



Noise Impact Assessment

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Summary

1.1. Proposal

The conversion of an existing farm building into a single residential dwelling is proposed at Cross Royd Farm, Hill Side Lane, S36 9QL.

1.2. Reason for Assessment

Due to the Proximity of an active quarry, a noise survey has been requested by the local authority in order to demonstrate that suitable living conditions within habitable spaces are achievable.

1.3. Planning Conditions & Criteria

For desirable internal and external noise level to be maintained, given in BS8233:2014 as:

- 35dB L_{Aeq} within living rooms (07:00 – 23:00)
- 30dB L_{Aeq} within bedrooms (23:00 – 07:00)
- 45dB L_{Amax} should not be regularly exceeded within bedrooms (23:00 – 07:00)
- <55dB $L_{Aeq,16hr}$ within external amenity spaces

Commercial noise shall be assessed using British Standard 'BS4142:2014 - Methods for Rating and Assessing Industrial and Commercial Sound'. The desirable outcome is that noise from the quarry will achieve a 'Low Impact' rating when assessed to BS4142:2014.

Vibration to be maintained within the vibration dose value (VDV) 'Low probability of adverse comment' range, stated in BS6472-1:2008 as:

- $0.2 - 0.4ms^{-1.75}$ (07:00 – 23:00)
- $0.1 - 0.2ms^{-1.75}$ (23:00 – 07:00)

1.4. Assessment Standards & Justification

'BS8233:2014 – Guidance on sound insulation and noise reduction for buildings' is a recognised standard for assessing and mitigating environmental noise levels upon a proposed noise sensitive development. The standard gives a rigorous calculation method for determining interior noise levels based on measured environmental noise levels.

'BS4142:2014 – Methods for rating and assessing industrial and commercial sound' is a recognised standard for determining the noise impact of fixed plant machinery via relation of noise emissions to the measured background noise level on site.

'BS6472-1:2008 Guide to evaluation of human exposure to vibration in buildings' is a recognised standard for determining the likelihood of comments due to vibration within residential buildings.

The vibration target is that the vibration dose value (VDV) will be within the 'Low probability of adverse comment' range, stated in BS6472-1:2008 as:

- $0.2 - 0.4ms^{-1.75}$ (07:00 – 23:00)
- $0.1 - 0.2ms^{-1.75}$ (23:00 – 07:00)

1.5. Measurements

To assess noise and vibration, measurements were undertaken over a 24 - hour weekday/night period between the hours of 13:08 on the 02/11/2017 and 13:17 on the 03/11/2017. The assessment included an attended period of 2h30min in-order to effectively identify and measure noise emerging from the neighbouring commercial site (active quarry).

Daytime (07:00 -23:00) $L_{Aeq,16h}$ and Night-time (23:00 – 07:00) $L_{Aeq, 8hr}$ noise levels were recorded respectively and are inclusive of elevated noise levels occurring from morning/evening rush hour traffic as-well as typical working activity from the neighbouring Quarry.

Measurement Summary				
Measurement	Date	Period	L_{Aeq} (dB)	L_{AFmax} (dB)
M1	02-03/11/2017	Day (16hr)	52.7	-
		Night (8hr)	49.2	73.5

L_{AFmax} represents the loudest, regularly occurring single noise events, recorded during night-time hours at 05:47.

1.6. Noise Assessment Outcome

It is determined that by using mitigation as specified in Section 1.7. for the building façades, the outcome summarised in the following table is achieved.

Internal Space	Noise Parameter	Internal Noise Level	Within Desirable Limit (BS8233)
Living Room	Daytime $L_{Aeq, 16hr}$	30.6	Yes
Bedroom	Night-time $L_{Aeq, 8hr}$	17.9	Yes
Night-time L_{AFmax}	Night-time L_{AFmax}	37.2	Yes

The grounds surrounding the proposed development are to remain as agricultural land, therefore is noise within external amenity space is not considered.

1.7. Mitigation Recommendations

1.7.1. Glazing & Ventilation Scheme

Internal Space	Glazing Minimum Performance, R_w+C_{tr}	Ventilation Minimum Performance, $D_{ne,w,+C_{tr}(open)}$
Living Rooms	25	40
Bedroom	25	40

Examples of glazing units and ventilators that would achieve the above performance requirements are shown in **Appendix F**.

1.8. Site & Measurement Location

Figure 1: Site & Measurement Locations



-  Noise Measurement Location
-  Vibration Measurement Location
-  Site Boundary

1. Environmental Noise Survey

1.1. Source Under Investigation

At the time of setup and collection of measuring equipment and during the attended measurement period, primary noise sources noted onsite were:

- Commercial noise from neighbouring quarry – Sawing and Forklifts
- Distant road traffic noise

Secondary noise sources noted onsite were:

- Dogs barking
- Chickens + Cockerels
- Aircraft passing overhead
- Vehicles along the adjacent road

2. Survey Measurements

Daytime and night-time noise and vibration measurements were undertaken over a 24 - hour weekday/night period between the hours of 13:08 on the 02/11/2017 and 13:17 on the 03/11/2017. The assessment also included an attended period of 2h30min.

3.1. Measurement Location

Noise levels were recorded in free-field conditions, at a height > 1.5m from the floor.

The Measurement location was representative of the west facing façade of the proposed development. The west facing façade is the closest façade to main source of intrusive commercial noise emitting from the neighbouring quarry and is also representative of the typical noise climate outside of normal quarry working hours 09:00-17:00.

3.2. Weather Conditions

Weather conditions were deemed satisfactory for environmental noise measurements; detailed weather conditions are given in **Appendix C**.

3.3. Measurement Equipment

Measurement equipment used complies with accuracy requirements for common environmental noise measurement standards. A detailed equipment list is given in **Appendix B** with calibration information in **Appendix D**.

3.4. Measurement Results

The results from the measurement intervals are summarised in the tables below. Full measurement details and information can be found in **Appendix E**.

Measured Noise Levels, 02-03/11/2017, S36 9QL

Results Summary				
Measurement	Date	Period	L _{Aeq} (dB)	L _{AFmax} (dB)
M1	02-03/11/2017	Day (16hr)	52.7	-
		Night (8hr)	49.2	73.5

L_{AFmax} represents the loudest, regularly occurring single noise event, recorded during night-time hours at 05:47.

4. BS8233:2014 Noise Assessment

4.1. Criteria

For desirable internal and external noise level to be maintained, given in BS8233:2014 as:

- 35dB L_{Aeq} within living rooms (07:00 – 23:00)
- 30dB L_{Aeq} within bedrooms (23:00 – 07:00)
- 45dB L_{Amax} should not be regularly exceeded within bedrooms (23:00 – 07:00)
- <55dB L_{Aeq,16hr} within external amenity spaces

4.3. Internal Noise Levels – Assumed Insulation

Internal noise levels have been calculated to demonstrate that the proposed development can achieve suitable internal noise levels inside habitable rooms, when appropriate glazing and ventilation systems are used.

In order to describe the likely internal exposure to environmental noise at the site, Peak Acoustics, Ltd. use suggested data from BS8233:2014 on standard construction. This will include all elements of the exposed living room and bedroom façades closest to the noise sources. The proposed development is currently a single-story dwelling and due to the number of small aircrafts noted during the attended period, noise break-in through the roof is also considered.

All assumed construction details are provided within **Appendix F**.

4.4. Daytime Internal Noise Levels

4.4.1. Living Rooms

Considering the insulation with the addition of glazing with a minimum performance rating of 25 $R_{w,+Ctr}$ and ventilation with a minimum performance rating of 40 $D_{ne,w,+Ctr (open)}$ daytime environmental noise could be reduced from 52.7 dB $L_{Aeq,16hr}$ to interior levels of **30.6 dB $L_{Aeq, 16hr}$** .

The desirable limit of BS8233:2014 suggests a guideline of 35dB $L_{Aeq, 16hr}$ for resting conditions, and up to 40dB is considered acceptable for necessary developments.

The assumed standard of construction would place the internal levels in living rooms in all zones as below 35dB, therefore within the desirable category.

4.5. Night-time Internal Noise Levels

4.5.1. Bedrooms

Considering the insulation with the addition of glazing with a minimum performance rating of 25 $R_{w,+Ctr}$ and ventilation with a minimum performance rating of 40 $D_{ne,w,+Ctr (open)}$ night-time environmental noise could be reduced from 49.2 dB $L_{Aeq,16hr}$ to interior levels of **17.9 dB $L_{Aeq,16hr}$** with maximum individual noise events reduced from 73.5 dB L_{AFmax} to **37.2 dB L_{AFmax}** .

BS8233:2014 suggests a desirable guideline of 30dB $L_{Aeq, 8hr}$ for sleeping conditions, with an acceptable limit of 35dB $L_{Aeq, 8hr}$. Individual noise events (Measured with fast time-weighted Maximum) should not normally exceed 45dB L_{AFmax} (as in BS8233:1999).

The above standard of construction would place the internal continuous levels in bedrooms in all zones as below 30dB and maximum noise level as below 45dB L_{AFmax} , therefore in the desirable category.

4.6. Effect Level and Exposure Outcomes

A summary of internal noise levels and their respective BS8233 classifications can be found below:

Internal Space	Noise Parameter	Internal Noise Level	Within Desirable Limit (BS8233)
Living Room	Daytime $L_{Aeq, 16hr}$	30.6	Yes
Bedroom	Night-time $L_{Aeq, 8hr}$	17.9	Yes
Night-time L_{AFmax}	Night-time L_{AFmax}	37.2	Yes

5. Vibration Assessment

5.1. Criteria

'BS6472-1:2008 - Guide to evaluation of human exposure to vibration in buildings' is a recognised standard for determining the likelihood of comments due to variation within residential buildings based on VDV (vibration dose value) measurements.

To comply with the guidance given in BS6472-1:2008, Target levels for vibration dose should be within the 'Low probability of adverse comment' range:

- 0.2 – 0.4ms^{1.75} (07:00 – 23:00)
- 0.1 – 0.2ms^{1.75} (23:00 – 07:00)

5.2. Measurements

Vibration measurement location can be identified within Section 1.8 'site and measurement location' of this report. A summary of results is shown below:

Vibration Measurement Summary			
Measurement	Date	Time of day	VDV Ms ^{1.75}
M1	02-03/11/2017	Day (16hr)	0.03
		Night(8hr)	0.02

A 24-hr vibration assessment was conducted on the 02/11/2017. This was in-order to establish what degree of vibration potential residents of the proposed dwelling would be subject to as a result of operations in the neighbouring quarry.

There was no blasting observed during the attended measurement period of 2h30min and it is understood that this process does not occur as part of the daily operation at the site. Movement from heavy mobile plant travelling along the quarry entrance directly behind the north facing façade of the proposed development was noted as regular event.

Daytime VDV (07:00 – 23:00) and Night-time VDV values have been measured respectively.

5.3. Vibration Outcome

Results from the 24h measurement and the corresponding VDV classification are tabulated below:

Vibration Measurement Results		
Period	VDV Ms ^{1.75}	Within BS6472-1-2008 Low probability of adverse comment range
VDV Daytime (07:00-23:00)	0.03	Yes
VDV Night-time (23:00-07:00)	0.02	Yes

Based on the results obtained over the full 24-hour measurement period, both daytime_{,16hr} and night-time_{,8hr} VDV values fall with the low probability of adverse comment range. Further mitigation measures aimed at reducing VDV is not deemed necessary at the proposed development.

6. BS4142 Assessment

6.1. Noise source

The dominant noise source considered for assessment is from commercial operations from an active quarry situated approximately 100m from the proposed development location. The quarry produces noise between typical working hour 09:00 - 17:00 and it is understood there is little variance in noise characteristics on a day to day basis.

6.2 Subjective impressions

The primary noise source noted during a 2h30min attended measurement period on 02/11/2017 was a consistent tonal noise generated by mechanical saws used for the cutting of stone.

A secondary noise source audible at the proposed development location was the sound of diesel fuelled folk lift trucks moving around the site.

Although the tonal noise is identifiable as emerging from the neighbouring quarry, the continuous nature of the noise better represents an anonymous noise source, such as that of steady road traffic.

It was noted onsite that although the operations at the commercial site were audible at the proposed development location, the noise was often masked by noise events that occurred from the nearby road network, aircraft passing overhead, dogs barking and from within the development site itself (cockerel calling).

6.3 Existing context

The area surrounding the proposed development site is a rural with a number of residential properties as well as agricultural land within close proximity. The nearby residential properties are within a similar proximity to the active quarry as the proposed development location.

6.4 Specific Sound Level, dB L_{As}

The noise source presented from the neighbour quarry is constant through-out typical daytime working hours other than when the production stops at lunchtime. In-order to obtain the specific sound level of the quarry noise as a source, residual noise levels of **41.1 dB L_{Aeq}** were obtained when production stopped, and ambient noise measurements were obtained during a period of full operation as **45.8 dB L_{Aeq}** (Measurement location – Section 3.1). Residual noise levels were then deducted from the measured ambient noise using the formula:

$$10\log_{10}[10^{L_{A2}/10} - 10^{L_{A1}/10}]$$

Where:

L_{A2} = Ambient Sound Pressure level

L_{A1} = Residual Sound Pressure Level

The resulting Specific Sound Level at the west facing façade location is **44.0 dB L_{As}**.

6.5 Sound Rating Level, dB L_{Ar}

The Specific Sound Level may be corrected for certain characteristics that make a sound more noticeable at the NSR location. Corrections for tonality, impulsivity and intermittency may be applied.

Using subjective method of assessment within BS4142:2014 **+2 dB** penalty is applied for tonality perceptible at the façade of the proposed development. This is due to noise emission established as the mechanical saws chopping stone. **+3 dB** is applied for intermittency from the movement of forklift trucks.

The resulting Sound Rating Level has been calculated as **49.0 dB L_{Ar}**

6.6 Background Sound Level, dB L_{A90}

The Background Sound Level considered for the purpose of the assessment was measured between 14:00 – 15:00 on 02/11/2017 as this was the lowest 1hr period containing a break in the noise source during working hours.

The background level was measured in free-field conditions as **33.0 dB L_{A90,1hr}**.

6.7 Rating Vs Background Level

BS4142:2014 describes the relationship between the rating level and background noise level as 'typically, the bigger the difference, the greater the magnitude of the impact.'

Depending on the context, a difference of around +10 dB or more is likely to be an indication of a significantly adverse impact. A difference of around +5 dB is likely to indicate an adverse impact. Where the rating level does not exceed the background level then this may be considered Low impact due to context.

The calculated Rating Level is **49.0 dB L_{Ar}** which is +16.0 dB above the background and is considered an indication of significantly adverse impact. Mitigation is therefore required in-order to meet the criteria of low impact .

7. Mitigation

Mitigation in the form a 2.4m barrier in the west corner of the associated agricultural land is recommended to achieve a rating of Low impact (proposed barrier location – **Appendix H**).

The current rating Level **49.0 dB L_{Ar}** and is therefore +16.0 dB in exceedance of background noise levels.

With correct installation of the proposed barrier a level reduction from 49.0 dB L_{Ar} to 36.9 dB L_{Ar} could be achieved. Considering the context, this would place noise levels within the ‘Low impact classification’.

The barrier should be of an acoustic grade that has a mass great enough to ensure that sound passing through the barrier is negligible compared to that diffracting around it, has no gaps or cracks within the structure or underneath and usually incorporates additional features such as weather resistant materials which aid the level of attenuated sound achievable.

Barrier calculations indicate that installation of a 2.4m acoustic fence, approx. 8.5m from the quarries main operating area and approx. 100m from the western façade position of the proposed development location 12.1 dB attenuation. Barrier calculations are given within **Appendix G**.

APPENDIX A - Measurement Details

Measurement	Kit	Start Date	Start Time	End Date	End Time
M1	A1 + Vib	02/11/2017	13:08	03/11/2017	13:17

APPENDIX B - Equipment Details

Kit	Equipment	Make	Model	Class	Serial Number
A1	Sound Meter	Svantek	958	1	34525
A1	Pre-Amp	Svantek	SV12L	1	41651
A1	Calibrator	Svantek	SV31	1	32507
A1	Accelerometer	Svantek	SV84	1	D8652

APPENDIX C - Meteorology Details

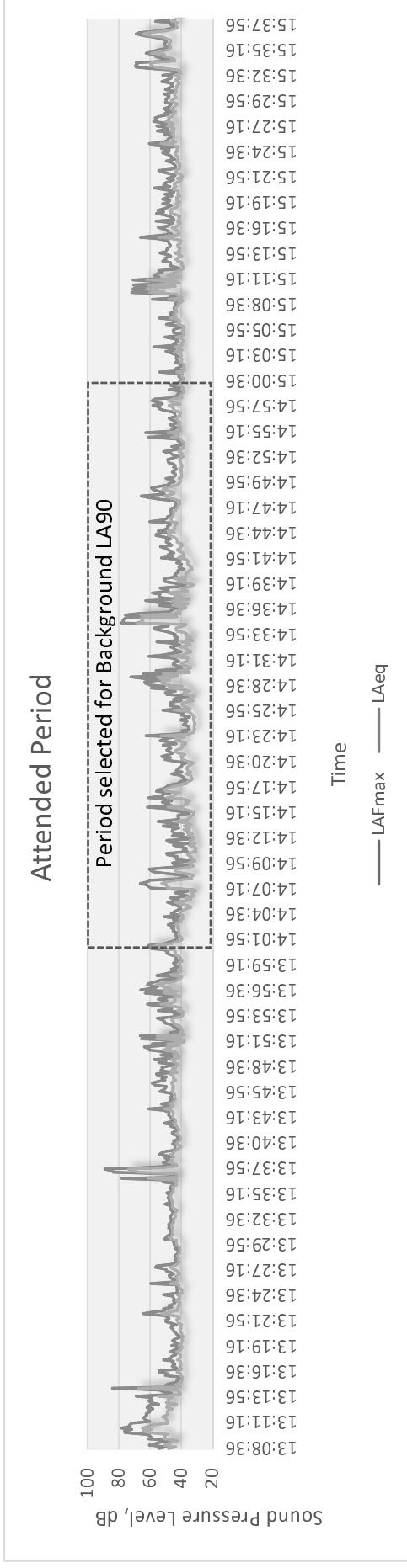
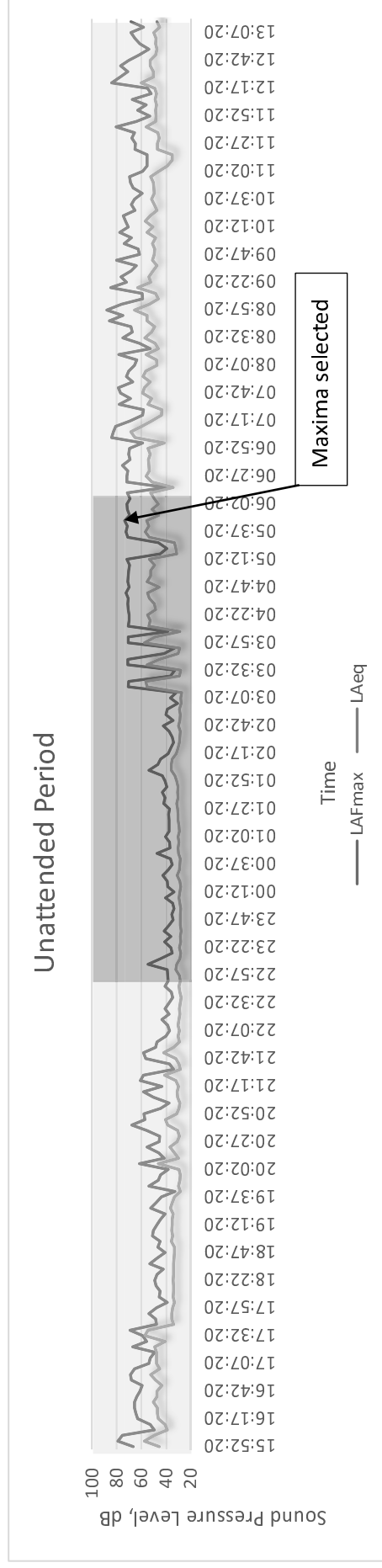
Measurement	Temp *C	Wind Speed m/s	Wind Direction	Humidity %	Precipitation mm	Cloud Cover (Oktas)
M1	12	3	N	80	0	5/8

APPENDIX D - Calibration Details

Measurement	Calibrator Ref Level (dB)	Level Before (dB)	Deviation Before (dB)	Level After (dB)	Deviation After (dB)
M1	114.0	114.7	-0.7	114.1	-0.1

APPENDIX E – Measurement Results

Noise Measurements, 02-03/11/2017, Measurement M1



Daytime period considered

Night-time period considered

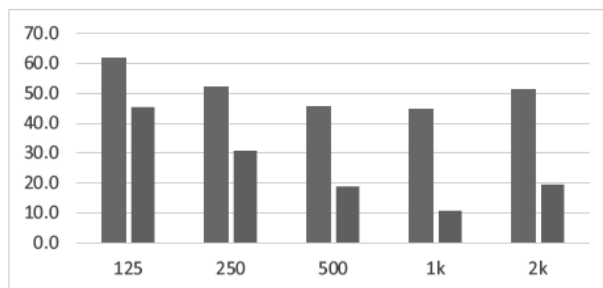
APPENDIX F – BS8233 Rigorous Design Calculations

BS8233:2014 Specification Calculation Summary

Daytime, Living Rooms

Room Properties		Sound Insulation Properties					
Room Width (m)	5.0	Freq. Hz	125	250	500	1k	2k
Room Depth (m)	4.0	Wall, dB R_{w+Ctr}	41	45	45	54	58
Room Height (m)	2.4	Roof, dB R_{w+Ctr}	27	37	43	48	52
Glazed Area (m ²)	1.5	Glazing, dB R_{w+Ctr}	24	20	25	34	37
Is dwelling within roof?	✓	Vents, D _{n,e,w+Ctr}	34	38	43	42	34

Noise Levels, dB



External Level	52.7 dB LAeq
Internal Level	30.6 dB LAeq
Insertion Loss	22.1 dB LAeq

Sound Insulation Requirement

Minimum Sound Insulation Requirement			Suitable Systems
Glazing	25	dB R_{w+Ctr}	Double Glazing 4/12/4mm
Ventilation	40	D _{n,e,w+Ctr}	Acoustically treated trickle vent Titon Xtra Sound Attenuator V75+C50

Technical Calculations

Frequency, Hz	125	250	500	1k	2k
Term 1	0.000124	5E-05	1.6E-05	2E-05	0.00012
Term 2	0.000498	0.00125	0.0004	5E-05	2.5E-05
Term 3	6.95E-05	2.8E-05	2.8E-05	3.5E-06	1.4E-06
Term 4	0.003325	0.00033	8.4E-05	2.6E-05	1.1E-05
Internal, dB L_{eq}	45.3	30.7	18.8	10.6	19.5
Internal, dB LAeq	29.2	22.1	15.6	10.6	20.7

Façade Components

Wall	Brick and block, 75mm cavity
Roof	Tiled, pitched roof
Glazing	Double Glazing
Vents	Acoustically treated trickle vent

Calculations conducted in accordance with BS8233:2014 rigorous calculation method

$$L_{eq,2} = L_{eq,ff} + 10 \log_{10} \left(\frac{A_h}{S} 10^{-\frac{-D_{h,2}}{10}} + \frac{S_{w1}}{S} 10^{-\frac{-R_{w1}}{10}} + \frac{S_{w2}}{S} 10^{-\frac{-R_{w2}}{10}} + \frac{S_{w3}}{S} 10^{-\frac{-R_{w3}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$$

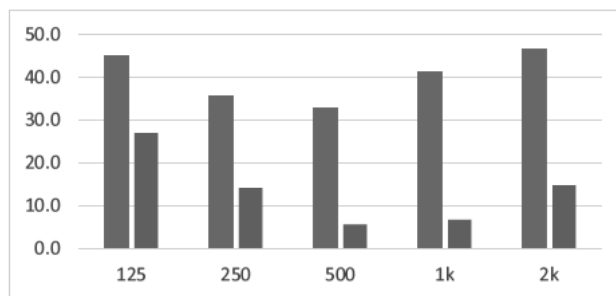
Suitable systems gives as reference only. Other products that achieve the required sound insulation values are available.

BS8233:2014 Specification Calculation Summary

Night-time, Bedrooms

Room Properties		Sound Insulation Properties					
Room Width (m)	3.0	Freq. Hz	125	250	500	1k	2k
Room Depth (m)	4.0	Wall, dB R_{w+Ctr}	41	45	45	54	58
Room Height (m)	2.4	Roof, dB R_{w+Ctr}	27	37	43	48	52
Glazed Area (m ²)	1.5	Glazing, dB R_{w+Ctr}	24	20	25	34	37
Is dwelling within roof?	✓	Vents, $D_{n,e,w+Ctr}$	34	38	43	42	34

Noise Levels, dB



External Level	49.2 dB LAeq
Internal Level	17.9 dB LAeq
Insertion Loss	31.3 dB LAeq

Sound Insulation Requirement

	Minimum Sound Insulation Requirement		Suitable Systems
Glazing	25	dB R_{w+Ctr}	Double Glazing 4/12/4mm
Ventilation	40	$D_{n,e,w+Ctr}$	Acoustically treated trickle vent Titon Xtra Sound Attenuator V75+C50

Technical Calculations

Frequency, Hz	125	250	500	1k	2k
Term 1	0.000207	8.3E-05	2.6E-05	3.3E-05	0.00021
Term 2	0.000829	0.00208	0.00066	8.3E-05	4.2E-05
Term 3	6.29E-05	2.5E-05	2.5E-05	3.2E-06	1.3E-06
Term 4	0.003325	0.00033	8.4E-05	2.6E-05	1.1E-05
Internal, dB L_{eq}	27.0	14.1	5.6	6.7	14.7
Internal, dB LAeq	10.9	5.5	2.4	6.7	15.9

Façade Components

Wall	Brick and block, 75mm cavity
Roof	Tiled, pitched roof
Glazing	Double Glazing
Vents	Acoustically treated trickle vent

Calculations conducted in accordance with BS8233:2014 rigorous calculation method

$$L_{eq,2} = L_{eq,ref} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{0a}}{10}} + \frac{S_{wi}}{S} 10^{\frac{-R_{wi}}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_{gl}}{S} 10^{\frac{-R_{gl}}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$$

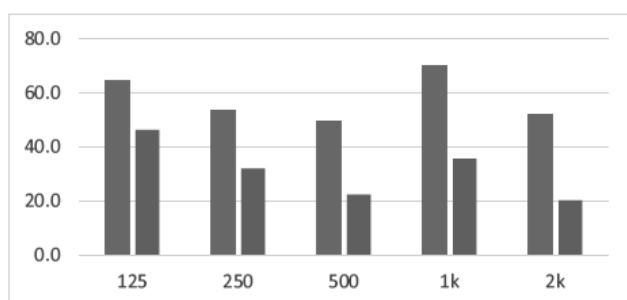
Suitable systems gives as reference only. Other products that achieve the required sound insulation values are available.

BS8233:2014 Specification Calculation Summary

Night-time, MAX

Room Properties		Sound Insulation Properties					
Room Width (m)	3.0	Freq. Hz	125	250	500	1k	2k
Room Depth (m)	4.0	Wall, dB R _{W+Ctr}	41	45	45	54	58
Room Height (m)	2.4	Roof, dB R _{W+Ctr}	27	37	43	48	52
Glazed Area (m ²)	1.5	Glazing, dB R _{W+Ctr}	24	20	25	34	37
Is dwelling within roof?	✓	Vents, D _{n,e,w+Ctr}	34	38	43	42	34

Noise Levels, dB



External Level	73.5 dB LAmax
Internal Level	37.2 dB LAmax
Insertion Loss	36.3 dB LAmax

Sound Insulation Requirement

	Minimum Sound Insulation Requirement		Suitable Systems
Glazing	25	dB R _{W+Ctr}	Double Glazing 4/12/4mm
Ventilation	40	D _{n,e,w+Ctr}	Acoustically treated trickle vent Titon Xtra Sound Attenuator V75+C50

Technical Calculations

Frequency, Hz	125	250	500	1k	2k
Term 1	0.000207	8.3E-05	2.6E-05	3.3E-05	0.00021
Term 2	0.000829	0.00208	0.00066	8.3E-05	4.2E-05
Term 3	6.29E-05	2.5E-05	2.5E-05	3.2E-06	1.3E-06
Term 4	0.003325	0.00033	8.4E-05	2.6E-05	1.1E-05
Internal, dB L _{eq}	46.3	32.0	22.4	35.7	20.2
Internal, dB LAeq	30.2	23.4	19.2	35.7	21.4

Façade Components

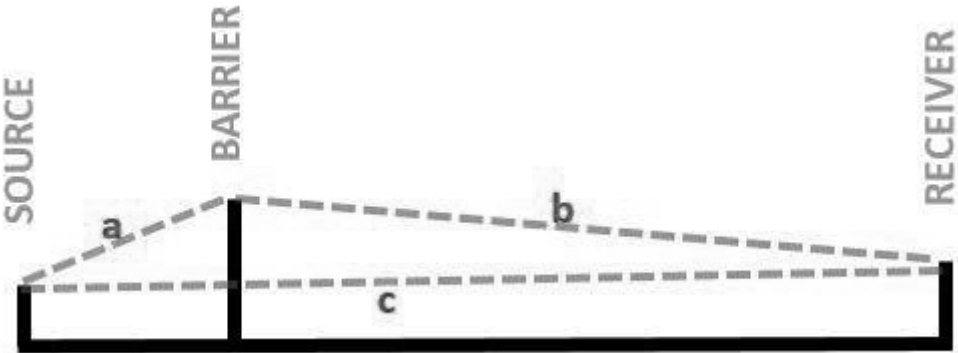
Wall	Brick and block, 75mm cavity
Roof	Tiled, pitched roof
Glazing	Double Glazing
Vents	Acoustically treated trickle vent

Calculations conducted in accordance with BS8233:2014 rigorous calculation method

$$L_{eq,2} = L_{eq,1} + 10 \log_{10} \left(\frac{A_0}{S} 10^{\frac{-D_{0,1}}{10}} + \frac{S_{w1}}{S} 10^{\frac{-R_{w1}}{10}} + \frac{S_{ew}}{S} 10^{\frac{-R_{ew}}{10}} + \frac{S_a}{S} 10^{\frac{-R_a}{10}} \right) + 10 \log_{10} \left(\frac{S}{A} \right) + 3$$

Suitable systems given as reference only. Other products that achieve the required sound insulation values are available.

APPENDIX G - Barrier Calculations

Barrier Calculation	
Barrier-to-Source Distance, (m)	8.5
Source Height from Ground	0.5
D Bar-to-NSR, (m)	100
NSR Height from Ground	0.5
BarrierTop Height from G0	2.4
(C) Direct Path	108.5
(A) Source-to BarrierTop, m	8.71
(B) NSR-to-BarrierTop, m	100.02
Path Diff., m	0.23
	
Nominal Frequency (Hz)	500
Velocity (m/s)	343
Wavelength	0.686
Fresnel Number (N)	0.66
Barrier Attenuation A, (dB)	12.1

APPENDIX H – Recommended Barrier Position

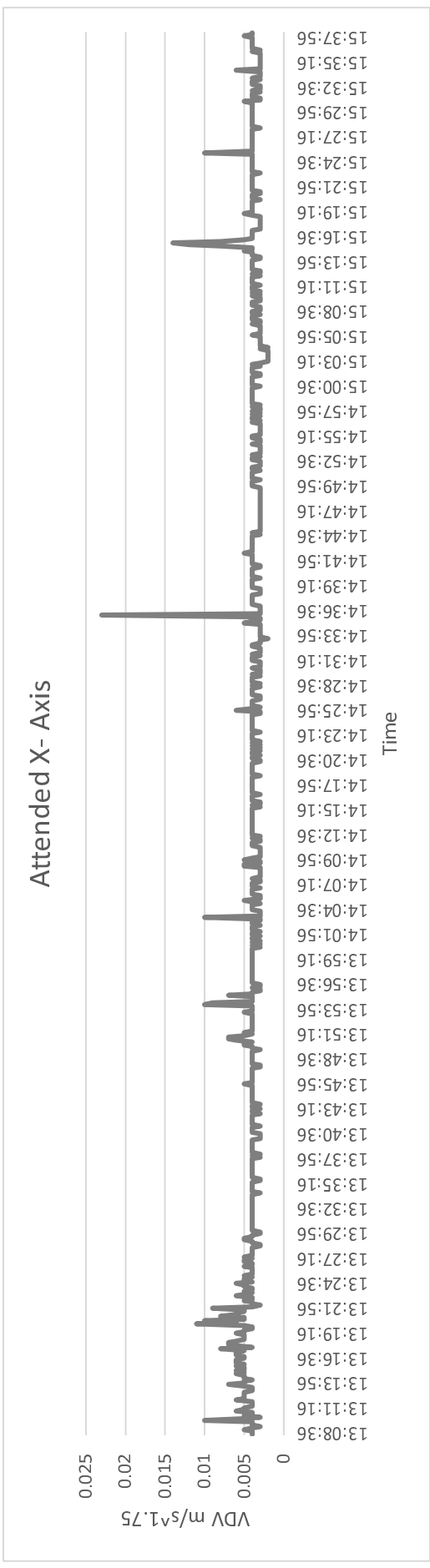
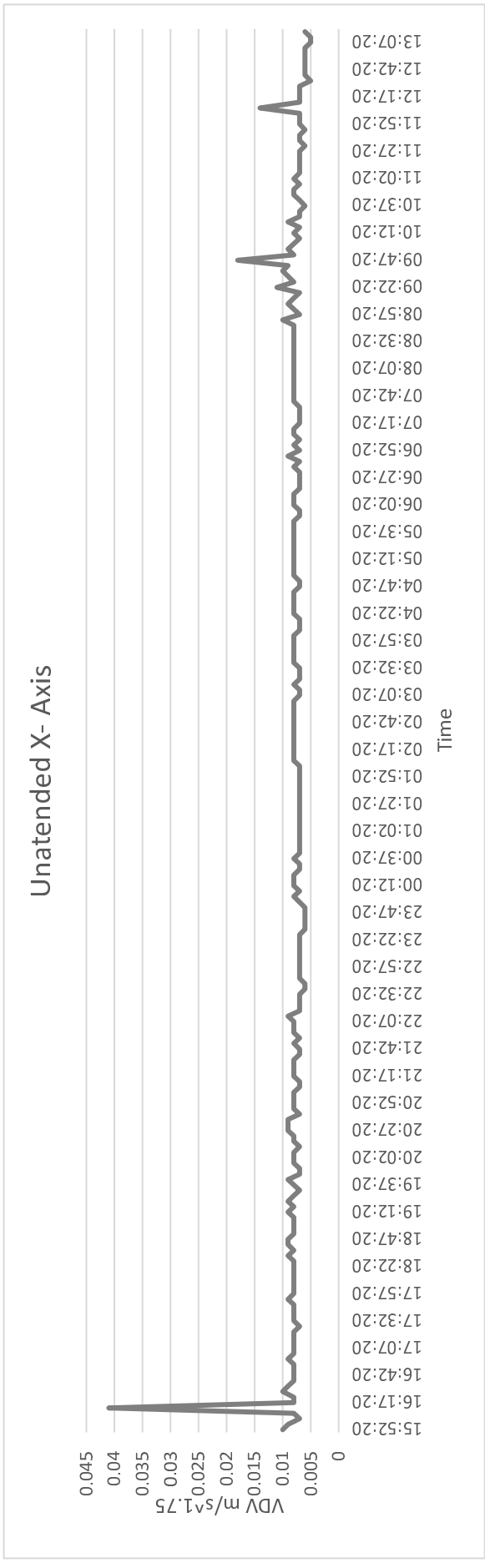


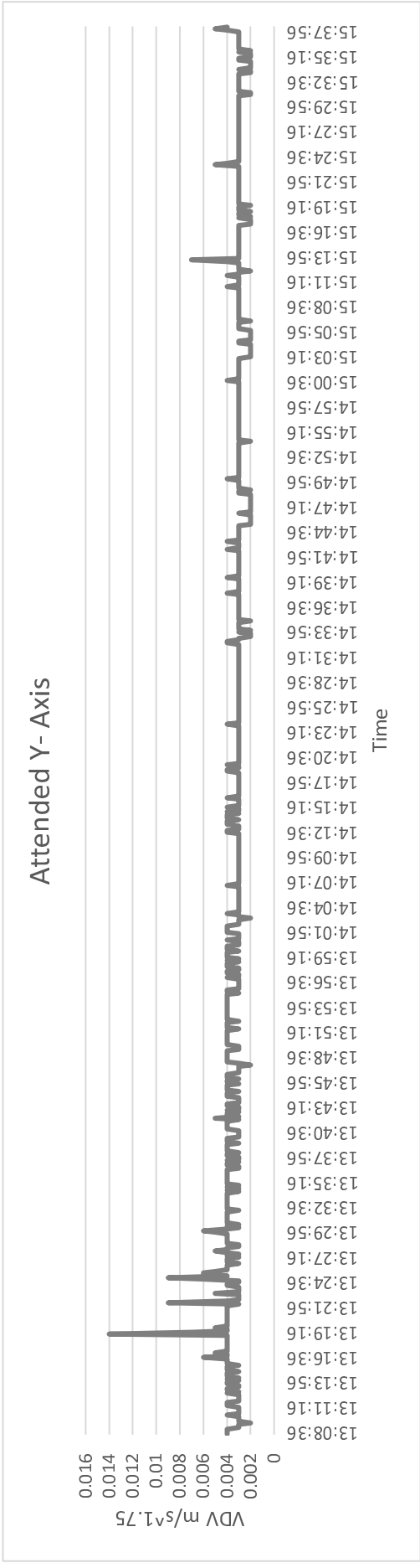
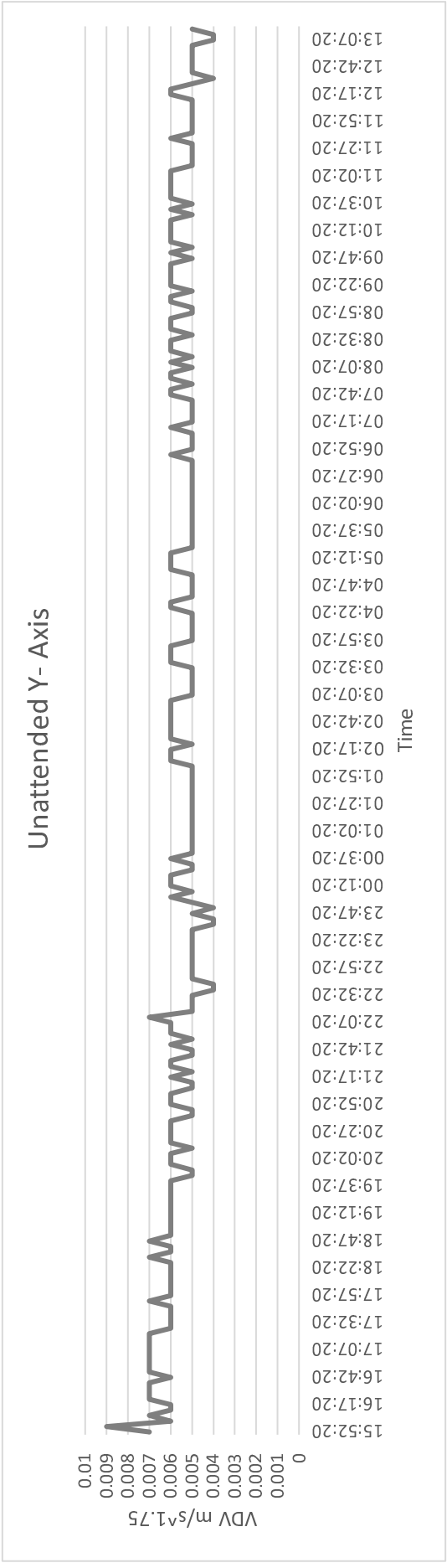
— Proposed acoustic fencing location

▲ Proposed development location

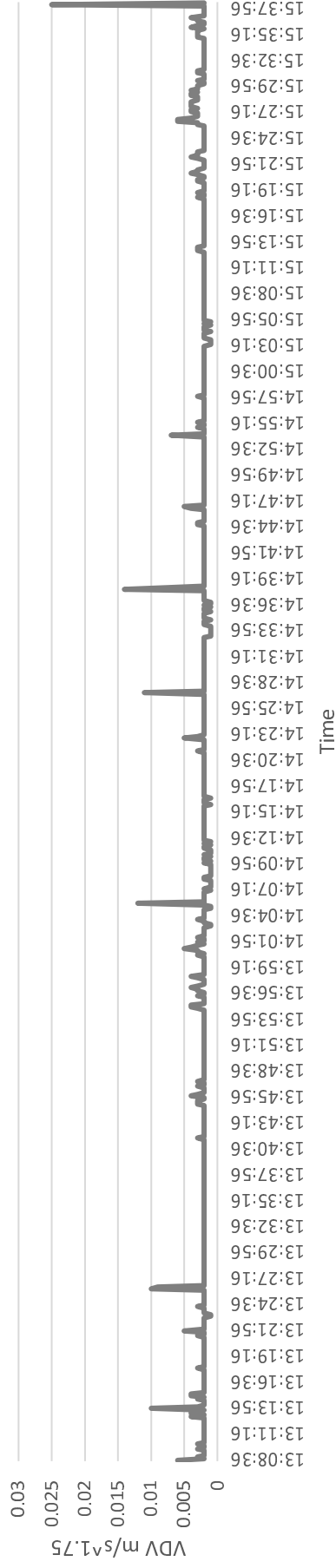
● Noise source

APPENDIX I - Vibration VDV Axis X, Y & Z





Attended Z-Axis



Unattended Z-Axis

