisocyanurate).

The nominal overall depth of the system, as received from the manufacturer, is 120mm and the mass of the system is approximately 1.2 kg/m^2.

3.3. Test Results – Ozone Panel 120

The results of the test are summarised below in **Table 3** and are presented graphically in **Figure 3**.

Partition Tested	Measured Sound Reduction: R (dB) 1/3 Octave Mid-band Frequency (Hz)																		Weighted Sound Reduction Index
	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	R_w (dB) / C_{tr} (dB)
Ozone Panel 120	22.9	22.7	22.5	23.8	25.2	25.8	26.6	26	21.1	18.9	25.5	30.2	29.5	29.5	32.3	35.2	38.7	42	27 / -3

Table 3: Summary Test Results – 19th June 2012

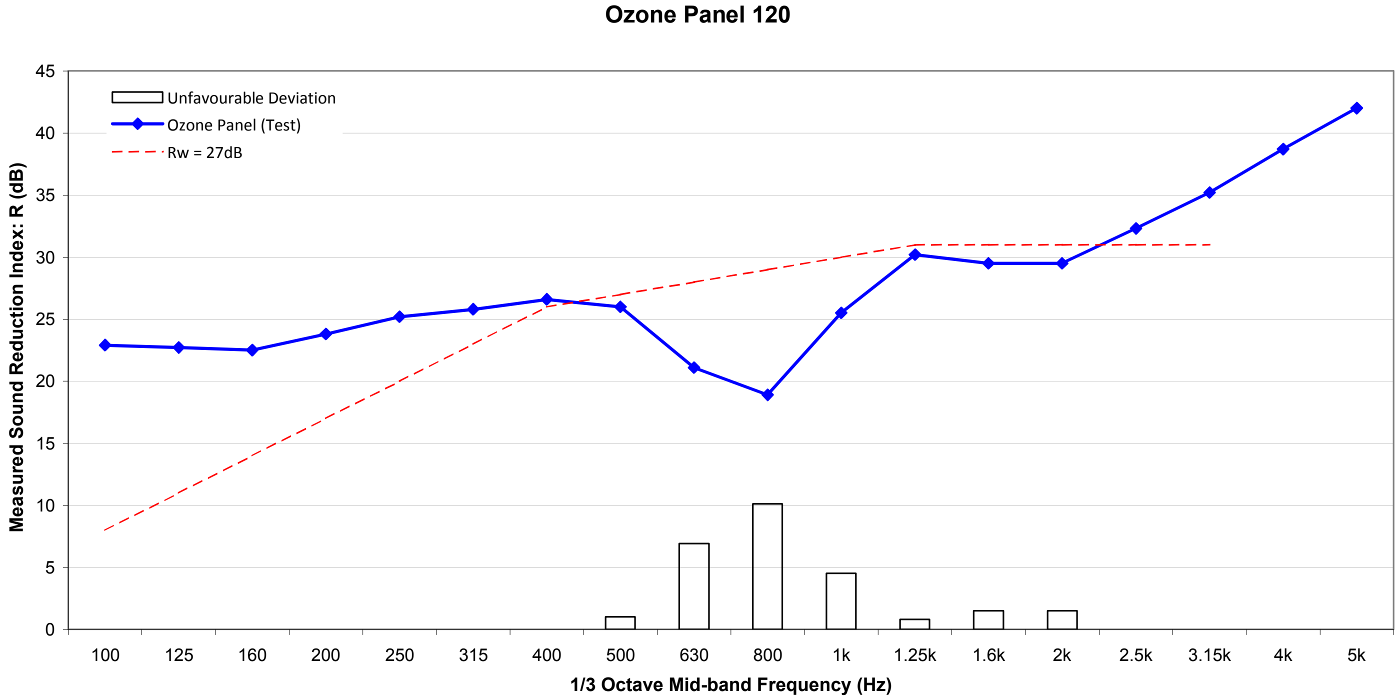


Figure 3: Test Results for Ozone Panel 120 (19th June 2012)

3.4. Discussion

The results of the initial round of laboratory testing have shown that the Ozone Panel System presents a weighted sound reduction index (R_w) of 27 dB and a weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}) of 24 dB.

This moderate rating is largely limited by the lightweight nature of the construction as well as the high rigidity of the system as a whole.

The most important limiting factor to sound insulation performance is the mass of the partition. Therefore the first stage of improving the sound insulation performance of the Ozone Panel System will be to introduce additional mass. As a rule, doubling the mass of a wall per unit area will increase soundproofing by 6 dB. The introduction of additional mass to a partition is generally achieved by adding extra layers of plasterboard.

In addition, it can be seen in **Figure 3** above that there is a significant reduction in the sound insulation performance (i.e., an increase in the transmission of sound) of the panel in the 800Hz region of the spectrum. It is considered that this is due to the coincidence effect.

In lay terms the coincidence effect occurs in rigid wall panels because the critical frequency (the frequency for which the wavelength of the incident sound wave is the same as that for bending waves within the panel) is within the audible frequency range. In effect the sound incident on the panel is exciting the panel instead of being dissipated by it and the result is a reduced sound insulation performance in the region of the critical frequency.

4. AIRBORNE SOUND INSULATION MODEL

The purpose of the sound insulation modelling exercise is to input the results of the initial laboratory tests into a computer model in order to predict the increase in sound insulation performance, which could be expected from incorporating the panel into various different partition constructions.

4.1. Design Criteria

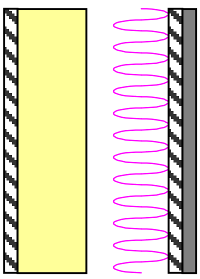
In designing a wall construction to incorporate the Ozone Panel 120 and to fulfil the widest range of building requirements possible the following design objectives were set:

- To achieve a weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}) ≥ 50 dB;
- To incorporate the Ozone Panel 120 into a discontinuous construction (with a minimum discontinuity of 20mm); and
- Beyond the acoustic requirements to consider the fire rating of the construction.

4.2. Constructions Modelled

Several constructions were modelled. Two options were identified as being the most suitable for further testing based on their predicted sound insulation performance.

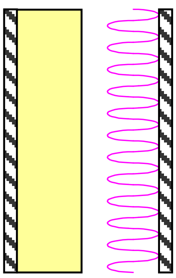
4.2.1. Construction A



Not to scale

- 16mm fire-rated plasterboard
- Ozone panel 120
- 90mm cavity (depth including insulation)
- 50mm fibrous insulation (density 14 kg/m^3)
- 16mm fire-rated plasterboard on steel or timber stud
- 10mm standard core plasterboard

4.2.2. Construction B



Not to scale

- 16mm fire-rated plasterboard
- Ozone panel 120
- 90mm cavity (depth including insulation)
- 50mm fibrous insulation (density 14 kg/m^3)
- 16mm fire-rated plasterboard on steel or timber stud

4.3. Prediction Results

The results of the predictions are summarised below in **Table 4** and are presented graphically in **Figure 4.**

Partition Tested	Predicted Sound Reduction: R (dB) 1/3 Octave Mid-band Frequency (Hz)																		Weighted Sound Reduction Index
	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	R_w (dB) / C_{tr} (dB)
Construction A	38	43	48	52	57	61	65	68	68	67	63	64	66	65	68	72	77	82	64 / - 9
Construction B	34.5	39.0	44.5	49.0	53.5	57.5	61.5	64.5	64.5	64.0	59.5	59.5	62.0	61.0	65.0	70.0	34.5	39.0	60 / - 8

Table 4: Summary Predictions for Constructions A and B

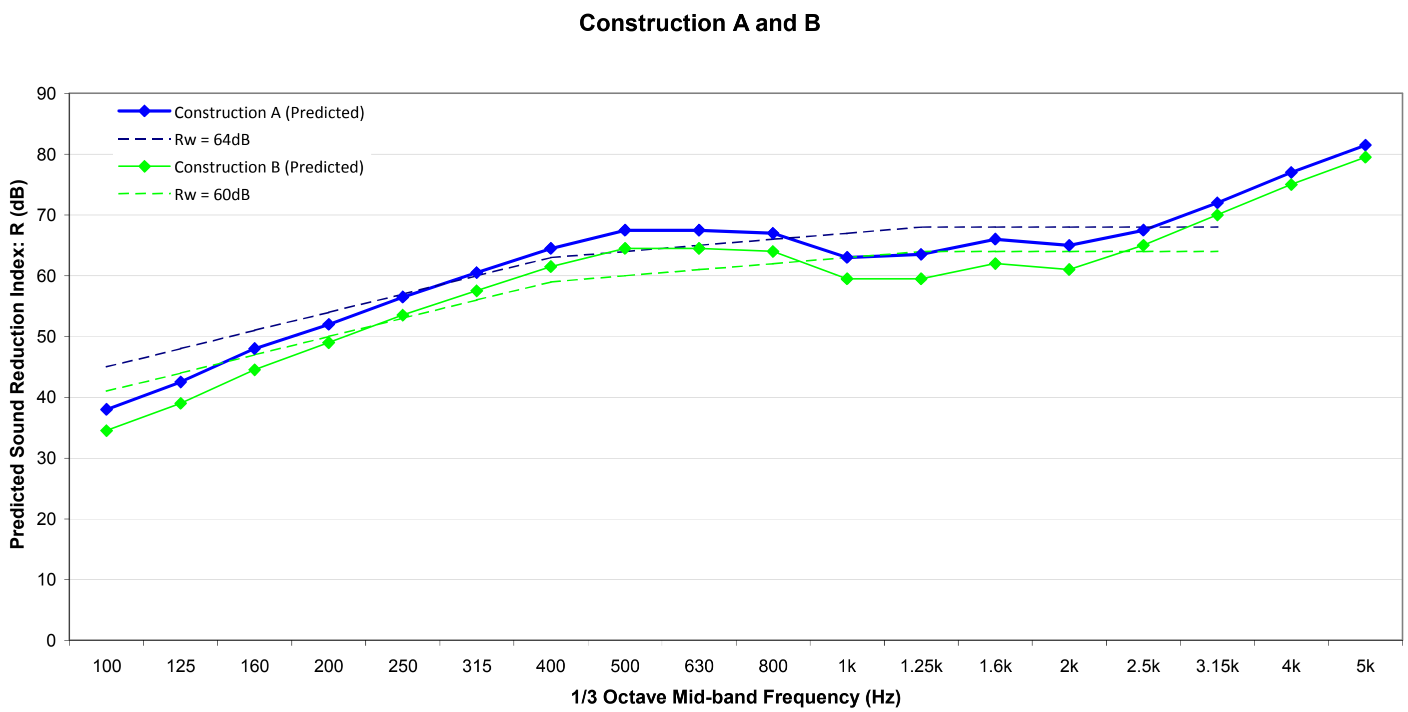


Figure 4: Prediction Results for Constructions A and B

4.4. Discussion

Constructions A and B are both predicted to meet the criteria set out by the NCC for inter-tenancy partitions.

Construction A is predicted to provide a weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}) of 55 dB.

Construction B is predicted to provide a weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}) of 52 dB.

Figure 4 above shows that the sound insulation performance of both Constructions A and B is predicted to be significantly higher than that of the Ozone Panel 120 as a stand-alone product. The predicted performance is higher across all frequencies and is a function of the significantly increased mass of the construction brought about by the introduction of plasterboard layers to the construction, the double panel construction, the absence of a mechanical link between the two leaves (i.e. discontinuity) and the introduction of damping from fibrous insulation in the cavity.

The influence of coincidence is greatly reduced due to the asymmetry of the construction (typically it is not recommended that a double panel construction is built with identical leaves for which the critical frequencies are the same)

Construction A was selected for laboratory testing on the basis that the predictions gave some margin, in terms of achieving the NCC criteria, whereas Construction B was considered to be borderline.

5. LABORATORY TESTING (PHASE 2)

The purpose of the second phase of laboratory testing is to assess the performance of the construction selected against NCC requirements and thereby verifies the effectiveness of the mathematical model.

5.1. *Testing Arrangement*

The second phase of the laboratory tests were carried out at CSIRO on 2nd July 2012. Details of the testing facility and conditions are included as **Appendix 2**.

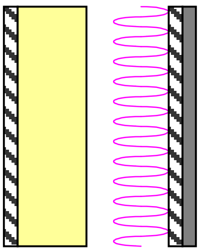
Construction A installed in the test chamber is shown below in **Figure 5**.

Figure 5: Construction A in situ - as viewed from the receiving room side

It should be noted that the ambient temperature at the time of the tests was 12 - 13° centigrade which is lower than the 15°c outlined as a recommended minimum ambient temperature for testing in **AS 1191: 2002.**

It is considered however that this would not significantly affect the outcome of the tests.

5.2. *Tested Configuration – Construction A*



Not to scale

- 16mm Boral Firestop
- Ozone panel 120
- 110mm cavity (depth including insulation)
- 90mm glass wool insulation (density 11 kg/m^3)
- 16mm Boral Firestop on 64mm steel studs at 600mm centres
- 10mm Boral standard core plasterboard

5.3. *Test Results – Construction A*

The results of the second phase of the laboratory tests are summarised below in **Table 5** and are presented graphically in **Figure 6**.

Partition Tested	Measured Sound Reduction: R (dB)																		Weighted Sound Reduction Index
	1/3 Octave Mid-band Frequency (Hz)																		
	100	125	160	200	250	315	400	500	630	800	1k	1.25k	1.6k	2k	2.5k	3.15k	4k	5k	R_w (dB) / C_{tr} (dB)
Construction A	36.6	39.7	44.3	48.9	52.4	57.5	60.0	60.4	59.1	63.5	66.2	67.7	67.1	64.5	65.7	70.5	73.2	75.7	61 / -8

Table 5: Summary Test Results – 2nd July 2012

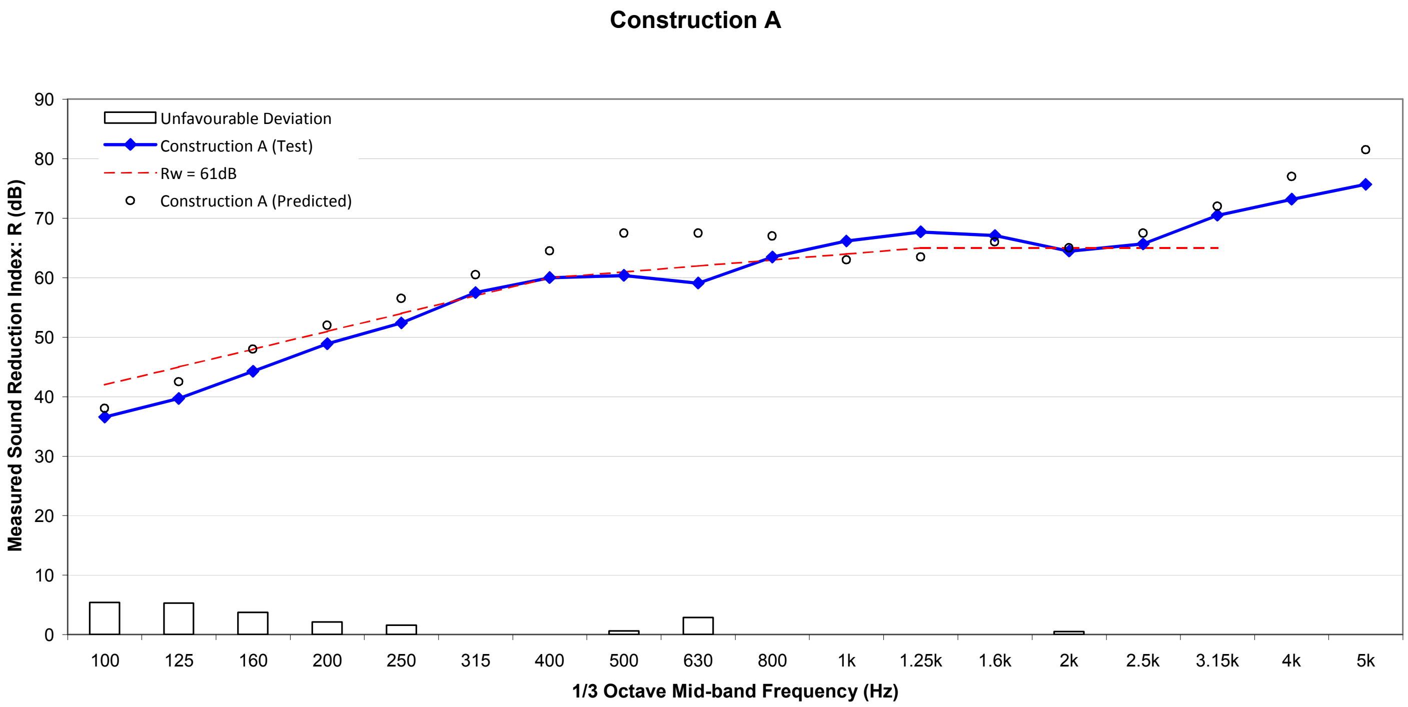


Figure 6: Test Results for Construction A (2nd July 2012)

5.4. Discussion

The results of the second round of laboratory testing have shown that the Ozone Panel System presents a weighted sound reduction index (R_w) of 61 dB and a weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}) of 53 dB when it is incorporated into Construction A as detailed above in **Section 6.2**. This performance is deemed to satisfy the NCC requirement for inter-tenancy walls.

The tested performance of the construction is 2dB lower than the predicted performance, this is considered to represent a good correlation between predicted and tested.

Figure 6 shows that the measured sound insulation performance curve of Construction A shows a similar response at low frequency, to the predicted performance curve albeit at a slightly lower level. The performance of the panel is lower than predicted in all but the 1000 – 1600Hz range where the panel performs better than expected.

There is a prominent coincidence dip at around in the 2000 – 2500Hz range. However the frequency at which the dip occurs is higher than predicted, thus indicating that the construction has a higher rigidity than was expected. The depth of the dip is similar to that which was predicted indicating that the level of damping in the construction has been accurately modelled.

6. CONCLUSION

Vipac Engineers & Scientists were commissioned by Ozone Panels Pty to carry out airborne sound insulation testing and an optimization exercise for the "Ozone Panel 120", a structural insulated panel (SIP) construction system.

The results of the initial round of laboratory testing have shown that the Ozone Panel System as a stand-alone system presents a weighted sound reduction index (R_w) of 27 dB and a weighted sound reduction index with spectrum adaptation term (R_w+C_{tr}) of 24 dB.

Using the results of the initial laboratory testing, a research exercise was undertaken using a mathematical model in order to investigate constructions, which could be utilised to improve the sound insulation performance of the product. The target of this exercise was that the proposed constructions should meet, as a minimum, the current National Construction Code (NCC) requirements for inter-tenancy partitions.

Several constructions were modelled. Two options were identified as being the most suitable for further testing based on their predicted sound insulation performance.

A second round of laboratory tests have shown that the system can be utilised in conjunction with additional materials to achieve a sound insulation performance which meets the NCC requirements for inter-tenancy partitions of (R_w+C_{tr}) $\geq$ 50 dB.

7. REFERENCES

1. National Construction Code “Volume one – Building Code of Australia Class 2 to Class 9 buildings”
2. AS 1191: 2002 “Acoustics - Method for laboratory measurement of airborne sound insulation of building elements”
3. AS/NZS 1276.1:1999 “Acoustics - Rating of sound insulation in buildings and of building elements - Airborne sound insulation”
4. AS/NZS ISO 717.1:2004 “Acoustics - Rating of sound insulation in buildings and of building elements - Airborne sound insulation”

APPENDIX 1: GLOSSARY OF TERMS

Standardized Level Difference D_{nT} (measured in situ)
In a specified frequency band, the difference in sound pressure level measured in-situ between a source room and a receiving room separated by the assessed construction, corrected for the reverberation time of the receiving room. D_{nT} accounts for secondary transmissions (e.g.: flanking transmission) and potential defects (e.g.: sound leakage through gaps) of the construction under test.

Sound Insulation
The capacity of a structure (e.g. a partition such as a wall or a floor) to prevent sound from reaching a receiving location. Sound energy is not necessarily absorbed; change in impedance, or reflection back toward the source, is often the principal mechanism.

Sound Reduction Index (measured in Laboratory Conditions), R
sometimes also referred to as Transmission Loss (TL)
Of a partition, in a specified frequency band, the fraction of the airborne sound power incident on the partition that is transmitted by the partition and radiated on the other side. R is measured in a laboratory (i.e. a facility complying with AS 1191: 2002) where secondary transmission (flanking) is negligible.

Weighted Sound Reduction Index, Rw and Weighted Standardized Level Difference, $D_{nT,w}$
Single-number ratings, which characterise the airborne, sound insulation of a material or building element over a range of frequencies (from 125Hz to 3.15kHz), based on the measurement of R (for R_w) and D_{nT} (for D_{nTw}). They are determined by matching the sound insulation curve vs. frequency with a reference curve.

Although expressed in dB R_w and D_{nTw} are not measures of the actual airborne sound insulation provided by the element tested but a rating that can be used for comparative assessment of different systems.

Spectrum Adaptation Terms for Weighted (airborne) Sound Insulation Rating, Ctr
The adaptation term Ctr is introduced to take into account different spectra of noise sources with significant contributions in the low frequencies.

Spectrum Adaptation term Ctr is relevant to noise sources such as urban road traffic, railway traffic at low speeds, propeller driven aircrafts, jet aircrafts at large distance, amplified music or factories emitting mainly low and medium frequency noise.

APPENDIX 2: CSIRO TESTING REPORT

CSIRO

Laboratory Measurement of Airborne Sound Insulation of Constructions Utilizing "Ozone" Sandwich Panelling

Report TL527/R1
July 2012

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SUMMARY

The airborne sound insulation indices (R) of two walls based on a proprietary sandwich panel, have been measured.

The measurements were performed in accordance with the requirements of AS 1191-2002 "Acoustics - Method for laboratory measurement of airborne sound insulation of building elements".

The Sound Transmission Class (STC) and the Weighted Sound Reduction Index (Rw) of the test specimens were calculated using the procedures respectively specified by AS 1276-1979 and AS/NZS ISO 717.1:2004.

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1. TEST SPECIMENS

1.1 Wall 1

- Wall 1 was constructed as a "naked" sandwich panel wall.
- The sandwich panels had an overall thickness of 120 mm, and consisted of outer skins of 16 mm thick grain-oriented strand board sandwiching an infill of "Baymer" polyester foam. The panels weighed approximately 23.5 kg/m^2.
- Panels were manufactured in a standard size, 2.50 x 1.25 m. The 3.68 m width of the test aperture was spanned using two panels at full width (1.25 m ea) and one cut down to 1.18 m. The 3.22 m height of the test aperture was spanned using one panel at full height (2.50 m) and one cut down to 0.72 m.
- The panels were joined by routing out the foam infill to a depth of approximately 45 mm, creating a cavity in each panel to accommodate half the width of a 90 mm timber joiner. Each join was fixed by nailing the outer boards to the joiner at 70 mm nail spacing along the full length of each join. Similarly, the outer peripheral frame was concealed within cavities routed out along the edges of the sandwich panel.
- All joins were caulked to avoid leakage of sound, and the periphery of the entire wall was caulked to give acoustic integrity.
- The wall was installed so that one face lay flush with the surrounding wall of the sending chamber; this placed the other face approximately 380 mm indented from the opening of the aperture at the receiving side.

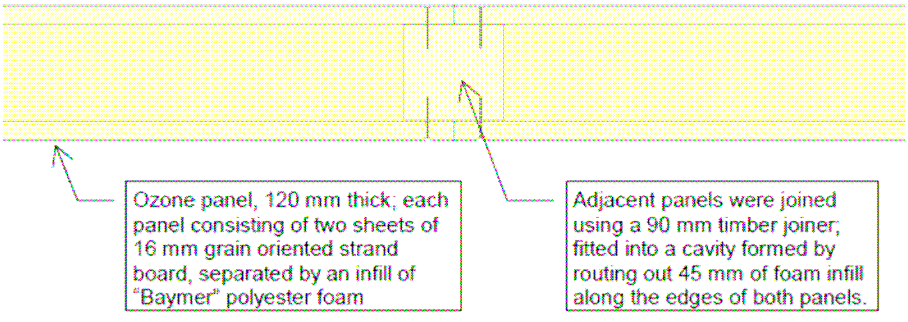

Figure 1, Construction of test wall 1

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1.2 Wall 2

Leaving wall 1 in place after its test, the following additional work was carried out to construct wall 2:-

- A layer of 16 mm Boral Firestop plasterboard was screw fixed directly to the sandwich panel wall on the side facing the source room.
- A 64 mm steel stud frame was constructed 20 mm from the receiving side of the sandwich panel wall. The studs were cut to length so as to push the stud track firmly against the top and bottom faces of the aperture liner; caulking compound was applied to the track to prevent movement within the aperture, no mechanical fasteners were used to hold the track in the aperture, or to hold the studs in the track.
- 90 mm thick glass wool insulation (11 kg/m^3) was installed in the stud frame.
- The receiving room side of the stud frame was then clad with 16 mm Boral Firestop plasterboard, screw fixed to the frame, and overclad with a layer of 10 mm Boral Standard Core plasterboard.
- The plasterboard joints of each layer of plasterboard were finished with bedding compound and fibre tape.
- The perimeter of the wall was sealed with caulking compound at each layer of plasterboard.

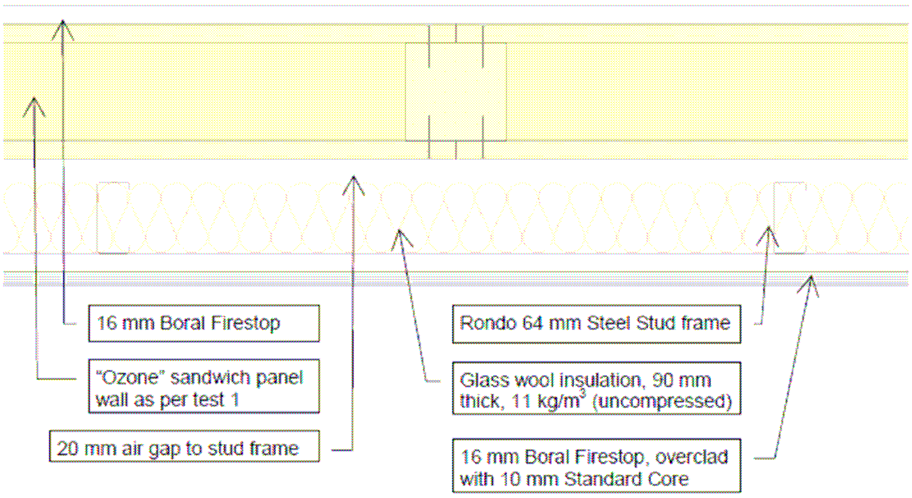

Figure 2, Construction of test wall 2

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1.3 Materials

Materials used in construction are listed in Table 1.

Table 1, Materials

Component	Specification/Description
"Ozone" Sandwich Panel	Sandwich panel consisting of a core of "Baymer" polyester foam between two sheets of 16 mm thick grain oriented strand board, Overall panel thickness: 120 mm. Panel width: 1.2 m
Plasterboard	16 mm Fire Rated: Boral Firestop [13.0 kg/m^2] 10 mm Standard: Boral Standard Core [6.8 kg/m^2]
Wall Framing	Rondo 64 mm #112 Steel studs (0.50 mm Base Metal Thickness) in Rondo 64 mm #111 track
Insulation	Fletcher Insulation R2.0 Glass Wool Wall Batts (Pink Batts), 90 mm thick, 11 kg/m^3 (uncompressed)
Caulking	Fuller Firesound
Jointing	Boral Basecote and Jointing tape

2. METHOD OF TEST

2.1 General

The test walls were constructed in the opening in the common wall between a pair of purpose-built reverberation rooms. In each case, a steady level of broadband random-noise was generated in one of the rooms, and the resulting sound pressure levels (100 Hz to 5 kHz) were measured in both rooms. The differences between the sound pressure levels in the rooms were converted to transmission loss values by correcting for the sound absorption characteristics of the receiving room.

2.2 Specific

The measurement was performed to comply with the requirements of AS 1191-2002 "Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions".

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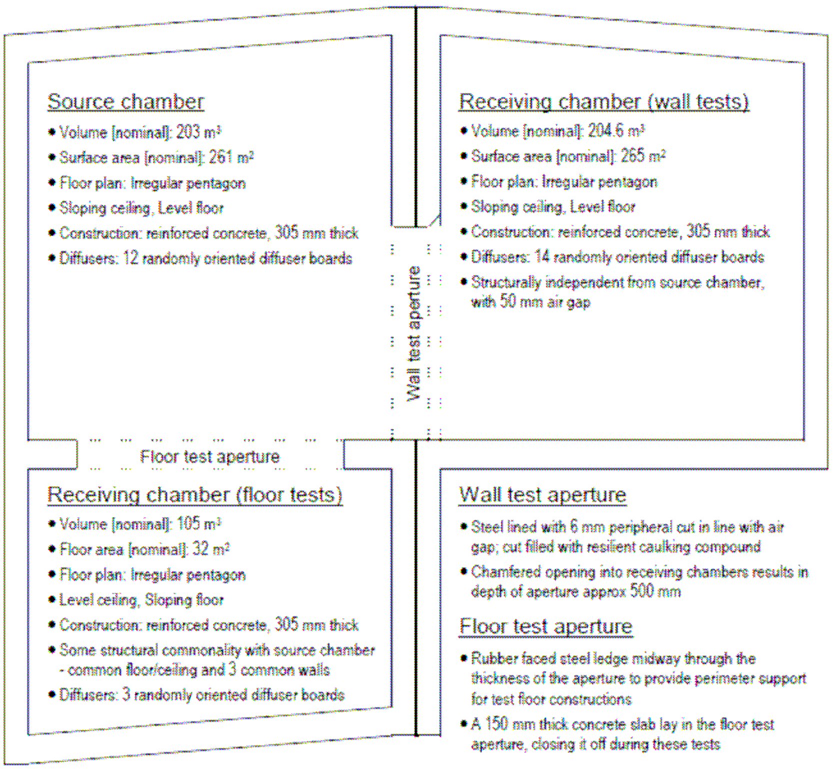
3. TEST LABORATORY

3.1 Description of Test Facility

The acoustic chambers used for these measurements consisted of one source chamber and two receiving chambers, as described below. The chambers were designed to minimise structure-borne noise (induced by test signals) from outflanking the test specimen, and to exclude external noise.



3.2 Environmental Conditions

The air temperature and humidity in the reverberation chambers, and atmospheric pressure were measured when each test was carried out. The environmental conditions measured are reported in the results summary (Table 5), and in the individual statements of results for each test.

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4. INSTRUMENTATION AND EQUIPMENT

4.1 Test Signal, Amplifiers & Loudspeakers

The sound source used was the amplified signal originating from the noise generator built into a Norwegian Electronics type 830 Real Time Analyser. Its random noise output was passed into a Graphic Equaliser (Klark Teknik DN27). The Graphic Equaliser was used to trim the shape of the spectrum such that approximately equal sound levels were achieved across the bands eventually broadcast into the sending room. The broadband output from the graphic equaliser was split into two frequency bands by a custom-built cross-over network. The low frequency bands (100 Hz to 1.6 kHz) were amplified to about 4 V by a Power Amplifier (Crown DC 300) and broadcast into the sending room from a 300 mm diameter loudspeaker (Rola 12UX) mounted on a flat 1 m^2 baffle, situated facing into one corner of the test room. The high frequency bands (2 kHz to 5 kHz) were likewise amplified by a Power Amplifier (Crown DC300A) to about 11 V before being delivered into a dodecahedral array of 50 mm diameter loudspeakers (Peerless direct radiator “tweeters”).

4.2 Microphones, Preamplifiers & Microphone Power Supply

The same single microphone (Brüel & Kjær Type 4166) and preamplifier (Brüel & Kjær Type 2619) mounted at the end of a rotating microphone boom (Brüel & Kjær Type 3923) which had a radius of 1.35 m, was used in each room. This apparatus was moved between the two rooms as required. The microphone boom continuously rotated with a 32 s period during measurements. The microphone was powered from the NE 830 analyser.

4.3 Measurement and Analysis Equipment

Microphone signals were analysed using a Norwegian Electronics type 830 Real-Time-Analyser (RTA). This enables measurements in each of the standard 1/3-octave bands simultaneously, and also can perform internal averaging of repeated measurements.

The reverberation times in the receiving room were measured by overlaying 60 decays using the internal program of the RTA.

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5. MEASUREMENT DETAILS

5.1 Measurement of Sound Levels

The sound pressure levels in both rooms were averaged over space (by allowing the microphone boom to rotate continuously during measurements), and time (by performing a 192 s integral of the sound level).

5.2 Correction for Background Sound Pressure Level

The background sound levels for all frequency bands were measured and used to apply corrections to the signal levels measured in the receiving room. Corrected signal levels are calculated according to the formula

$$\text{Corrected } L_{p2} = 10\log_{10}[10^{L_{pr}/10} - 10^{L_{br}/10}]\text{dB}$$

Where L_{p2} is the corrected signal level, L_{pr} is the measured signal level, and L_{br} is the measured background level. Background corrections are limited to 1.3 dB if the measured signal level is within 6 dB of background; in which case the measurement is at the limit of what is achievable in the laboratory.

The magnitude of all corrections made for background levels are presented in Table 2. Data values at the measurable limit are denoted with an asterisk.

Table 2, Background corrections

Frequency (Hz)	Size of Background Correction (dB)	
	TL527-1	TL527-2
100	-	-
125	-	-
160	-	-
200	-	-
250	-	-
315	-	0.2
400	-	0.5
500	-	-
630	-	-
800	-	-
1000	-	0.1
1250	-	0.3
1600	-	0.1
2000	-	0.1
2500	-	0.1
3150	-	0.3
4000	-	0.7
5000	-	1.3 *

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5.3 Absorption of Receiving Room

The average reverberation time of the receiving room was determined for each 1/3-octave frequency. The equivalent absorption area (A) at each frequency was then determined using the equation,

$$A = 0.161\ V / T_{60}$$

where V is the volume of the receiving room, and T_{60} is the space averaged reverberation time of the room, s.

For each 1/3-octave frequency band, the reverberation time values and corresponding equivalent absorption area are presented in Table 3.

Table 3, Reverberation Times and Equivalent Absorption Area.

Freq (Hz)	Reverberation times and equivalent absorption area for each test wall			
	TL527-1		TL527-2	
	Reverberation time, s (T_{60})	Equivalent absorption area, m^2	Reverberation time, s (T_{60})	Equivalent absorption area, m^2
100	9.03	3.76	9.18	3.68
125	8.80	3.86	9.52	3.55
160	8.47	4.01	10.02	3.37
200	9.46	3.59	10.26	3.29
250	9.51	3.57	10.66	3.17
315	8.79	3.86	9.76	3.46
400	8.25	4.12	9.13	3.70
500	7.72	4.40	8.54	3.95
630	6.89	4.93	7.72	4.37
800	5.72	5.94	6.78	4.98
1000	5.69	5.97	6.03	5.60
1250	5.19	6.54	5.38	6.27
1600	4.35	7.81	4.60	7.34
2000	3.71	9.15	4.03	8.38
2500	3.26	10.42	3.50	9.64
3150	2.84	11.96	2.96	11.40
4000	2.38	14.27	2.42	13.95
5000	1.93	17.59	1.96	17.22

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5.4 Precision of Results

Table 4 lists typical 95% confidence limits for the repeatability of airborne sound insulation results (for any given specimen). These values have been determined using the procedure outlined in AS 1191-1985 Appendix A4.3. (i.e. In a once-off test, eight (8) independent R measurements were performed on a test wall with one strongly absorbent face - and the 95% confidence limits at each frequency were determined.)

Table 4, 95% confidence limits for repeatability of airborne sound insulation results

Band centre frequency, Hz	95% Confidence limit on measured R values (±) dB
100 - 500	0.8
630 - 2500	0.5
3150 - 5000	0.9

5.5 Analysis of Measurements

The airborne sound transmission loss is obtained by using the equation:

$$R = L_{send} - L_{recv} + 10 \, Log_{10}(S/A)$$

In this equation L_{send}, is the measured SPL at each 1/3-octave frequency band in the sending room, and L_{recv} is the corresponding SPL (background-corrected) measured in the receiving rooms, S is the area of the specimen (m^2) and A is the equivalent absorption area of the receiving room (m^2) obtained from the reverberation time measurements detailed in Table 3.

5.6 Test Results

Table 5 presents a summary of the airborne sound insulation results, including the sound reduction indices determined from the test, and the corresponding performance index numbers.

The sound insulation values (R) at each 1/3-octave band, shown in both tabular and graphical form are included in the Appendices.

The values of Sound Transmission Class (STC), the Weighted Sound Reduction Index (R_w) with the Spectral Adaption Terms (C; C_{tr}) have been determined according to the standards AS 1276-1979, AS/NZS ISO 717.1:2004 and ISO 717-1:1996.

Prior to calculating the single number performance indices, R_w, C and C_{tr} for the specimens, the R values at each 1/3-octave band were rounded to the nearest 0.1 dB.

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MEASUREMENT DETAILS

Prior to calculating the single number performance index, STC, the R values at each 1/3-octave band were rounded to the nearest 1 dB.

Table 5, Summary of results

Test ID No	TL527-1 R_w (C; C_{tr}): 27 (-1; -3)	TL527-2 R_w (C; C_{tr}): 61 (-2; -8)
Date of Test	19-June-2012	2-Jul-2012
Temp & humidity: Source	12 ℃, 74%	11 ℃, 72%
Temp & humidity: Receiving	13 ℃, 74%	11 ℃, 78%
Air pressure	1022 hPa	1019 hPa
Construction (from sending side to receiving side)	• 120mm thick "Ozone" Sandwich Panel (approx 23.5 kg/m²)	• 16 mm Fire Rated Plasterboard • 120 mm thick "Ozone" Sandwich Panel • 20 mm Air Gap • 64 mm Steel Stud frame with Glass Wool insulation [90 mm thick, 14 kg/m³] • 16 mm Fire Rated Plasterboard • 10 mm Standard Core Plasterboard
Freq, Hz	1/3 – Octave "R" values	
100	22.9	36.8
125	22.7	39.7
160	22.5	44.3
200	23.8	48.9
250	25.2	52.4
315	25.8	57.5
400	26.6	60.0
500	26.0	60.4
630	21.1	59.1
800	18.9	63.5
1000	25.5	66.2
1250	30.2	67.7
1600	29.5	67.1
2000	29.5	64.5
2500	32.3	65.7
3150	35.2	70.5
4000	38.7	73.2
5000	42.0	75.7 *
Performance Index Numbers		
Rw	27	61
C	-1	-2
Ctr	-3	-8
Rw + Ctr	24	53
STC	25	62

* Indicates 'R' values at the limit of what could be measured at the laboratory.

Officer conducting measurement: Mr. David Truett

Report reviewed by: Dr. Christopher Preston

Date report issued: 27 July 2012

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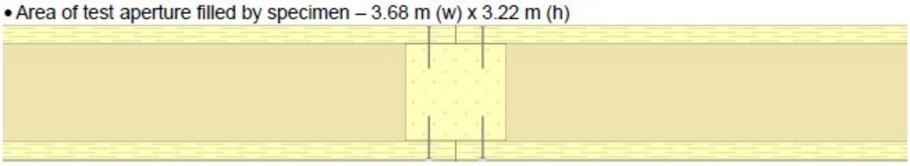
APPENDIX 1

Statement of Results (Airborne Sound Insulation Test)

CSIRO Test: TL527-1 Commissioned by: **Vipac Engineers & Scientists Ltd**

Construction of Wall Tested:

- 120 mm thick "Ozone" Sandwich Panel (outer layers 16 mm grain oriented strand board separated by "Baymer" polyester foam infill)
- Joined by nailing at 70 mm spacing to 90 mm square timber joiners in cavities created by routing out the core infill along the edges of the joins
- Area of test aperture filled by specimen – 3.68 m (w) x 3.22 m (h)



Results:-

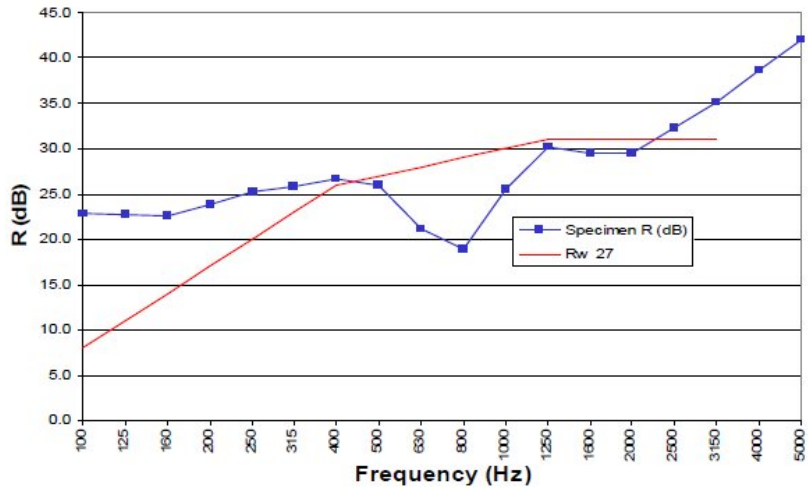
R_w (C; C_{tr}): 27 (-1; -3)

R_w: 27
C: -1
C_{tr}: -3
$R_w + C_{tr}$: 24
STC: 25

Test Conditions:-

Date of Test: 19 June 2012
Atmospheric pressure: 1022 hPa
Source chamber: 12 °C, 74 % R.H.
Receiving chamber: 13 °C, 74 % R.H.

Freq (Hz)	Sound Reduction Index, R (dB)
100	22.9
125	22.7
160	22.5
200	23.8
250	25.2
315	25.8
400	26.6
500	26.0
630	21.1
800	18.9
1000	25.5
1250	30.2
1600	29.5
2000	29.5
2500	32.3
3150	35.2
4000	38.7
5000	42.0



These are the results of testing carried out at CSIRO Acoustic Laboratories, 37 Graham Rd, Highett, Australia 3190 in accordance with the Australian standard AS 1191-2002. Calculations have been carried out in accordance with AS/NZS ISO 717.1-2004 and AS 1276-1979. This appendix may serve as a standalone statement of results for the particular construction described; full details are contained in CSIRO Report TL527/R1.

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MATERIALS SCIENCE & ENGINEERING

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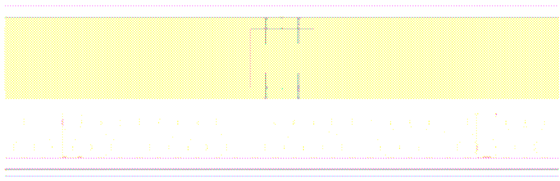
APPENDIX 2

Statement of Results (Airborne Sound Insulation Test)

CSIRO Test: TL527-2 Commissioned by: **Vipac Engineers & Scientists Ltd**

Construction of Wall Tested:

- 16 mm Fire Rated Plasterboard
- 120 mm thick "Ozone Sandwich panel (outer layers 16 mm grain oriented strand board separated by "Baymer" polyester foam infill)
- 20 mm Air Gap
- 64 mm Steel Stud frame with Glass wool insulation [14 kg/m^3]
- 16 mm Fire Rated plasterboard
- 10 mm Standard Core plasterboard



Results:-

R_w (C; C_{tr}): 61 (-2; -8)

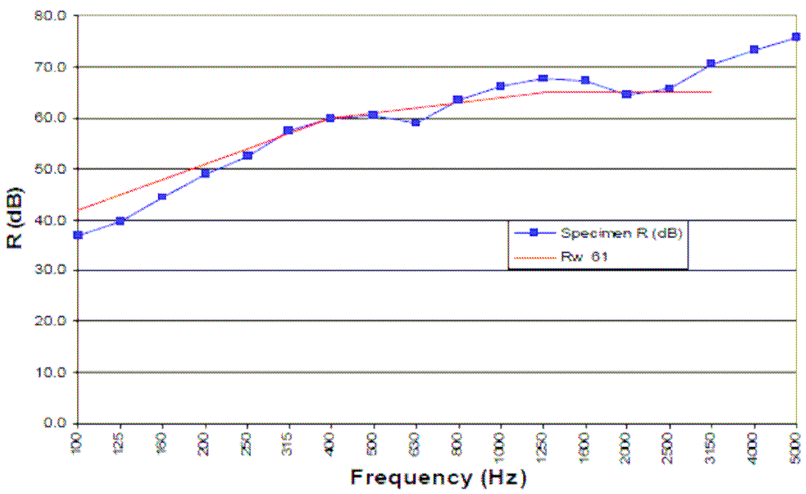
R_w: 61
C: -2
C_{tr}: -8
$R_w + C_{tr}$: 53
STC: 62

Test Conditions:-

Date of Test: 02 July 2012
Atmospheric pressure: 1019 hPa
Source chamber: 16 °C, 68 % R.H.
Receiving chamber: 16 °C, 62 % R.H.

Freq (Hz)	Sound Reduction Index, R (dB)
100	36.8
125	39.7
160	44.3
200	48.9
250	52.4
315	57.5
400	60.0
500	60.4
630	59.1
800	63.5
1000	66.2
1250	67.7
1600	67.1
2000	64.5
2500	65.7
3150	70.5
4000	73.2
5000	75.7 *

* indicates 'R' values at the limit of what could be measured in the laboratory



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