Proposed residential development at land between St Christopher’s Drive and A605 Oundle Bypass, Oundle

Outline Noise Impact Assessment

Report ref.
MM588/17180/Rev. 0

Issued to
Persimmon - Charles Church

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1. **INTRODUCTION**

Persimmon – Charles Church (Persimmon) are seeking outline planning permission for a new residential development on land between St Christopher’s Drive and A605 Oundle Bypass, Oundle Northamptonshire. The site is currently a green field site and the proposal is for up to 95 new properties. Persimmon are seeking outline planning permission for the proposal from East Northamptonshire Council following the refusal of an earlier outline application and the dismissal of a subsequent appeal.

Spectrum Acoustic Consultants have been engaged by Persimmon to carry out an investigation of the noise environment at the site and to provide an outline Noise Impact Assessment report for submission with the outline planning application. The intention of this report is to assess the potential for adverse effects as a result of noise on a proposed residential development at the site and where necessary, to indicate the magnitude of mitigation measures that would be required to ensure that acceptable living conditions can be provided for residents of the new development.

2. **SITE DESCRIPTION AND PROPOSALS**

The development site is located between St Christopher's Drive and A605 Oundle Bypass, Oundle Northamptonshire. The site is a green field site which lies on the west side of the A605, to the east of Oundle. Just beyond the east boundary of site runs the A605, with an area of vegetation separating the majority of the site from the road. The A605 is a busy single lane bypass with a speed limit of 60 mph.

An existing residential area is located to the north west of the site and Prince William Secondary School is located to the south west. Playing fields for the school adjoin the southern site boundary. To the east, beyond the A605 are open fields. To the north, adjoining the northern corner of the site is a commercial/industrial area. The nearest unit to the site is currently occupied by “Hutchinson’s”, a crop production specialist.

A site location plan is included in Appendix A.

Detailed layout plans have not yet been developed for the site as the proposal is in outline, however Persimmon are seeking permission for up to 95 dwellings on site. This noise impact assessment works on the assumption that these dwellings will be in the form of 2 storey houses and provides a prediction of noise levels across the site.

3. **GUIDELINES FOR ACCEPTABILITY**

3.1 **NOISE POLICY GUIDELINES - NATIONAL PLANNING POLICY FRAMEWORK (NPPF)**


It says that the planning system should contribute to and enhance the environment by (among other things) preventing development from contributing to, being put at risk from, or being adversely affected by unacceptable levels of noise pollution. (Para. 109)

Paragraph 123 states that 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 restrictions put on them because of changes in nearby land uses since they were established; and
• Identify and protect areas of tranquility which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.”

The NPPF refers to the **Noise Policy Statement for England (NPSE)** which sets out the long term vision of Government noise policy as follows: *Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.*

The NPSE aims to clarify the principles and aims in existing policy documents, legislation and guidance that relate to noise. Its noise policy aims are to:

• 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.

through the effective management and control of environmental, neighbour and neighbourhood noise.

These aims are developed by reference to the concepts NOEL (No Observed Effect Level) and LOAEL (Lowest Observed Adverse Effect Level). NPSE also refers to SOAEL (Significant Observed Adverse Effect Level).

It recognises that there is no universally applicable threshold for these concepts. Consequently, the SOAEL is likely to be different for different noise sources and receptors and at different times. Even so, significant effects should be avoided, taking account of sustainability aims.

Where noise impact is between LOAEL and SOAEL, the NPSE requires that all reasonable steps should be taken to mitigate adverse effects while taking account sustainable development aims. It notes (para. 2.7) that the NPSE should consider noise alongside other relevant issues and noise should not to be considered in isolation.

The **Planning Practice Guide (PPG)** refers to the NPPF and provides further guidance on the interpretation of no, lowest and significant observed adverse effect level described in the NPSE.

The PPG provides a commentary on the noise exposure hierarchy, based on the ‘likely average response’.
Perception | Examples of Outcomes | Increasing Effect Level | Action |
--- | --- | --- | --- |
Not noticeable | No Effect | No Observed Effect | No specific measures required |
Noticeable and not intrusive | Noise can be heard, but does not cause any change in behaviour or attitude. Can slightly affect the acoustic character of the area but not such that there is a perceived change in the quality of life. | No Observed Adverse Effect | No specific measures required |
Noticeable and intrusive | Noise can be heard and causes small changes in behaviour and/or attitude, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a perceived change in the quality of life. | Lowest Observed Adverse Effect Level Observed Adverse Effect | Mitigate and reduce to a minimum |
Noticeable and disruptive | The noise causes a material change in behaviour and/or attitude, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area. | Significant Observed Adverse Effect Level Significant Observed Adverse Effect | Avoid |
Noticeable and very disruptive | Extensive and regular changes in behaviour and/or an inability to mitigate effect of noise leading to psychological stress or physiological effects, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory | Unacceptable Adverse Effect | Prevent |

The PPG recognises a broad range of factors which can influence the relationship between noise level and the impact on those affected. Accordingly, the examples in the above table may not be relevant to a specific development and which should be considered on its merits within the specific context under consideration.

### 3.2 BS 8233:2014 AND WHO

BS 8233:2014 *Guidance on sound insulation and noise reduction for buildings* gives absolute noise limits for steady state noise without a specific character (such as that from road traffic) inside residential properties as follows:
BS 8233 also provides guidelines for noise levels in residential gardens. It says:

*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 $L_{A_{eq,T}}$, with an upper guideline value of 55 dB $L_{A_{eq,T}}$ 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 development needs can be met, might be warranted. In such a situation, development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited.*

These guidelines are in keeping with “Guidelines for Community Noise” published by the World Health Organization, 1999.

### Table 1: Indoor ambient noise levels for dwellings

<table>
<thead>
<tr>
<th>Activity</th>
<th>Location</th>
<th>07:00 to 23:00</th>
<th>23:00 to 07:00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resting</td>
<td>Living room</td>
<td>35 dB $L_{Aeq,16hr}$</td>
<td>—</td>
</tr>
<tr>
<td>Dining</td>
<td>Dining room/area</td>
<td>40 dB $L_{Aeq,16hr}$</td>
<td>—</td>
</tr>
<tr>
<td>Sleeping (daytime resting)</td>
<td>Bedroom</td>
<td>35 dB $L_{Aeq,16hr}$</td>
<td>30 dB $L_{Aeq,8hr}$</td>
</tr>
</tbody>
</table>

### Table 2: WHO guideline values for community noise

The values in Table 2 need further elaboration. There is a variability in individual response to environmental noise, with some people being more noise-sensitive than others. The levels given for outdoor living areas are the noise level below which few people will be moderately/seriously annoyed; they do not represent an onset of moderate/serious annoyance for the general population. In effect, the levels protect the more sensitive section of the population. Likewise, the $L_{A_{max}}$ value is not the highest single noisy event that occurs during the night, but rather the WHO guidelines note *For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB $L_{A_{max}}$ more than 10 to 15 times per night.*

Also, the scope of the WHO document is wider than that of BS8233. Whereas BS8233 advises the guidelines are primarily intended for consideration of “anonymous noise” (which is not defined), WHO state that the guidelines relate to community noise, which is defined as all noise, including neighbourhood noise, and that *…typical neighbourhood noise comes from a range of noise sources including from premises and installations related to the catering trade (restaurant, cafeterias, discotheques, etc.); from live or recorded music, etc.*
$L_{Aeq,T}$ is the average noise level, measured over the time period $T$. BS8233 and WHO advise that the time period for the daytime should be a 16-hour average (07:00-23:00). The night period is defined as 23:00-07:00.

4. **AMBIENT NOISE SURVEY**

In order to support the assessment of the effect of noise on the proposed development, existing ambient noise levels at the site have been measured. Details of the measurement and analysis of noise across the site is described in following sections.

4.1 **SURVEY DATE, LOCATION AND EQUIPMENT**

Ambient noise measurements were carried out during a site survey between 14 and 17 November 2017. This survey consisted of unattended, fixed-position noise loggers at two locations on the subject site measuring noise in contiguous 5-minute periods.

Noise logger 1 was located close to the eastern site boundary approximately 15m from the edge of the A605 carriageway. The microphone was raised to a height of 4.5m above ground level. The location was not screened from noise on A605 (except by the strip of vegetation along the roadside which provides an insignificant amount of attention at higher frequencies).

Noise logger 2 was located on the south-western site boundary where the site borders the grounds of Prince William School. The microphone was raised to a height of 3m above ground level. At this location, the microphone was more distant from the A605 but again was partially screened from the A605 by the topography of the site and by vegetation around the boundary of the site. Both these measurement locations are shown on the site location plan in Appendix A.

The following equipment was used during the survey:

- Bruel & Kjaer Type 2250 Sound Level Meter s/n 2726905
- Bruel & Kjaer Type 4189 Microphone s/n 2710995
- Bruel & Kjaer Type 4231 Acoustic Calibrator s/n 2730220
- Bruel & Kjaer Type 2260 Sound Level Meter s/n 2311704
- Bruel & Kjaer Type 4189 Microphone s/n 2733049
- Bruel & Kjaer Type 4231 Acoustic Calibrator s/n 2688672
- Bruel & Kjaer Type ZC 0026 Preamplifier s/n

Before and after the survey, the sound level meters were field-calibrated in accordance with the manufacturer’s guidelines, and no significant drift was observed. The meters, microphones and field calibrators are laboratory calibrated biennially in accordance with UKAS procedures or to traceable National Standards.

4.2 **RESULTS**

The measurements from the fixed noise loggers have been summarised into contiguous 5 minute periods to present the noise profile throughout the monitoring period. Noise parameters consisted of equivalent continuous ($L_{Aeq}$) noise levels and statistical noise levels (termed $L_n$, where $n$ is the percentage of time the level is exceeded during the measurement period).
Overall band measurements were stored for later analysis. In addition maximum ($L_{A_{\text{max}}}$) noise levels were recorded in contiguous 5 minute periods. The results of the noise logger measurements are shown graphically in Appendix B.

The charts in Appendix B show noise levels that gradually increase during the morning, peaking during early morning rush hour; remaining consistent during the daytime, peaking again during evening rush hour; gradually decreasing throughout the evening and then dropping during the night-time. This is entirely consistent with a noise environment dominated by road traffic noise. This aligns with observations on site.

No audible activity from Hutchinson’s was observed at all during the two site visits carried out. Neither was any activity from Hutchinson’s identifiable from the measurements and recordings made throughout the 4 days of measurement. During site visits, it was observed that there were various activities generating noise at different premises within the adjacent commercial/industrial area, however none of this activity was not audible on the site.

The measured noise data was validated using weather data taken from Weather Underground$^1$ which provides historic measured weather data from thousands of personal and airport-based weather stations throughout the UK. Measurements of wind speed and direction at a number of locations within the local area were analysed and broadly consistent results were observed. These measurements were used to identifying prevailing wind direction and typical wind speeds on site to improve the accuracy of the prediction model.

The results of the noise logger measurements were then summarised into relevant daytime (07:00-23:00 hours) and night-time (23:00-07:00 hours) periods, coinciding with the widely agreed definitions. Daytime and night-time noise levels are determined by taking the typical $L_{A_{10,18\text{hr}}}$ measured in accordance with Calculation of Road Traffic Noise, Department of Transport and Welsh Office, 1988. These $L_{A_{10,18\text{hr}}}$ values are then converted to $L_{A_{\text{eq},16\text{hr}}}$ and $L_{A_{\text{eq},8\text{hr}}}$ levels using the conversion procedure (Method 3) in ‘Method for converting the UK road traffic noise index $L_{A_{10,18\text{hr}}}$ to the EU noise indices for road noise mapping (Defra 2006)’. The resultant levels are commensurate with the mean measured $L_{A_{\text{eq},\text{day}}}$ and $L_{A_{\text{eq},\text{night}}}$ across the measurement period.

Typical $L_{A_{\text{Fmax},\text{night}}}$ levels for each night were determined based on the 10-15th highest measured 5 minute $L_{A_{\text{Fmax}}}$ between 23:00 and 07:00 each night, in accordance with guidance in the WHO$^2$. The highest of these typical $L_{A_{\text{Fmax},\text{night}}}$ values was then used to represent the typical night-time $L_{A_{\text{Fmax}}}$.

Table 3 below summarises the measured daytime and night-time $L_{A_{\text{eq}}}$ levels and design $L_{A_{\text{max}}}$ levels.

<table>
<thead>
<tr>
<th>Noise metric</th>
<th>Noise Logger 1 – measured level (dB)</th>
<th>Noise logger 2 – measured level (dB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daytime $L_{A_{\text{eq}}}$</td>
<td>73</td>
<td>53</td>
</tr>
<tr>
<td>Night-time $L_{A_{\text{eq}}}$</td>
<td>64</td>
<td>45</td>
</tr>
<tr>
<td>Night-time $L_{A_{\text{max}}}$</td>
<td>83</td>
<td>60</td>
</tr>
</tbody>
</table>

Table 3: Summary of results of noise monitoring

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$^1$ Weather Underground is a subsidiary of The Weather Company and IBM. Weather data collected using Weather Underground API https://www.wunderground.com/weather/api/.

$^2$ The WHO “Guidelines for community noise” document states that, for a ‘good nights’ sleep, the $L_{A_{\text{max}}}$ level should not exceed 45 dB more than 10 to 15 times.
5. **ASSESSMENT OF NOISE AT PROPOSED RESIDENCES**

5.1 **NOISE PREDICTION MODEL**

In order to assess noise at site it is necessary to predict how noise propagates across the site.

5.1.1 Noise prediction methodology

Noise levels across the site are predicted using proprietary numerical noise modelling software (Predictor3). This software package meets the requirements of ISO 9613 Part 2:19964. The noise model takes account of the following in its calculations procedures:

- Source sound power level (for point, line and area sources)
- Reflection from nearby structures and source directivity
- Distance from noise source (geometric spreading)
- Atmospheric absorption
- Acoustic screening of intervening structures and topography
- Ground absorption
- Ground effects (which includes the height of ground relative to the noise source)

The accuracy of the predictions is maximised by validating predicted levels using the long-term measured at the two noise logger locations. Predicted levels were shown to be equal to measured levels (within measurement/modelling tolerances). This gives a high level of confidence in the accuracy of the predicted levels.

5.1.2 Results

The results of the noise prediction model show that noise levels across the site, particularly closer to the A605, are relatively high as a result of road traffic on the A605. Consequently, it is recommended that a 3m acoustic fence is installed to control noise from the A605. Accordingly, a 3m fence has been incorporated into the model. The requirements for the acoustic fence are outlined in Section 6.1.

Contour plots showing the predicted noise propagation across the site both in the daytime and night-time (with the acoustic fence in place) are included in Appendix D.

5.2 **INDOOR AMBIENT NOISE LEVELS**

In accordance with BS8233 and WHO, a significant factor in determining whether a development is acceptable is the predicted level of internal noise in the proposed dwellings. Based on the measured and predicted external noise levels, indicative calculations of intrusive noise into typical dwellings have been carried out. These calculations show expected internal noise levels in typical living rooms and bedrooms.

These calculations make assumptions about the size and construction of the building façade elements, as well as acoustic properties of the receiving room, such as the volume and reverberation time based on common dwellings. It is then possible to provide an indication of the level of mitigation (in terms of glazing and ventilation to habitable rooms) that will be required at this site to ensure that acceptable internal ambient levels are achieved.

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3 Bruel and Kjaer – Predictor ( Predictor-LimA) v11.00 Environmental Noise Calculation Software Package, Type 7810
Sound insulation data for the façade elements have been taken from sources such as standard data provided by BRE and DETR, Spectrum’s library of measurement data, calculations using Marshall Day’s Insul software as well as manufacturer’s data and the BRE/CIRIA publication ‘Sound Control for Homes’. Information regarding typical internal finishes for the type of rooms considered is based on acoustic properties Spectrum have measured in a range of occupied dwellings.

In the most noise-exposed areas of the site, for internal ambient noise levels inside habitable rooms to meet the BS8233 and WHO criteria with open windows, the external noise levels has to exceed the internal noise limits by no more than 10-15 dB. This is equivalent to an upper guideline level of $L_{Aeq, T}$ 50 dB during the daytime and $L_{Aeq, T}$ 45 dB during the night-time. As Table 3 shows, external noise levels exceed these levels across the majority of the site.

Consequently, two mitigation measures are recommended: an acoustic barrier on the site boundary and façade sound insulation measures to the dwellings. The recommended measures are detailed in Section 6 and require the use of closed windows and passive background ventilators to ensure sufficient ventilation. The façade sound insulation measures required are modest.

Calculations of intrusive noise into key habitable rooms in the most noise-exposed property are included in Appendix D. These calculations show that internal ambient noise levels are predicted to be below internal ambient noise level limits (taken from the BS8233 and WHO criteria) in the most noise-exposed properties, assuming the mitigation measures recommended below in Section 6 are incorporated. This is a good indication that any potential for adverse effect can be effectively mitigation and reduced such that no adverse effect is likely.

5.3 OUTDOOR AMENITY AREA NOISE LEVELS

The proposed scheme will provide external amenity space for each property. As noise levels are predicted to be relatively high across the site, a noise barrier on (or close to) the eastern site boundary has been recommended as a mitigation measure and incorporated into the noise prediction model.

As shown on the contour plots in Appendix D, external noise levels across the site with the noise barrier in place are predicted to range from around $L_{Aeq}$ 47 dB to around $L_{Aeq}$ 61 dB. Importantly, these predictions do not account for the further screening that many of the proposed properties will provide for each other. Once properties have been constructed on site, external noise levels in gardens are likely to reduce by an additional 5-10 dB across a large part of the site. This means that external noise levels in external amenity areas for most properties will be either below the lower WHO guideline level (which is also cited by BS8233 as a desirable level) or between the lower and upper WHO guideline levels (cited by BS8233 as acceptable).

However, for gardens at the most noise-exposed properties, namely those closest to the eastern site boundary, noise levels in gardens are predicted to be up to $L_{Aeq}$ 61 dB (although this will depend on the ultimate layout). Although this exceeds the upper WHO threshold and BS8233 upper guideline, BS8233 advises that 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. It goes on to recommend that in such circumstances: development should be designed to achieve the lowest practicable levels in these external amenity spaces, but should not be prohibited. In this case, as discussed, a large acoustic barrier is recommended in order to mitigate noise level as far as practicable.
In context of the whole site the import factors are that while a small percentage of garden areas may be exposed noise levels in excess of the guidelines, these have been reduced as far as possible. Furthermore, across the majority of the site, noise levels in gardens will meet the guidelines and in areas which benefit from significant screening and are more distant from the A605, noise levels will meet the lower, desirable guideline criteria. In addition, with the recommended noise barrier in place it will be straightforward to achieve acceptable internal ambient noise levels in all properties across the site without having to resort to excessively high acoustic glazing or ventilation systems.

In summary then, although there may be exceedances in some areas, measures have been incorporated to reduce noise levels in external amenity areas as far as reasonably practicable and guideline levels will be met across the majority of the site.

6. PROPOSED MITIGATION MEASURES

6.1 ACOUSTIC FENCE

In to ensure that noise levels are reduced as far as possible in external amenity areas Spectrum recommend that acoustic fencing is installed along (or close to) the eastern site boundary. This acoustic fence should have the following properties:

- 3m (or greater) in height
- No holes or penetrations
- A surface density of at least 10 kg/m²

These requirements can readily be met with common approaches to fencing, for example a close-boarded timber fence. The fencing should be installed in the locations shown on the marked up drawing included in Appendix C.

In lieu of a fence, it will also be possible to incorporate a bund of equivalent height, or a combination of both these elements to the same total height.

6.2 FAÇADE ACOUSTIC SPECIFICATION

As the calculations in Appendix E demonstrate, double glazing with a minimum performance of $R_{w(Cr)} \geq 38(-6)$ dB coupled with standard hit-and-miss trickle vents with a minimum performance of $D_{h,e,w(Cr)} \geq 32(0)$ dB will provide sufficient sound insulation to ensure the guideline levels for internal ambient noise in habitable rooms (in line with BS8233 and WHO) are achieved in all properties across the development.

Glazing and trickle ventilation systems must be selected to meet these performance requirements. It is also important to note that the standard for glazing applies to the whole window or, if applicable, sliding or hinging door, including frames and seals. Typically to meet an acoustic performance standard of $R_{w(Cr)} \geq 38(-6)$ dB, glazing with a build-up of 10/12/6 will suffice. Similarly, there are a number of common window-frame mounted trickle vent products which will achieve $D_{h,e,w(Cr)} \geq 32(0)$ dB. These performance standards can be issued to suppliers who will be able to provide systems which meet the requirements.
The acoustic requirements for each window or glazed door are specified in terms of both the $R_w$ and the $R_w + C_r$ performance standards. $R_w$ is the standard weighted sound reduction of a façade element. $R_w + C_r$ (which is sometimes written as $R_{tra}$) is the weighted sound reduction of a façade element with respect to road traffic noise. Both performance requirements listed here are required to be met or exceeded by the selected glazing system. Similarly with the ventilation requirement the value in parentheses is the $D_{n,e,w} + C_{tr}$ performance standard. The selected ventilation system must meet both performance values.

7. CONCLUSION

Persimmon Homes have commissioned Spectrum Acoustic Consultants to complete a noise impact assessment to accompany an application for outline planning permission for a proposed residential development at land between St Christopher’s Drive and A605 Oundle Bypass, Oundle.

Road traffic noise is the dominant noise source at the proposed development site. Using measured noise levels on site noise levels as a basis, noise levels across the site have been predicted using computer noise modelling software. Internal ambient noise levels inside a sample dwelling have been calculated based on the predicted external noise levels.

The assessment demonstrates that it will be possible for internal ambient noise levels to meet the guideline levels in BS8233 and WHO Guidelines for Community Noise through a series of noise mitigation measures in the form of uprated glazing systems and passive vents.

Overall, this report demonstrates that, with appropriate noise mitigation measures in place, a significant adverse noise impact on the proposed development is unlikely.
APPENDIX A

Site location plan showing measurement positions
APPENDIX B

Chart showing measured noise levels
Noise levels at location 1: Logger on eastern site boundary, near A605 (14 to 17 November 2017)

LAeq (dB)  LA90 (dB)  LAFMax (dB)

Tue 14 Nov              |                                        Wed 15 Nov |                                      Thur 16 Nov                                      |  Fri 17 Nov
Noise levels at location 2: Logger on southern site boundary, bordering Prince William School grounds (14 to 17 November 2017)
APPENDIX C

Site location plan showing recommended noise barrier location
APPENDIX D

Contour plots showing noise across the site
APPENDIX E

Calculations of intrusive noise
Estimation of the indoor ambient noise level in a room based on the external noise levels and façade sound insulation taken from equations in Section 6.7.2.1 of BS8233:1999

\[
L_{\text{internal}} = L_{\text{external}} - \Sigma R + 10 \log S + 10 \log T - 10 \log 0.163V + 3 + C
\]

Where:
- \(L_{\text{internal}}\) - estimated indoor reverberant sound pressure level
- \(L_{\text{external}}\) - measured external sound pressure level (LAeq, 16hr) - i.e. the design external LAeq
- \(C\) - correction factor to convert the measured external sound pressure level to 'free field' (6dB for measurements within millimetres of the façade, 3dB for measurements 2m from the façade)
- \(\Sigma R\) - overall sound reduction of the façade
- \(T\) - reverberation time inside the room in question
- \(V\) - volume of the room in question

### Estimation of Indoor Noise Level

**External Noise Spectral Data**

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
<th>8k</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAeq, 16hr</td>
<td>60</td>
<td>59</td>
<td>55</td>
<td>55</td>
<td>59</td>
<td>58</td>
<td>43</td>
<td>28</td>
</tr>
<tr>
<td>Façade Correction Factor, C</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

**Reduction of façade elements**

Double glazing (e.g. 10/12/6) Rw(Ctr) 38(-6)dB

<table>
<thead>
<tr>
<th>Area: 6 m²</th>
<th>R: 20 26 27 34 40 38 46 44</th>
</tr>
</thead>
</table>

Brick and block external wall

<table>
<thead>
<tr>
<th>Area: 30.0 m²</th>
<th>R: 34 40 44 45 51 56 60 63</th>
</tr>
</thead>
</table>

Hit and miss trickle vent (Dnew+Ctr 32 dB)

<table>
<thead>
<tr>
<th>Number of: 2</th>
<th>Dnew: 30 38 37 34 30 34 37 46</th>
</tr>
</thead>
</table>

**Room Data**

Living Room Reverberation Time

| 0.6 | 0.6 | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.3 |

Total Façade Area

| 36.0 m² |

Room Volume

| 36.0 m³ |

**Overall sound reduction of the facade**

Combined sound reduction

| 25.9 | 32.3 | 33.2 | 35.0 | 32.4 | 36.0 | 39.4 | 46.8 |

**Estimated Indoor Noise Level**

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
<th>63</th>
<th>125</th>
<th>250</th>
<th>500</th>
<th>1k</th>
<th>2k</th>
<th>4k</th>
<th>8k</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated Indoor Noise Level</td>
<td>34</td>
<td>41</td>
<td>31</td>
<td>29</td>
<td>32</td>
<td>33</td>
<td>14</td>
<td>0</td>
</tr>
</tbody>
</table>
Estimation of the indoor ambient noise level in a room based on the external noise levels and façade sound insulation taken from equations in Section 6.7.2.1 of BS8233:1999

\[ L_{\text{internal}} = L_{\text{external}} - \Sigma R + 10 \log S + 10 \log T - 10 \log 0.163V + 3 + C \]

Where:
- \( L_{\text{internal}} \) - estimated indoor reverberant sound pressure level
- \( L_{\text{external}} \) - measured external sound pressure level (\( L_{\text{Aeq}}, 8\text{hr} \)) - i.e. the design external \( L_{\text{Aeq}} \)
- \( C \) - correction factor to convert the measured external sound pressure level to ‘free field’ (6dB for measurements within millimetres of the façade, 3dB for measurements 2m from the façade)
- \( \Sigma R \) - overall sound reduction of the facade
- \( T \) - reverberation time inside the room in question
- \( V \) - volume of the room in question

### External Noise Spectral Data

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
<th>63</th>
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<th>2k</th>
<th>4k</th>
<th>8k</th>
</tr>
</thead>
<tbody>
<tr>
<td>LAeq, 8hr</td>
<td>51</td>
<td>50</td>
<td>44</td>
<td>47</td>
<td>51</td>
<td>49</td>
<td>34</td>
<td>19</td>
</tr>
<tr>
<td>Façade Correction Factor, C</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

### Reduction of façade elements

<table>
<thead>
<tr>
<th>Component</th>
<th>Area (m²)</th>
<th>R: 20</th>
<th>26</th>
<th>27</th>
<th>34</th>
<th>40</th>
<th>38</th>
<th>46</th>
<th>44</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double glazing (e.g. 10/12/6) Rw(Ctr) 38(-6)dB</td>
<td>2</td>
<td>20</td>
<td>26</td>
<td>27</td>
<td>34</td>
<td>40</td>
<td>38</td>
<td>46</td>
<td>44</td>
</tr>
<tr>
<td>Brick and block external wall</td>
<td>10.0</td>
<td>34</td>
<td>40</td>
<td>44</td>
<td>45</td>
<td>51</td>
<td>56</td>
<td>60</td>
<td>63</td>
</tr>
<tr>
<td>Hit and miss trickle vent (Dnew+Ctr 32 dB)</td>
<td>2</td>
<td>30</td>
<td>38</td>
<td>37</td>
<td>34</td>
<td>30</td>
<td>34</td>
<td>37</td>
<td>46</td>
</tr>
</tbody>
</table>

### Room Data

<table>
<thead>
<tr>
<th></th>
<th></th>
<th>0.4</th>
<th>0.5</th>
<th>0.4</th>
<th>0.4</th>
<th>0.3</th>
<th>0.3</th>
<th>0.3</th>
<th>0.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedroom Reverberation Time</td>
<td></td>
<td>12.0</td>
<td>m²</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Façade Area</td>
<td></td>
<td>24.0</td>
<td>m³</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Overall sound reduction of the facade

<table>
<thead>
<tr>
<th>Combined sound reduction</th>
<th>24.4</th>
<th>31.2</th>
<th>31.6</th>
<th>31.2</th>
<th>27.7</th>
<th>31.6</th>
<th>34.7</th>
<th>43.1</th>
</tr>
</thead>
</table>

### Estimated Indoor Noise Level

<table>
<thead>
<tr>
<th>Octave Band Centre Frequency (Hz)</th>
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<tbody>
<tr>
<td>Estimated Indoor Noise Level dB(A)</td>
<td>25</td>
<td>30</td>
<td>17</td>
<td>19</td>
<td>23</td>
<td>24</td>
<td>5</td>
<td>0</td>
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Estimation of the indoor ambient noise level in a room based on the external noise levels and façade sound insulation taken from equations in Section 6.7.2.1 of BS8233:1999

\[ L_{\text{internal}} = L_{\text{external}} - \Sigma R + 10 \log S + 10 \log T - 10 \log 0.163V + 3 + C \]

Where:

- \( L_{\text{internal}} \) - estimated indoor reverberant sound pressure level
- \( L_{\text{external}} \) - measured external sound pressure level (LAFMax) - i.e. the design external LAFMax
- \( C \) - correction factor to convert the measured external sound pressure level to 'free field' (6dB for measurements within millimetres of the façade, 3dB for measurements 2m from the façade)
- \( \Sigma R \) - overall sound reduction of the facade
- \( T \) - reverberation time inside the room in question
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External Noise Spectral Data

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</tr>
</thead>
<tbody>
<tr>
<td>LAFMax</td>
<td>70</td>
<td>72</td>
<td>66</td>
<td>68</td>
<td>70</td>
<td>65</td>
<td>50</td>
<td>35</td>
</tr>
</tbody>
</table>

Façade Correction Factor, C

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<th>4k</th>
<th>8k</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
</tbody>
</table>

Reduction of façade elements

Double glazing (e.g. 10/12/6) Rw(Ctr) 38(-6)dB

| Area: 2 m² | R: 20 | 26 | 27 | 34 | 40 | 38 | 46 | 44 |

Brick and block external wall

Area: 10.0 m²

| R: 34 | 40 | 44 | 45 | 51 | 56 | 60 | 63 |

Hit and miss trickle vent (Dnew+Ctr 32 dB)

| Number of: 2 |
| Dnew: 30 | 38 | 37 | 34 | 30 | 34 | 37 | 46 |

Room Data

| Bedroom Reverberation Time | 0.4 0.5 0.4 0.4 0.3 0.3 0.3 0.2 |
| Total Façade Area | 12.0 m² |
| Room Volume | 24.0 m³ |

Overall sound reduction of the façade

| Combined sound reduction | 24.4 31.2 31.6 31.2 27.7 31.6 34.7 43.1 |

Estimated Indoor Noise Level

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</tr>
</thead>
<tbody>
<tr>
<td>Estimated Indoor Noise Level</td>
<td>43</td>
<td>52</td>
<td>40</td>
<td>40</td>
<td>43</td>
<td>40</td>
<td>21</td>
<td>3</td>
</tr>
</tbody>
</table>