DECC

Loreto Kirribilli
85 Carabella Street, Kirribilli

Noise and Vibration Testing

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1 Introduction

White Noise Acoustics has been engaged to undertake noise and vibration testing of the excavation activities being undertaken on the Loreto School site at 85 Carabella Street, Kirribilli.

The monitoring was undertaken at the site in accordance with the requirements of the *Construction Noise and Vibration Assessment (Ref: TJ415-01F05 Acoustic Stage 1 DA Assessment (r7))*

This report details the results of the testing conducted at the site and comparisons with the projects specified criteria including attended noise and vibration conducted on the 9th December, 2019.

2 Development Description

The proposed development includes the works associated with the Loreto School on the site at 85 Carabella Street, Kirribilli.

This assessment includes the attended noise and vibration testing conducted as part of the sample excavation works including hydraulic hammering and conducted on the 9th December, 2019.

The site location and monitor positions are detailed in the figure below.

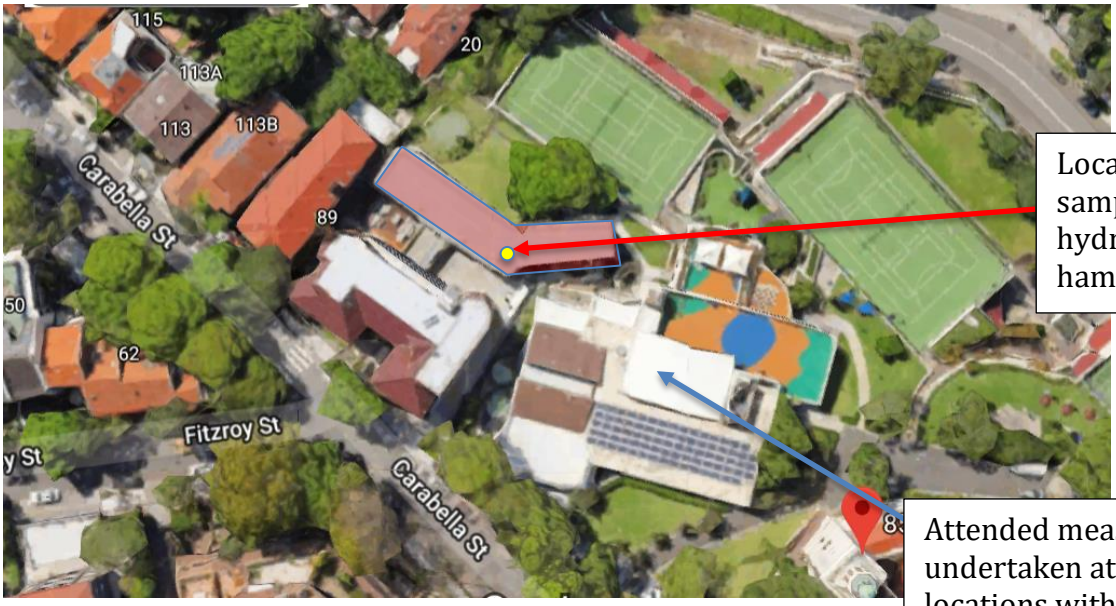


Figure 1 – Site Location

3 Vibration

The measurements have been undertaken at the site in accordance with the requirements of the *Construction Noise and Vibration Assessment (Ref: TJ415-01F05 Acoustic Stage 1 DA Assessment (r7))* and the relevant vibration criteria which activities on the site are required to be assessed in conjunction with include the German Standard DIN4150-3 for potential building damage and the British Standard BS6472 for human comfort.

The details of the required vibration limits based on the standards above are detailed in this section of the report.

3.1 Vibration Criteria - Human Comfort

This section of the report details the assessment of construction vibration impacts on surrounding receivers including human comfort. The relevant standard for the assessment of tactile vibration on human comfort includes the British Standard BS6472 *'Assessing Vibration – A Technical Guideline'*.

The requirements of the standard are detailed in the following table.

Table 1 - Continuous vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	RMS acceleration (m/s^2)	
		Preferred	Maximum
Residences	Daytime	0.010	0.020
Offices, schools, educational institutions and places of worship	Day or night-time	0.020	0.040
Workshops	Day or night-time	0.04	0.080

Table 2 - Impulsive vibration acceleration criteria (m/s^2) 1 Hz-80 Hz

Location	Assessment period	RMS acceleration (m/s^2)	
		Preferred	Maximum
Residences	Daytime	0.30	0.60
Offices, schools, educational institutions and places of worship	Day or night-time	0.64	1.28
Workshops	Day or night-time	0.64	1.28

3.2 Vibration Criteria – Building Contents and Structure

The vibration effects on the building structures is based on the German Standard DIN 4150: Part 3 – 1999 "Effects of Vibration on Structure".

For continuous or repetitive vibration, standard DIN 4150 Part 3-1999 provides criteria based on values for peak particle velocity (mm/s) measured at the foundation of the building; these are summarised in Table 3. The criteria are frequency dependent and specific to particular categories of structures and is detailed in the table below.

Table 3 - Structural damage criteria as per standard DIN 4150 Part 3 - 1999

Type of Structure	Peak Component Particle Velocity, mm/s			
	Vibration at the foundation at a frequency of			Vibration of horizontal plane of highest floor at all frequencies
	1 Hz to 10 Hz	10 Hz to 50 Hz	50 Hz to 100 Hz[1]	
Buildings used for commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
Structures that, because of their sensitivity to vibration, do not correspond to those listed in lines 1 and 2 and are of great intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8
Note 1: For frequencies above 100Hz, at least the values specified in this column shall be applied.				

Based on the table above the structure to the west of the site would conservatively be assessed as a structure of a sensitive nature and a suitable vibration criterion of 3 mm/s has been applied in this report. It is noted that this criterion is likely to be conservative based on the structure of the neighbouring building and a greater vibration impact on the neighbouring structure would not be expected to result in damage.

3.3 Vibration Measurements

This section of the report details the measured vibration levels which were undertaken at the site. Vibration measurements where undertaken at a number of locations detailed in this section of the report.

Vibration measurements were conducted using a Bruel and Kjaer 2250C type meter on the 9th December, 2019 during a period when sample hydraulic hammering was being undertaken on the site.

3.4 Vibration Measurement Results

The results of the vibration testing undertaken at a number of locations within the school are detailed within the table below.

Table 4 - Vibration Measurements

Location	Assessment period	Vibration Assessment Type	Suitable Vibration Criteria	Measured maximum vibration
External to the building approximately 5m from hammering (on concrete slab)	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<2.5 mm/s
		Human comfort	0.6 m/s^2	<0.2 m/s^2
Junior School, Year 6 Classroom	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.5 mm/s
		Human comfort	0.6 m/s^2	<0.12 m/s^2
Junior School, Year 3 Classroom	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.3 mm/s
		Human comfort	0.6 m/s^2	<0.10 m/s^2
REC Office	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.1 mm/s
		Human comfort	0.6 m/s^2	<0.09 m/s^2
Library	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2
Hall	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2
Centenary Hall	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2
Temporary Class Room	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2
Marion Centre – Junior Art Room 1	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.7 mm/s
		Human comfort	0.6 m/s^2	<0.10 m/s^2
Marion Centre – Junior Art Room 2	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.6 mm/s
		Human comfort	0.6 m/s^2	<0.09 m/s^2
Marion Centre – Junior Art Room 3	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2

Table 4 (continued) - Vibration Measurements

Location	Assessment period	Vibration Assessment Type	Suitable Vibration Criteria	Measured maximum vibration
Marion Centre – Art Staff Room	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2
Marion Centre – Level 2	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2
Marion Centre – Staff Offices	Period with hydraulic hammering was being undertaken	Building damage	10 mm/s	<1.0 mm/s
		Human comfort	0.6 m/s^2	<0.07 m/s^2

The measured vibration levels recorded at all surrounding locations are within the maximum building damage and human comfort criteria during periods when hydraulic hammering was being undertaken.

4 Noise

This section of the report details the results of the noise measurements undertaken at a number of locations within the Loreto School as a result of hydraulic hammering being undertaken on the excavation on the site.

4.1 Construction Noise

This section of the report details the relevant construction noise criteria which is applicable to the site including the EPA's *Interim Construction Noise Guideline* (ICNG).

4.1.1 Interim Construction Noise Guideline

Noise criteria for construction and demolition activities are discussed in the *Interim Construction Noise Guideline* (ICNG). The ICNG also recommends procedures to address potential impacts of construction noise on residences and other sensitive land uses. The main objectives of the ICNG are summarised as follows:

- Promote a clear understanding of ways to identify and minimise noise from construction works;
- Focus on applying all "feasible" and "reasonable" work practices to minimise construction noise impacts;
- Encourage construction to be undertaken only during the recommended standard hours unless approval is given for works that cannot be undertaken during these hours;
- Streamline the assessment and approval stages and reduce time spent dealing with complaints at the project implementation stage; and
- Provide flexibility in selecting site-specific feasible and reasonable work practices in order to minimise noise impacts.

The ICNG contains a quantitative assessment method which is applicable to this project. Guidance levels are given for airborne noise at residences and other sensitive land uses.

The quantitative assessment method involves predicting noise levels at sensitive receivers and comparing them with the Noise Management Levels (NMLs). The NML affectation categories for receivers have been reproduced from the guideline and are listed in the table below.

Table 5 – Noise Management Levels from Construction – Quantitative Assessment

Receiver Type	Time of Day	Noise Management Level LAeq(15minute)1,2	How to Apply
Residential	Recommended standard hours: Monday to Friday 7 am to 6 pm Saturday 8 am to 1 pm No work on Sundays or public holidays	Noise affected RBL + 10 dB	The noise affected level represents the point above which there may be some community reaction to noise. • Where the predicted or measured LAeq(15minute) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. • The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.
		Highly noise affected 75 dBA	The highly noise affected level represents the point above which there may be strong community reaction to noise. • Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: 1. Times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences. 2. If the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
	School Receivers	When in Use	Recommended Internal Noise Levels – 45 dB(A)

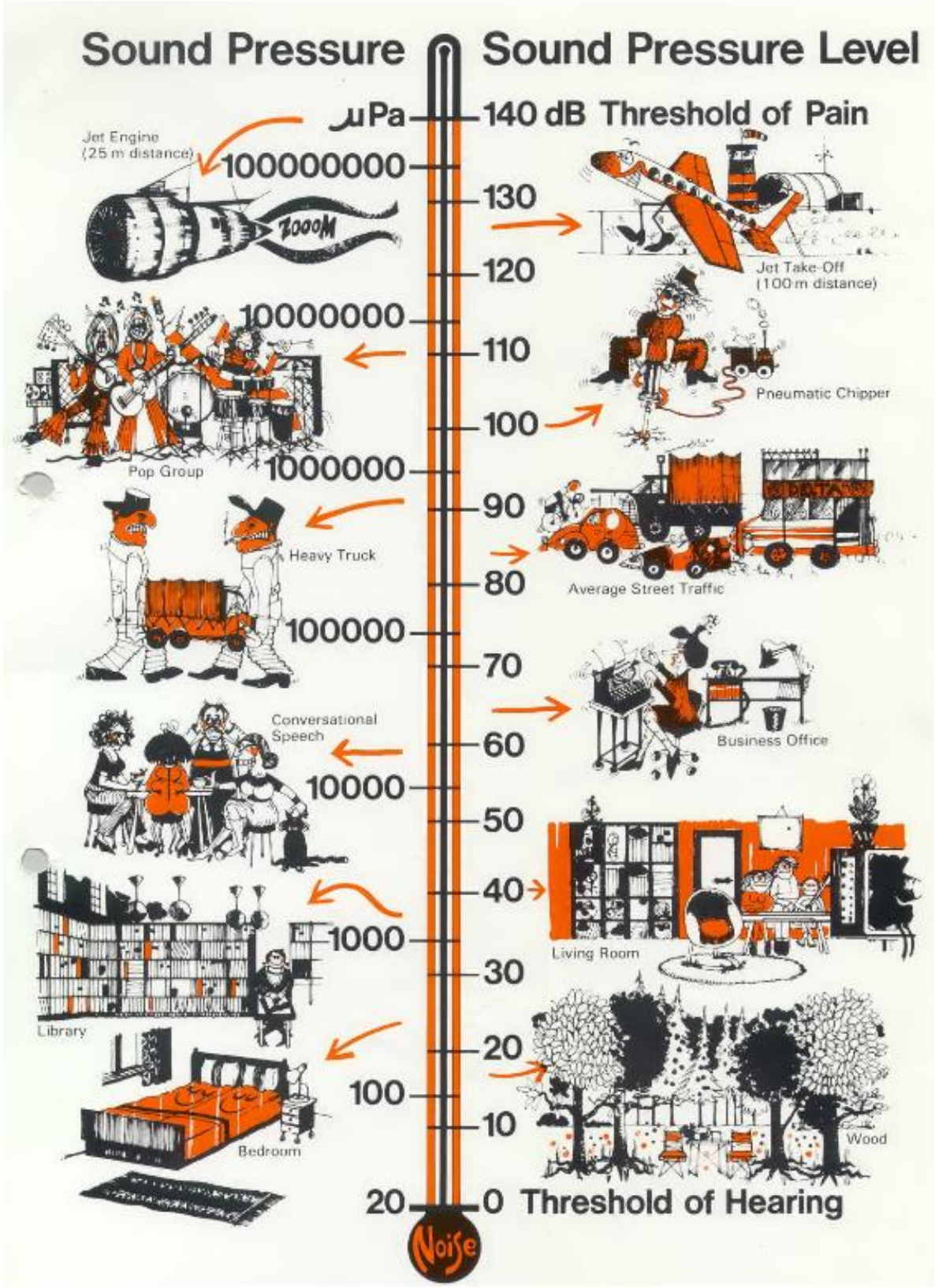
4.2 Measured Internal Noise Levels

The results of the internal noise level measurements undertaken at a number of locations within the school are detailed in the table below.

Table 6 - Vibration Measurements

Location	Assessment period	Measured Internal Noise Level	Comments
Junior School, Year 6 Classroom	Period with hydraulic hammering was being undertaken	63-68 dB(A) with windows closed	Noise a result of noise leaking via open seals and frames within the door.
		Up tp 75 dB(A) with windows open	
Junior School, Year 3 Classroom	Period with hydraulic hammering was being undertaken	Up to 73 dB(A)	Future glass (double glassing) will significantly reduce noise levels
REC Office	Period with hydraulic hammering was being undertaken	Up to 63 dB(A)	Noise levels audible but not at am magnitude which would prevent the area from being used
Library	Period with hydraulic hammering was being undertaken	Up to 52 dB(A)	Noise levels audible but not at am magnitude which would prevent the area from being used
Hall	Period with hydraulic hammering was being undertaken	Up to 60 dB(A)	Noise levels audible but not at am magnitude which would prevent the area from being used
Centenary Hall	Period with hydraulic hammering was being undertaken	Up to 41 dB(A)	Noise levels from hammering just audible
Temporary Class Room	Period with hydraulic hammering was being undertaken	Up to 36 dB(A)	Noise levels from hammering barely audible
Marion Centre – Junior Art Room 1	Period with hydraulic hammering was being undertaken	Up to 68 dB(A)	Noise levels audible and would impact use of the space
Marion Centre – Junior Art Room 2	Period with hydraulic hammering was being undertaken	Up to 66 dB(A)	Noise levels audible and would impact use of the space
Marion Centre – Junior Art Room 3	Period with hydraulic hammering was being undertaken	Up to 48 dB(A)	Noise levels audible but would not impact use of the space
Marion Centre – Art Staff Room	Period with hydraulic hammering was being undertaken	Up to 43 dB(A)	Noise levels audible but would not impact use of the space
Marion Centre – Level 2	Period with hydraulic hammering was being undertaken	Up to 69 dB(A)	Noise levels audible and would impact use of the space
Marion Centre – Staff Offices	Period with hydraulic hammering was being undertaken	Up to 68 dB(A)	Noise levels audible and would impact use of the space. Possible to manage using noise cancelling head phones.

In addition to the information included within the table above a comparison of the magnitude of the noise levels is included in the figure below.



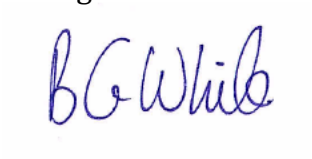
5 Conclusion

This report details the results of the noise and vibration measurements resulting from the sample hydraulic hammering for excavation conducted as part of the Loretto School Kirribilli.

The results of the attended noise and vibration measurements are detailed within this report.

For any additional information please do not hesitate to contact the person below.

Regards



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6 Appendix A – Glossary of Terms

Ambient Sound	The totally encompassing sound in a given situation at a given time, usually composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Character, acoustic	The total of the qualities making up the individuality of the noise. The pitch or shape of a sound's frequency content (spectrum) dictate a sound's character.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of every day sounds; 0dB the faintest sound we can hear 30dB a quiet library or in a quiet location in the country 45dB typical office space. Ambience in the city at night 60dB Martin Place at lunch time 70dB the sound of a car passing on the street 80dB loud music played at home 90dB the sound of a truck passing on the street 100dB the sound of a rock band 115dB limit of sound permitted in industry 120dB deafening
dB(A)	*A-weighted decibels* The ear is not as effective in hearing low frequency sounds as it is hearing high frequency sounds. That is, low frequency sounds of the same dB level are not heard as loud as high frequency sounds. The sound level meter replicates the human response of the ear by using an electronic filter which is called the "A" filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is measured using the A filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Frequency	Frequency is synonymous to *pitch*. Sounds have a pitch which is peculiar to the nature of the sound generator. For example, the sound of a tiny bell has a high pitch and the sound of a bass drum has a low pitch. Frequency or pitch can be measured on a scale in units of Hertz or Hz.
Loudness	A rise of 10 dB in sound level corresponds approximately to a doubling of subjective loudness. That is, a sound of 85 dB is twice as loud as a sound of 75 dB which is twice as loud as a sound of 65 dB and so on
L_{Max}	The maximum sound pressure level measured over a given period.
L_{Min}	The minimum sound pressure level measured over a given period.
L_1	The sound pressure level that is exceeded for 1% of the time for which the given sound is measured.
L_{10}	The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.
L_{90}	The level of noise exceeded for 90% of the time. The bottom 10% of the sample is the L_{90} noise level expressed in units of dB(A).
L_{eq}	The "equivalent noise level" is the summation of noise events and integrated over a selected period of time.
Background Sound Low	The average of the lowest levels of the sound levels measured in an affected area in the absence of noise from occupants and from unwanted, external ambient noise sources. Usually taken to mean the L_{A90} value
Ctr	A frequency adaptation term applied in accordance with the procedures described in ISO 717.
dB (A)	'A' Weighted overall sound pressure level

Noise Reduction	The difference in sound pressure level between any two areas. The term “noise reduction” does not specify any grade or performance quality unless accompanied by a specification of the units and conditions under which the units shall apply
NR Noise Rating	Single number evaluation of the background noise level. The NR level is normally around 5 to 6 dB below the “A” weighted noise level. The NR curve describes a spectrum of noise levels and is categorised by the level at 1000 Hz ie the NR 50 curve has a value of 50 dB at 1000 Hz. The NR rating is a tangential system where a noise spectrum is classified by the NR curve that just encompasses the entire noise spectrum consideration.
R_w	Weighted Sound Reduction Index - Laboratory test measurement procedure that provides a single number indication of the acoustic performance of a partition or single element. Calculation procedures for Rw are defined in ISO 140-2:1991 “Measurement of Sound Insulation in Buildings and of Building Elements Part 2: Determination, verification and application of precision data”.
R'_w	Field obtained Weighted Sound Reduction Index - this figure is generally up to 3-5 lower than the laboratory test determined level data due to flanked sound transmission and imperfect site construction.
Sound Isolation	A reference to the degree of acoustical separation between any two areas. Sound isolation may refer to sound transmission loss of a partition or to noise reduction from any unwanted noise source. The term “sound isolation” does not specify any grade or performance quality and requires the units to be specified for any contractual condition
Sound Pressure Level, L_P dB	A measurement obtained directly using a microphone and sound level meter. Sound pressure level varies with distance from a source and with changes to the measuring environment. Sound pressure level equals 20 times the logarithm to the base 10 of the ratio of the rms sound pressure to the reference sound pressure of 20 micro Pascals.
Sound Power Level, L_W dB	Sound power level is a measure of the sound energy emitted by a source, does not change with distance, and cannot be directly measured. Sound power level of a machine may vary depending on the actual operating load and is calculated from sound pressure level measurements with appropriate corrections for distance and/or environmental conditions. Sound power levels is equal to 10 times the logarithm to the base 10 of the ratio of the sound power of the source to the reference sound power of 1 picoWatt
Speech Privacy	A non-technical term but one of common usage. Speech privacy and speech intelligibility are opposites and a high level of speech privacy means a low level of speech intelligibility. It should be recognised that acceptable levels of speech privacy do not require that speech from an adjacent room is inaudible.
Transmission Loss	Equivalent to Sound Transmission Loss and to Sound Reduction Index in terminology used in countries other than Australia. A formal test rating of sound transmission properties of any construction, by usually a wall, floor, roof etc. The transmission loss of all materials varies with frequency and may be determined by either laboratory or field tests. Australian Standards apply to test methods for both situations.