Noise Survey and
Façade Acoustic Design Strategy
Salcombe Avenue, Jarrow

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Prepared by:	**Beth Paxton BA AMIOA**
Checked by:	**Richard Hinton BSc MIOA**

Apex Acoustics Limited
Design Works
William Street
Gateshead
NE10 0JP

Tel: 0191 620 0750
www.apexacoustics.co.uk

Prepared for: **CEAD Limited**
Toffee Factory
Lower Steenburgs Yard
Quayside
Newcastle upon Tyne
NE1 2DF

1. Revision register

Version	Changes from previous version	Issued by	Date
A	First issue	BP	07/02/17
B	Client amended; Paras 3.6, 9.6, 9.7, Tables 1, 9, 11, 12, 13, Figures 1, 4, 6, 7 amended.	BP	18/4/17

2. Contents

3. Summary

3.1 This report has been prepared in support of a Planning Application for a residential development at Salcombe Avenue, Jarrow.

3.2 Noise levels affecting the proposed development from road traffic have been measured during the day, and the façade noise impact calculated.

3.3 Calculated noise levels are used to determine the potential façade sound insulation treatments to meet the internal noise level requirements of the Local Planning Authority.

3.4 A set of minimum glazing and ventilation strategy options, interpreted from Approved Document F (AD-F), is proposed as shown in Table 1.

3.5 Figure 1 shows the sound insulation treatments required for each façade based on the options detailed in Table 1.

3.6 Noise levels in gardens are calculated to be reduced where considered practicable on the basis of the acoustic barrier mitigation measures described in Section 9, shown as green lines in Figure 1.

3.7 A limit of 28 dB(A) in bedrooms and living rooms is suggested for mechanical services noise.

<table>
<tr><th>Façade affected</th><th>Rooms affected</th><th>Glazing / mm</th><th>Trickle ventilator</th><th>Potential ventilation strategy</th></tr>
<tr><td rowspan="2">Red</td><td>Bedrooms</td><td>10-12-6
Double glazing</td><td rowspan="3">None permissible</td><td rowspan="3">AD-F System 4, mechanical supply and extract with heat recovery (MVHR)</td></tr>
<tr><td>Living / dining rooms</td><td>6-12-6.4 PVB
Double glazing</td></tr>
<tr><td>Orange</td><td>All</td><td>6-12-6
Double glazing</td></tr>
</table>

Table 1: Summary of minimum façade sound insulation treatment

Figure 1: Site plan marked with required sound insulation treatments and mitigation measures

4. Introduction

4.1 A residential development consisting of 20 no. dwellings has been proposed at Salcombe Avenue, Jarrow.

4.2 The site location is shown in Figure 2.

4.3 Apex Acoustics has been commissioned to undertake a noise survey and provide advice on the sound insulation of the façade to achieve the internal levels required by the Local Planning Authority.

4.4 The purpose of this report is to identify the usual acoustic design parameters of the Local Environmental Health Department, and the manner in which internal noise levels may be achieved in practice.

4.5 This assessment is based on measurements of road traffic noise and other noise sources, room and window dimensions on the architects' plans, assumptions about room conditions, with glazing and ventilation strategy options proposed in this report.

4.6 Internal noise transmission and the sound insulation requirements of the Building Regulations are not considered in this report.

Figure 2: Site location outlined in red and measurement position indicated by marker

5. Guidance and acceptable levels

5.1 The National Planning Policy Framework (NPPF, 2012), Reference 1, sets out the Government's economic, environmental and social planning policies for England.

5.2 The NPPF is consistent with the Noise Policy Statement for England (NPSE), Reference 2.

5.3 The aims and further details of the NPPF and NPSE are discussed in Appendix 1.

5.4 The Local Authority have commented on the site as follows:

"The predominant noise source in this location is road traffic noise from the busy A19. Monitoring should be undertaken in accordance with the calculation of road traffic noise procedure, and assessment positions should reflect the location of proposed properties. Measured day time and night time noise levels should be compared against recommended noise levels found in BS8233:2014 and the World Health Organisation guidelines on community noise. If assessment indicates that noise levels are predicted to be above the proposed guideline levels, then mitigation in the form of screening, glazing and ventilation should be considered and suggested."

5.5 Table 4 of BS 8233, Reference 3, defines guideline upper limits for internal ambient noise levels in dwellings for steady external noise sources, as shown in Table 2.

Activity	Location	Guideline upper limit, $L_{Aeq,T}$ / dB	
		07:00 to 23:00	23:00 to 07:00
Resting	Living rooms	35	-
Dining	Dining room/area	40	-
Sleeping (daytime resting)	Bedroom	35	30

Table 2: Guideline indoor ambient noise levels defined in BS 8233

5.6 The Local Authority requirements are consistent with these values, and are presented in Table 3.

Situation	Local Authority upper limits, $L_{Aeq, T}$ / dB
Living rooms, daytime	35
Bedrooms, night time	30

Table 3: Local authority internal noise level requirements

5.7 BS 8233 advises on external noise level limits in private gardens and states as follows:

"For traditional external areas that are used for amenity space, such as gardens and patios, it is desirable that the external noise level does not exceed 50 dB $L_{Aeq, T}$, with an upper guideline value of 55 dB $L_{Aeq, T}$ which would be acceptable in noisier environments. However, it is also recognized that these guideline values are not achievable in all circumstances where development might be desirable. In higher noise areas, such as city centres or urban areas adjoining the strategic transport network, a compromise between elevated noise levels and other factors, such as the convenience of living in these locations or making efficient use of land resources to ensure developments needs can be met, might be warranted."

6. Noise sources and measurements

6.1 Measurements of the existing noise environment were made between 12:00 and 15:00 on 25th November 2016 at the position indicated by the marker in Figure 2.

6.2 The microphone was located at 1.8 m above ground level, away from other reflecting surfaces, such that the measurements are considered to be free field.

6.3 The equipment used is listed in Table 4.

Equipment	Model	Serial no.
Sound Level Meter	NTi XL2	A2A-04045-D2
Calibrator	Larson Davis Cal 200	11705

Table 4: Equipment used

6.4 Both meter and calibrator have current calibration certificates traceable to national standards.

6.5 At the time of the measurements, the temperature was around 4 °C; the wind speed measured was around 0.3 m/s.

6.6 The most significant noise source affecting the proposed development was road traffic noise on the A 19.

6.7 The time history of the $L_{Aeq,\ 1\ sec}$ recorded is shown in Figure 3.

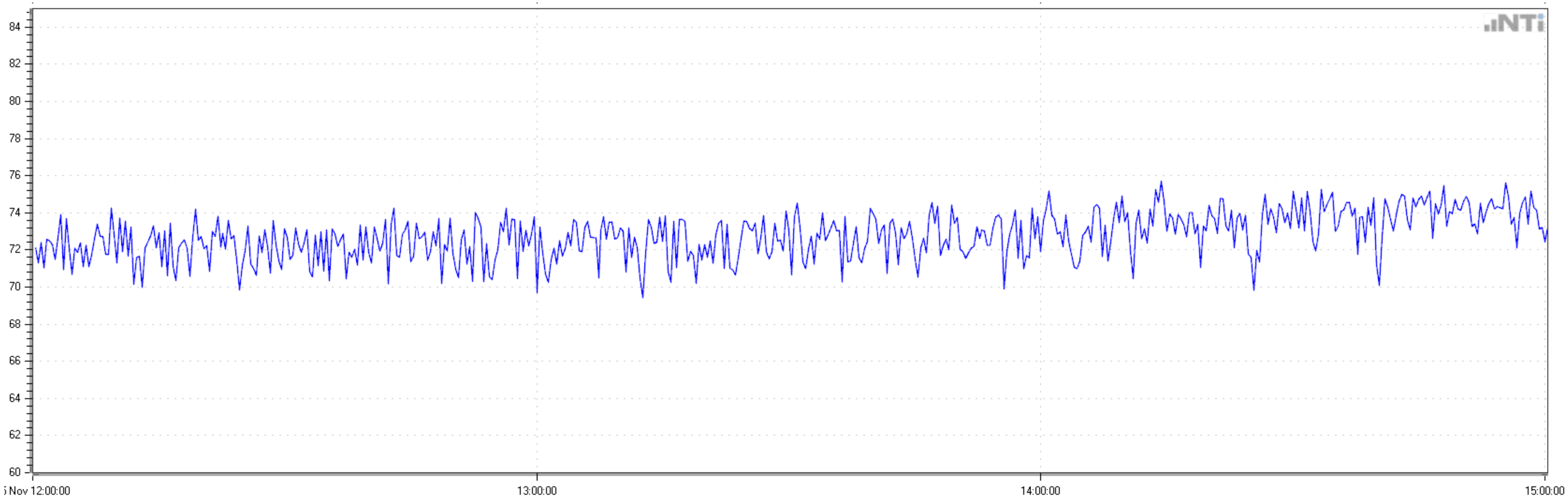

Figure 3: $L_{Aeq,\ 1\ sec}$ between 12:00 and 15:00 hrs

7. Results

7.1 The measured noise levels are shown in Table 5.

Measurement position	Start time / hh:mm	$L_{Aeq,3\,hr}$ / dB(A)	Octave Band Centre Frequency / Hz						
			63	125	250	500	1k	2k	4k
1	12:00	**73**	47	50	51	63	72	65	50

Table 5: Measured A-weighted noise levels

7.2 The calculation method of the overall daytime noise level, $L_{Aeq,\,16\,hr}$ and night-time noise level, $L_{Aeq,\,8\,hr}$, from the measured data is described in Appendix 3, in accordance with CRTN, Reference 5, and Transport Research Laboratory, Reference 6.

7.3 The measured values of the L_{A10} for three consecutive hours are shown in Table 6.

Time Period	Measured noise level, L_{A10} / dB
First hour	74
Second hour	74
Third hour	75

Table 6: Measured L_{A10} over three consecutive hours

7.4 The calculated daytime $L_{Aeq,\,16\,hr}$ and night-time $L_{Aeq,\,8\,hr}$ noise levels are shown in Table 7.

Parameter	$L_{Aeq,\,T}$ / dB
Daytime, $L_{Aeq,\,16\,hr}$	72
Night time, $L_{Aeq,\,8\,hr}$	68

Table 7: Calculated noise levels

8. Environmental noise modelling

8.1 Noise transmission and propagation is modelled using proprietary software, CadnaA, Reference 7. This models noise propagation outdoors according to ISO 9613, Reference 8.

8.2 The parameters used, source of data and details are described in Table 8.

Parameter	Source	Details
Model dimensions	Google Earth	British Transverse Mercator coordinates
Site location and layout	Architects drawings	Architects' drawings, Reference 9
Topography – within site	Site observations and Google Street view	Modelled with no changes in topography
Topography – Outside of site	Site observations and Google Street view	Modelled with no changes in topography
Building heights – proposed buildings	Drawings	Architects drawings', Reference 9
Building heights – outside of site	Site observations and Google Street view	3 m per storey + 2 m roof (residential properties)
Receptor positions	Site observations and Google Street view	On the façade closest to the source at a height of 1.5 m and 4 m to represent ground and first floor window heights respectively
Building and barrier absorption coefficient	ISO 9613-2	0.21 to represent a reflection loss of 1 dB
G, Ground factor	ISO 9613-2	Porous ground, G = 1; hard ground, G = 0 locally on model
Max. order of reflections	Apex Acoustics	Three

Table 8: Modelling parameters and assumptions

8.3 Using the calculated daytime noise levels to ascribe sound power levels to the surrounding roads, the noise impact at the proposed building façade is calculated.

8.4 A 3D view of the noise model is shown in Figure 4.

Figure 4: 3D view of the model from the south-west

9. Calculated noise levels

9.1 Due to the proximity of the site to the A 19, external noise levels within gardens are considered.

9.2 **Without barriers**

9.3 Gardens are exposed to external noise levels above the guideline upper limit set by BS 8233 of 55 dB $L_{Aeq,\,T}$.

9.4 Sound contours at 1.5 m without mitigation are shown in Figure 5.

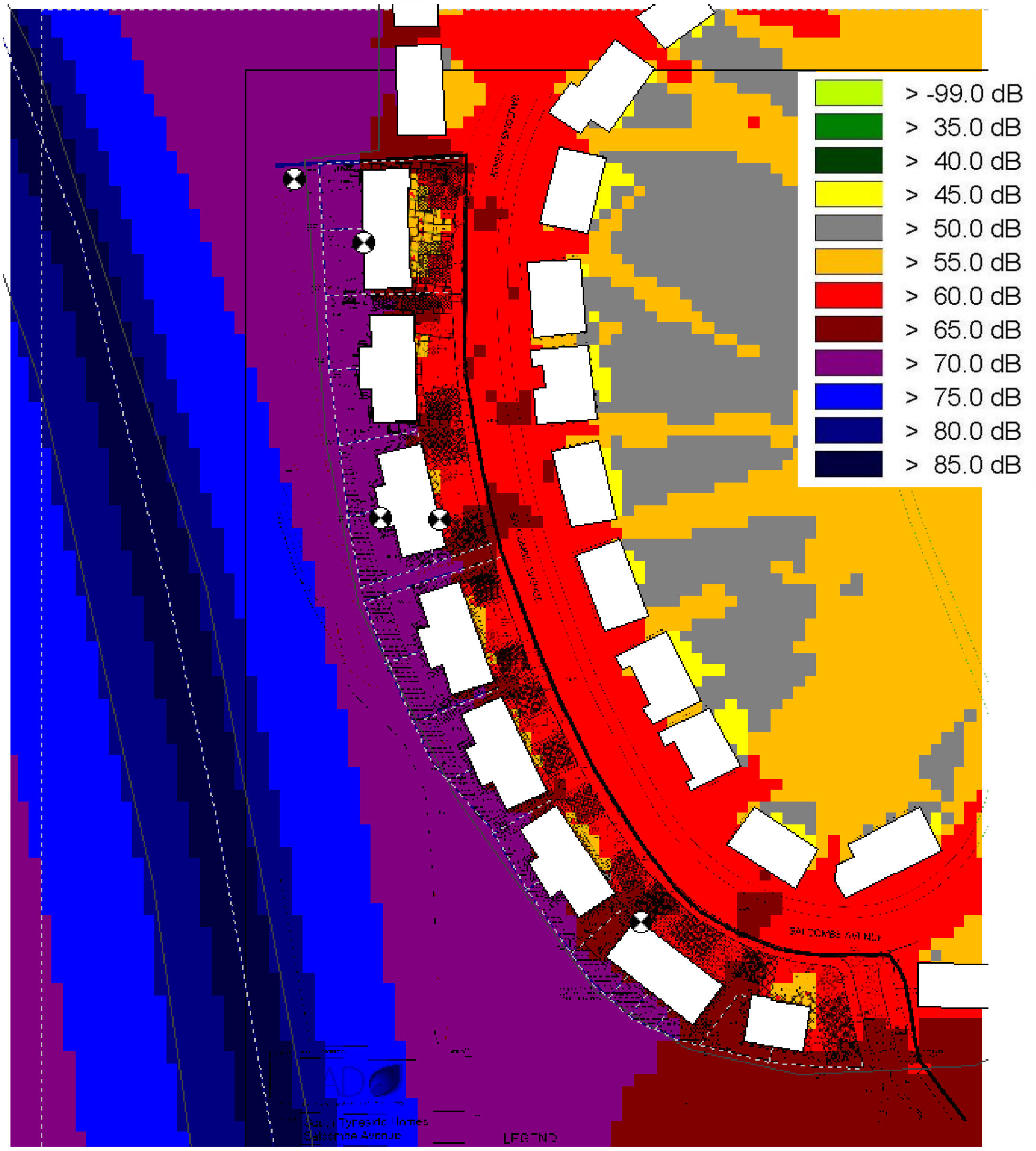

Figure 5: Plan viewing sound contours at 1.5 m in daytime without mitigation

9.5 **With barriers**

9.6 Barriers of 1.8 m height are proposed to the garden boundaries to mitigate garden noise levels.

9.7 The locations of proposed barriers are shown in **green** in Figure 1.

9.8 A plan view of the model with the graphical results at 1.5 m above the ground during the day and at 4 m above the ground during the night is shown in Figure 6 and Figure 7, respectively.

9.9 To be effective in practice, the barriers should have no cracks or gaps, be continuous to the ground, and have a surface density ≥ 10 kg/m^2 such as a close-boarded timber fence or brick wall.

9.10 The guideline daytime levels of 55 dB $L_{Aeq,T}$ in gardens are still exceeded with the proposed barriers; the proposed barriers and their effects are included in the further calculations outlined in this report.

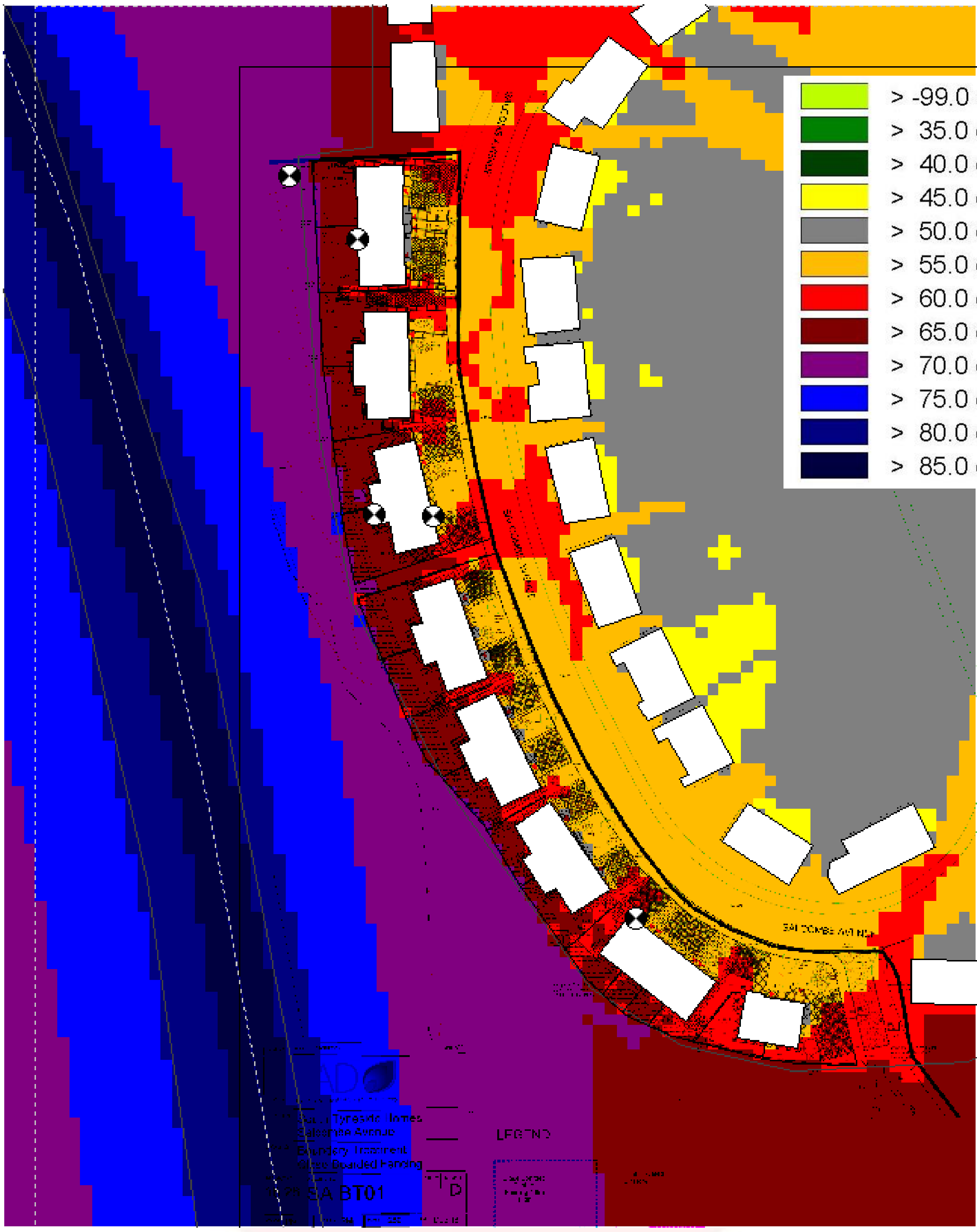

Figure 6: Noise contours at 1.5 m during the daytime with proposed barriers

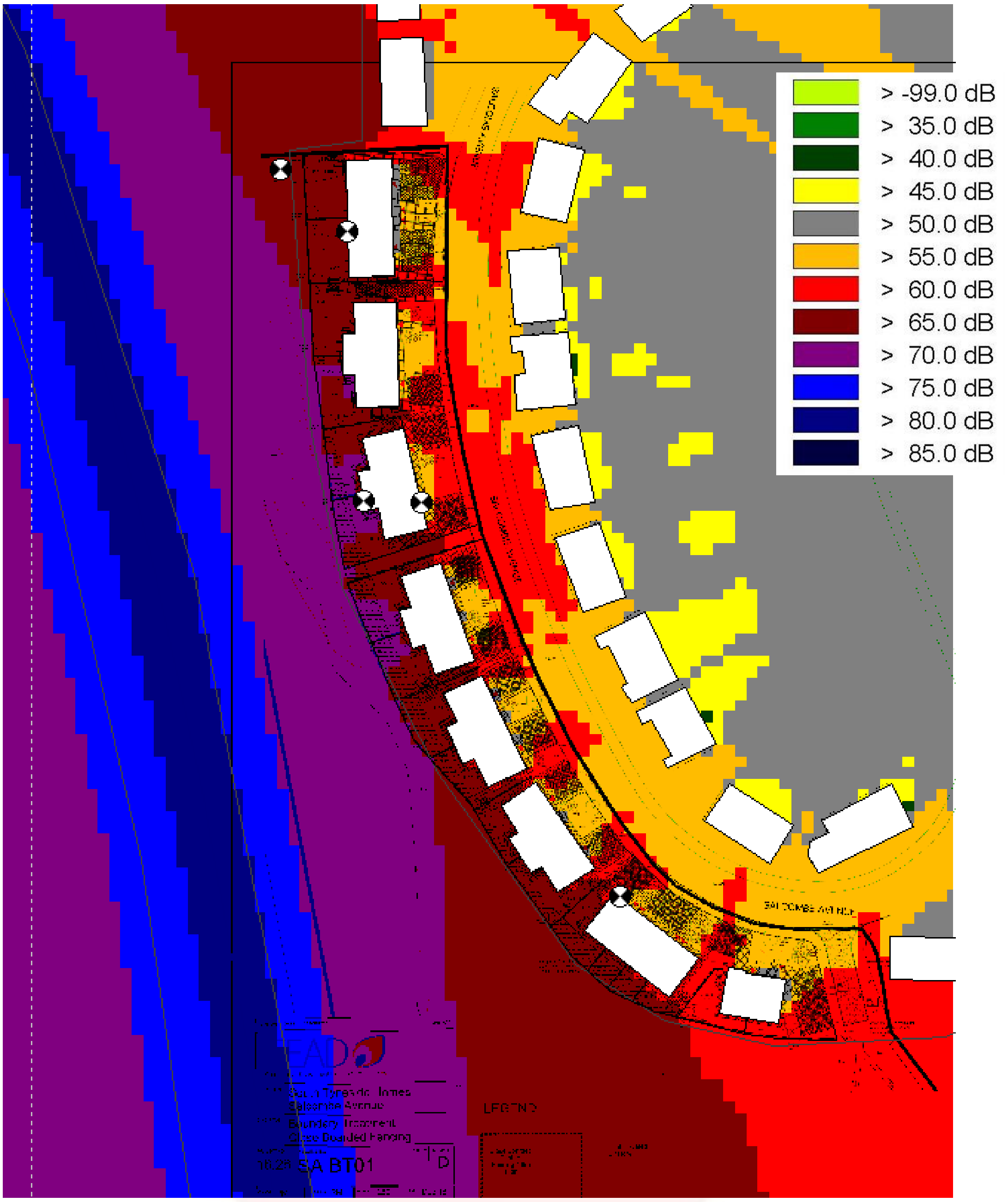

Figure 7: Noise contours at 4 m during the night time with proposed barriers

10. Facade noise calculations

10.1 The calculation method for façade sound insulation is in accordance with BS 8233 and the principles of BS EN 12354-3, Reference 10, as described in Appendix 4 and detailed in the Apex Method, Reference 11.

10.2 **Ventilation strategy**

10.3 The proposed development will be required to meet Part F of the Building Regulations, with regard to ventilation provision, as described in Approved Document F (AD-F), Reference 12.

10.4 For AD-F System 1, Background ventilators and intermittent extract fans, and AD-F System 3, Continuous mechanical extract (MEV), the quantity of trickle vents required is calculated not to be feasible acoustically.

10.5 Therefore in this case it has been assumed AD-F System 4, Continuous mechanical supply and extract with heat recovery (MVHR), is to be used. No trickle vents are calculated to be permissible.

10.6 Should AD-F System 4, Continuous mechanical supply and extract with heat recovery (MVHR), be implemented, trickle vents are not required.

10.7 It should be emphasised that the above is not intended to constitute a ventilation strategy design, which is the responsibility of the mechanical engineers. Assumptions regarding the ventilation strategy are required in order to carry out the acoustic assessment.

10.8 Once the ventilation strategy is established, if the details vary from those described above, the proposed details should be reassessed for acoustic performance.

10.9 **Reverberation time**

10.10 From ISO 16283, Reference 13, the reverberation time is typically 0.5 seconds across the relevant frequency range for a furnished living room. This value is used for both living rooms and bedrooms.

10.11 **Dimensions and unit descriptions**

10.12 The room and window dimensions are taken from the architects' plans and elevations, Reference 9.

10.13 **Glazing**

10.14 The acoustic performance of the proposed glazing listed in the summary table is taken from Pilkington, Reference 14.

10.15 Opening windows may be acceptable to provide purge ventilation; all opening lights should be well fitted with compressible seals.

10.16 **Rooms most exposed to noise ingress**

10.17 Calculations are carried out for those rooms most exposed to noise ingress as the worst cases. If these have sufficient sound insulation to meet the internal level criteria, noise levels in less exposed but similarly protected rooms will be lower and therefore also comply with the Local Authority requirements.

10.18 The most exposed rooms are those with the largest ratio of window area to room volume, as well as those closest and most exposed to the noise sources.

10.19 **Calculated noise impact**

10.20 Façade noise calculations are carried out in octave bands between 125 Hz and 2 kHz as indicated in BS 8233.

10.21 The calculated spectra used in the façade noise calculations are shown in Table 9. The façade labels in Table 9 refer to those marked in Figure 1.

Façade affected	Rooms affected	Parameter	dB(A)	Octave Band Centre Frequency / Hz				
				125	250	500	1k	2k
Red	Bedrooms	Daytime $L_{Aeq,16\ hr}$	**70**	46	52	63	69	61
		Night time $L_{Aeq,8\ hr}$	**67**	42	48	59	65	57
	Living / dining	Daytime $L_{Aeq,16\ hr}$	**68**	44	51	62	66	57
Orange	Bedrooms	Daytime $L_{Aeq,16\ hr}$	**60**	38	44	53	58	50
		Night time $L_{Aeq,8\ hr}$	**56**	34	40	49	54	46

Table 9: A-weighted external free-field noise levels used to calculate façade sound insulation

10.22 A summary of the calculated internal levels is shown in Table 10.

Dwelling description	Calculated internal level / dB		Full calculation
	Daytime $L_{Aeq,\ 16\ hr}$	Night time $L_{Aeq,\ 8\ hr}$	
Plot 4, Bedroom 2	31	27	Table 11
Plot 8 Living / dining room	32	-	Table 12
Plot 15, Bedroom 2	25	21	Table 13

Table 10: Summary of calculated worst case internal noise levels

11. Noise aspects of mechanical services design

11.1 The potential for noise issues from mechanical services is discussed in Appendix 5.

11.2 An upper limit of 28 dB(A) in bedrooms and living rooms is suggested for mechanical services noise when ventilating at the minimum low rate in accordance with AD-F. This would be classified as a Class C environment according to the COST TU0901 collaboration programme, Reference 15.

11.3 The mechanical services noise limits are both to prevent the total noise from all sources exceeding the limits identified, and to prevent mechanical services noise causing annoyance that may result in occupants curtailing the operation of the ventilation system as described in Problems in Residential Design for Ventilation and Noise, Reference 16.

11.4 It is suggested that the specification includes a requirement for commissioning measurements of noise from the mechanical services, to ensure that the contractor pays sufficient attention to the design and construction requirements to meet this limit.

11.5 Measurements of mechanical services noise should be made in accordance with the Association of Noise Consultants Guidelines, Reference 17.

12. Conclusion

12.1 Noise levels affecting the proposed development have been measured and the highest noise impact calculated.

12.2 On the basis of the measurements, assumptions and details in this report, it is calculated that the minimum façade sound insulation provision as shown in the summary table is required.

12.3 It is suggested that a ventilation strategy of MVHR may be appropriate.

12.4 Noise levels in gardens are calculated to be mitigated as is considered practicable on the basis of the mitigation measures described in Section 9.

12.5 A noise limit of 28 dB(A) in bedrooms and living rooms is proposed for mechanical services noise when ventilating at the minimum low rate in accordance with AD-F; it is suggested that commissioning measurements are undertaken to demonstrate that this is achieved in practice.

13. References

1. National Planning Policy Framework, Department for Communities and Local Government, March 2012.
2. Noise Policy Statement for England, Department for Environment, Food and Rural Affairs, March 2010.
3. BS 8233: 2014, Guidance on sound insulation and noise reduction for buildings.
4. Guidelines for Community Noise, Edited by Birgitta Bergland, Thomas Lindvall, Dietrich H Schwela, World Health Organisation, 1999.
5. Calculation of Road Traffic Noise, Department of Transport, 1988.
6. Transport Research Laboratory / Defra, Method for converting the UK road traffic noise index $L_{A10,\ 18\ hr}$ to the EU noise indices for noise mapping, 2006.
7. CadnaA environmental noise modelling software, version 2017, Datakustik GmbH.
8. ISO 9613: Acoustics - Attenuation of sound during propagation outdoors
9. CEAD drawings, South Tyneside Homes Salcombe Avenue, Project 16.28, Proposed Site Plan Drawing no. PG SP02 Rev A Dec 16, Boundary treatment Close Boarded Fencing Drawing no. SA BT01 Rev - Dec 16, Proposed Bungalow Elevations Drawing no. SA.EL.05 Rev * May 15, Proposed Bungalows Ground Floor GA Drawing no. SA.PL.05 Rev * Dec 16, Proposed Bungalows Section AA Drawing no. SA.SC.10 Rev - Dec 16, Proposed Apartment Elevations Gable Drawing no. SA.EL.04 Rev * Dec 16, Proposed Apartment GF, FF Drawing no. SA.PL.03 Rev * Dec 16, Proposed Apartment Elevations Drawing no. SA.EL.03 Rev * Dec 16, Proposed Apartment Section CC Drawing no. SA.SC.09 Rev * Dec 16, Proposed Terraced Units Elevations Drawing no. SA.EL.05 Rev * Dec 16, Proposed Terraced Units Ground and First Floor Drawing no. SA.PL.09 Rev * May 15, Proposed Apartment Elevations Drawing no. SA.EL.07 Rev * Dec 16, Proposed Apartment GF, FF

Drawing no. SA.PL.09 Rev * Dec 16, Proposed Apartment Section CC Drawing no. SA.SC.15 Rev * Dec 16.

10. BS EN 12354-3:2000, Building Acoustics – Estimation of acoustic performance of buildings from the performance of elements – Part 3: Airborne sound insulation against outdoor sound.
11. Practical Acoustic Design – the Apex Method, Proceedings of the Institute of Acoustics Vol 36 Pt 3 2014. Full paper and Poster presentation at Institute of Acoustics Conference 2014, available to download from www.apexacoustics.co.uk
12. Approved Document F 2010 Edition, The Building Regulations 2000.
13. BS EN ISO 16283-1:2014 Acoustics – Field measurement of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation.
14. Pilkington Optiphon™ Laminated Glass for noise control, Pilkington, 8222 – June 2014
15. Integrating and Harmonizing Sound Insulation Aspects in Sustainable Urban Housing Constructions. Building acoustics throughout Europe Volume 1: Towards a common framework in building acoustics throughout Europe, COST Action TU0901, 2014, free download from http://goo.gl/y6Xj3K
16. Harvie-Clark, J. and Siddall, M. Problems in residential design for ventilation and noise, Proc. Institute of Acoustics 2013; 35 (1): 74-87, download from www.apexacoustics.co.uk
17. ANC Guidelines: Noise Measurement in Buildings, Part 1: Noise from Building Services, Association of Noise Consultants, 2011
18. Noise from domestic ventilation systems, Apex Acoustics, poster presentation at the Institute of Acoustics Conference 2014, download from www.apexacoustics.co.uk

14. Appendix 1: Current policy and guidance

14.1 **National Planning Policy Framework (NPPF)**

14.2 The National Planning Policy Framework (NPPF, 2012) sets out the Government's economic, environmental and social planning policies for England and "these policies articulate the Government's vision of sustainable development". In respect of noise, Paragraph 123 of the NPPF states the following:

"Planning policies and decisions should aim to:

- avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development
- mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions,
- recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restriction put on them because of changes in nearby land uses since they were established; and
- identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason."

14.3 **Noise Policy Statement for England (NPSE)**

14.4 The NPPF is consistent with the Noise Policy Statement for England which states three policy aims as follows:

"Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- avoid significant adverse impacts on health and quality of life;

- mitigate and minimise adverse impacts on health and quality of life; and
- where possible, contribute to the improvement of health and quality of life.”

14.5 The NPSE defines adverse noise impact as follows:

- No Observed Effect Level (NOEL)
  This is the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.
- Lowest Observed Adverse Effect Level (LOAEL)
  This is the level above which adverse effects on health and quality of life can be detected.
- Significant Observed Adverse Effect Level (SOAEL)
  This is the level above which significant adverse effects on health and quality of life occur

14.6 Together, the first two aims of the NPPF and the NPSE require that no significant adverse impact should occur and that, where a noise level which falls between a level which represents the lowest observable adverse effect and a level which represents a significant observed adverse effect, then according to the explanatory notes in the statement:

“… all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life whilst also taking into consideration the guiding principles of sustainable development. This does not mean that such effects cannot occur.”

14.7 It is considered that meeting the internal ambient noise level limits given in BS 8233, which are in line with those given by the World Health Organisation, Reference 4, adequately achieve the first and second aims of the NPSE.

15. Appendix 2: WHO Community Noise Guideline values

15.1 Section 4.2.3 of WHO Community Noise Guideline Values discusses how electrophysiological and behavioural methods have demonstrated that both continuous and intermittent noise indoors lead to sleep disturbance.

15.2 The more intense the background noise, the more disturbing is its effect on sleep. Measurable effects on sleep start at background noise levels of about 30 dB L_{Aeq}. Physiological effects include changes in the pattern of sleep stages, especially a reduction in the proportion of REM sleep.

15.3 Subjective effects have also been identified, such as difficulty in falling asleep, perceived sleep quality, and adverse after-effects such as headache and tiredness. Sensitive groups mainly include elderly persons, shift workers and persons with physical or mental disorders.

15.4 Where noise is continuous, the equivalent sound pressure level should not exceed 30 dB(A) indoors, if negative effects on sleep are to be avoided. When the noise is composed of a large proportion of low-frequency sounds a still lower guideline value is recommended, because low frequency noise (e.g. from ventilation systems) can disturb rest and sleep even at low sound pressure levels. It should be noted that the adverse effect of noise partly depends on the nature of the source.

15.5 If the noise is not continuous, L_{Amax} or SEL are used to indicate the probability of noise induced awakenings. Effects have been observed at individual L_{Amax} exposures of 45 dB or less. Consequently, it is important to limit the number of noise events with a L_{Amax} exceeding 45 dB. Therefore, the guidelines should be based on a combination of values of 30 dB $L_{Aeq,8h}$ and 45 dB L_{Amax}. However, Section 3.4 of the WHO guidelines note that for a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10–15 times per night (Vallet & Vernet 1991).

15.6 To protect sensitive persons, a still lower guideline value would be preferred when the background level is low. Sleep disturbance from intermittent noise events increases with the maximum noise level. Even if the total equivalent noise level is fairly low, a small number of noise events with a high maximum sound pressure level will affect sleep.

15.7 Therefore, to avoid sleep disturbance, guidelines for community noise should be expressed in terms of equivalent sound pressure levels, as well as L_{Amax} / SEL and the number of noise events. Measures reducing disturbance during the first part of the night are believed to be the most effective for reducing problems in falling asleep.

16. Appendix 3: Calculation of daytime and night-time levels

16.1 **Calculation of $L_{A10, 18hr}$ using CRTN shortened measurement procedure**

16.2 The shortened measurement procedure outlined in CRTN, paragraph 43 can be used to calculate the $L_{A10,18hr}$ from measurements of the L_{A10} made over any 3 consecutive hours between 10:00 and 17:00. The measured values are shown in Table 6.

16.3 For the shortened measurement procedure the arithmetic mean of the three noise levels shown is taken and the $L_{A10,18hr}$ calculated from the $L_{A10,3hr}$ as shown in the equation below:

$$L_{A10,18hr} = L_{A10,3hr} - 1\text{ dB}$$

16.4 **Calculation of daytime and night time levels from the $L_{A10, 18hr}$**

16.5 The TRL use the following equations to determine day ($L_{Aeq, 8\,hr}$), evening ($L_{Aeq, 4\,hr}$) and night-time ($L_{Aeq, 8\,hr}$) noise levels from the equations below for different road types.

16.6 For non-motorway roads:

$$L_{day} = 0.95 \times L_{A10,18hr} + 1.44\text{ dB}$$

$$L_{evening} = 0.97 \times L_{A10,18hr} - 2.87\text{ dB}$$

$$L_{night} = 0.90 \times L_{A10,18hr} - 3.77\text{ dB}$$

16.7 For motorways:

$$L_{day} = 0.98 \times L_{A10,18hr} + 0.09\text{ dB}$$

$$L_{evening} = 0.89 \times L_{A10,18hr} + 5.08\text{ dB}$$

$$L_{night} = 0.87 \times L_{A10,18hr} + 4.24\text{ dB}$$

16.8 Day and evening levels can then be summed with an appropriate time weighting to determine the daytime $L_{Aeq,16hr}$.

17. Appendix 4: Calculation of façade noise ingress

17.1 The noise level in a room due to sound penetrating a façade element may be calculated according to BS EN 12354-3 and BS 8233 from:

$$L_2 = L_{1,in} - R + 10 \times Log\left(\frac{S}{V}\right) + 10 \times Log(T) + 11$$

Equation 1.

Where:

- L_2 = noise level in room due to sound through façade portion of area S and mean sound reduction index R, dB
- L_1, in = external free-field noise level at the position of the façade, dB.
- R = sound reduction index of portion, dB
- S = area of façade portion, m^2.
- V = room volume, m^3
- T = reverberation time, s.

17.2 For small façade components, such as ventilators, the noise level in a room may be calculated according to the same standards as above from:

$$L_2 = L_{1,in} - D_{n,e} - 10 \times Log(V) + 10 \times Log(T) + 21$$

Equation 2.

Where:

- $D_{n,\,e}$ = element-normalised sound level difference of the ventilator.

Other components have the same meaning as above.

17.3 The sound reduction of the masonry portion of the facade is much higher than that of the glazing and ventilation provision. Therefore noise penetration through the masonry is disregarded as insignificant compared to noise penetration through the glazing and ventilation provision.

17.4 The noise penetration through the vents and the glazing is calculated as above and then combined in each frequency band to give an overall internal level from the external sources by these routes. Calculations are carried out in five octave bands as indicated in BS 8233.

Plot 4, Bedroom 2	
Volume, V / m^3	18
Window area, S / m^2	2
Reverberation Time, T / s	0.5

Octave centre frequency	**dB(A)**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**
Daytime freefield noise, L_{1in} / dB(A) L_{eq}	**70**	**46**	**52**	**63**	**69**	**61**
10/12/6 double glazing, R / dB		26	27	34	40	38
Equation 1, L_2 / dB(A) L_{eq}	**31**	18	23	26	26	21

Octave centre frequency	**dB(A)**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**
Night time freefield noise, L_{1in} / dB(A) L_{eq}	**67**	**42**	**48**	**59**	**65**	**57**
10/12/6 double glazing, R / dB		26	27	34	40	38
Equation 1, L_2 / dB(A) L_{eq}	**27**	14	19	23	23	17

Table 11: Calculations for Plot 4, Bedroom 2

Plot 8 Living / dining room	
Volume, V / m^3	53
Window area, S / m^2	4
Reverberation Time, T / s	0.5

Octave centre frequency	**dB(A)**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**
Daytime freefield noise, L_{1in} / dB(A) L_{eq}	**68**	**44**	**51**	**62**	**66**	**57**
6/12/6.4 PVB double glazing, R / dB		21	20	31	39	37
Equation 1, L_2 / dB(A) L_{eq}	**32**	20	28	28	24	17

Table 12: Calculations for Plot 8 Living / dining room

Plot 15, Bedroom 2	
Volume, V / m^3	25
Window area, S / m^2	2
Reverberation Time, T / s	0.5

Octave centre frequency	**dB(A)**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**
Daytime freefield noise, L_{1in} / dB(A) L_{eq}	**60**	**38**	**44**	**53**	**58**	**50**
6/12/6 double glazing, R / dB		20	19	29	38	36
Equation 1, L_2 / dB(A) L_{eq}	**25**	14	21	20	16	10

Octave centre frequency	**dB(A)**	**125 Hz**	**250 Hz**	**500 Hz**	**1 kHz**	**2 kHz**
Night time freefield noise, L_{1in} / dB(A) L_{eq}	**56**	**34**	**40**	**49**	**54**	**46**
6/12/6 double glazing, R / dB		20	19	29	38	36
Equation 1, L_2 / dB(A) L_{eq}	**21**	11	17	17	13	7

Table 13: Calculations for Plot 15, Bedroom 2

18. Appendix 5: Mechanical ventilation systems

18.1 **Noise from the MVHR unit**

18.2 Noise from mechanical ventilation systems is not currently controlled under the Building Regulations.

18.3 There is no formal requirement to associate any particular ventilation condition with any particular noise level limit.

18.4 There is guidance in Approved Document F (AD-F) that noise from mechanical services should not exceed 30 dB(A) in bedrooms and living rooms, and not exceed a limit of 35 dB(A) in kitchens, when ventilating at the minimum low rate according to AD-F.

18.5 Problems with the dissociation of ventilation condition and noise level are discussed by Harvie-Clark and Siddall, Reference 16.

18.6 On the basis of the literature review presented by Harvie-Clark and Siddall, it is suggested that these limits may cause annoyance to a significant proportion of people. Annoyance can result in occupants curtailing the operation of the ventilation system. Such action leads to inadequate ventilation resulting in poor air quality, which is well correlated with a range of adverse health effects, as described in Reference 16.

18.7 Tolerance to domestic mechanical ventilation system noise has not yet been investigated in the UK, and may well be culturally- dependent. However, it is suggested that appropriate noise level limits associated with the minimum low ventilation rate may be informed by COST Action TU0901, Reference 15.

Table 5.4. *Sound levels in dwellings due to building service equipment. Class limits.*[1]

Type of space and sources [2]	Class A L_{eq} or L_{maxF} (dB)	Class B L_{eq} or L_{maxF} (dB)	Class C L_{eq} or L_{maxF} (dB)	Class D L_{eq} or L_{maxF} (dB)	Class E L_{eq} or L_{maxF} (dB)	Class F L_{eq} or L_{maxF} (dB)
In dwellings due to ventilation / heating / cooling installation L_{eq}.	≤ 20	≤ 24	≤ 28	≤ 32	≤ 36	≤ 40

18.8 This European project of scientific collaboration associates noise levels with different classes of performance in its Table 5.4, as reproduced below.

18.9 This classification system is set to become an ISO Standard in approximately 2018, when the classification system is likely to be adopted into English Building Regulations.

18.10 It is suggested that for reasonable conditions the values for at least Class C area adopted as the design target, ie 28 dB(A).

18.11 It is suggested that the client include a requirement for commissioning measurements of MVHR noise to ensure that these levels are met in practice. Measurements should be made according to the Association of Noise Consultants Guidelines.

18.12 There is currently considered to be insufficient understanding of appropriate noise limits during the minimum high ventilation rate (boost condition), and therefore limits for this condition are not proposed.

18.13 **Noise implications of other design issues**

18.14 As well as ducted noise from the MVHR unit, there is potential for ventilation systems which are not well designed to develop a negative noise impact. For example, locating the unit on a light-weight wall, or in the loft directly over bedrooms may be inappropriate and lead to an adverse noise impact.

18.15 If the filters are not regularly changed, the fan may increase in effort to counteract the additional flow resistance, resulting in higher noise levels. The unit should therefore be in a place that facilitates its operation and maintenance.

18.16 Further guidance on issues with domestic mechanical services that can cause noise problems are identified in Noise from Domestic Ventilation Systems, Reference 18.

18.17 **Cross-talk between rooms**

18.18 Where there are ducts between rooms, there is potential for noise transmission between them; this is generally undesirable for the residents, but is not currently regulated. It is suggested that the level of cross-talk between rooms is limited such that $D_{ne,w} \geq 45$ dB.

18.19 Distribution systems that utilise single ducts from a plenum to each vent typically overcome the requirement for cross-talk attenuators.

18.20 **Purge ventilation and over heating**

18.21 Overheating has traditionally been controlled by the use of purge ventilation; over heating is not controlled under the Building Regulations, and there is no universally accepted definition.

18.22 In locations with an unfavourable external noise environment, utilising open windows to provide purge ventilation during the night time is unlikely to be compatible with undisturbed sleep, and is therefore undesirable.

18.23 As a means of sufficient ventilation for air quality purposes that is compatible with maintaining the façade sound insulation is proposed in this report, it is suggested that the designers give sufficient attention to preventing overheating such that purge ventilation is not required during the night time period.