APPENDIX 6

SOUND SURVEY REPORT

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Assessment of railway noise and vibration

affecting proposed houses

on land at South Worple Way, East Sheen

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1. INTRODUCTION

1.1 A development of five houses is proposed on land at South Worple Way, East Sheen which is currently occupied by a row of garages. The site is alongside a railway line, and consequently this assessment of noise and vibration from the railway has been commissioned.

1.2 Reference is made to current planning policy and guidelines to determine the suitability of the site for residential use in view of the railway noise and vibration levels. Where appropriate, mitigation measures are proposed.

2. NATIONAL PLANNING POLICY

2.1 The February 2019 National Planning Policy Framework describes how noise should be taken into account when determining planning applications. At paragraph 170(e) it states, "Planning policies and decisions should contribute to and enhance the natural and local environment by … preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of … noise pollution".

2.2 The 2010 Noise Policy Statement for England utilises two established concepts from toxicology that are currently being applied to noise impacts, for example, by the World Health Organisation. They are:

- NOEL – No Observed Effect Level. Below this level, there is no detectable effect on health and quality of life due to the noise.
- LOAEL – Lowest Observed Adverse Effect Level. This is the level above which adverse effects on health and quality of life can be detected.

2.3 The NPSE extends these to the concept of a

- SOAEL – Significant Observed Adverse Effect Level. This is the level above which significant adverse effects on health and quality of life occur.

2.4 The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development. The NPSE states that it is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times. The NPSE acknowledges that further research is required to increase understanding of what may constitute a significant adverse impact on health and quality of life from noise.

2.5 The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL and SOAEL. It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur.

2.6 The adverse effect levels are described in more detail in the DCLG Planning Practice Guidance as follows:

At the lowest extreme, when noise is not noticeable, there is by definition no effect. As the noise exposure increases, it will cross the no observed effect level as it becomes noticeable. However, the noise has no adverse effect so long as the exposure is such that it does not cause any change in behaviour or attitude. The noise can slightly affect the acoustic character of an area but not to the extent there is a perceived change in quality of life. If the noise exposure is at this level no specific measures are required to manage the acoustic environment.

As the exposure increases further, it crosses the lowest observed adverse effect level boundary above which the noise starts to cause small changes in behaviour and attitude, for example, having to turn up the volume on the television or needing to speak more loudly to be heard. The noise therefore starts to have an adverse effect and consideration needs to be given to mitigating and minimising those effects (taking account of the economic and social benefits being derived from the activity causing the noise).

Increasing noise exposure will at some point cause the significant observed adverse effect level boundary to be crossed. Above this level the noise causes a material change in behaviour such as keeping windows closed for most of the time or avoiding certain activities during periods when the noise is present. If the exposure is above this level the planning process should be used to avoid this effect occurring, by use of appropriate mitigation such as by altering the design and layout. Such decisions must be made taking account of the economic and social benefit of the activity causing the noise, but it is undesirable for such exposure to be caused.

At the highest extreme, noise exposure would cause extensive and sustained changes in behaviour without an ability to mitigate the effect of noise. The impacts on health and quality of life are such that regardless of the benefits of the activity causing the noise, this situation should be prevented from occurring.

2.7 The DCLG Planning Practice Guidance provides the following table which summarises 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
		Lowest Observed Adverse Effect Level	
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.	Observed Adverse Effect	Mitigate and reduce to a minimum
		Significant Observed Adverse Effect Level	
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	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

3. WORLD HEALTH ORGANISATION (WHO) GUIDELINES

3.1 The 1999 WHO "Guidelines for Community Noise" recommend noise levels indoors of 35 dB $L_{Aeq,\ 16\ hour}$ during the day to prevent moderate annoyance, and 30 dB $L_{Aeq,\ 8\ hours}$ in bedrooms at night to avoid sleep disturbance. The guidelines also note that, for noise which is not continuous at night, it is important to limit the number of noise events exceeding 45 dB $L_{Amax,\ fast}$ since sleep disturbance from intermittent noise events increases with the maximum level. Even if the total equivalent level (L_{Aeq}) is fairly low, the number of noise events with a high maximum sound pressure level will affect sleep.

3.2 The guidelines assume the noise reduction through a bedroom window that is open for ventilation will be 15 dB, and consequently set guidelines for noise levels outside an open bedroom window of 45 dB $L_{Aeq,\ 8\ hour}$, with intermittent noise events not exceeding 60 dB $L_{Amax,fast}$.

4. BRITISH STANDARD BS 8233: 2014

4.1 British Standard BS 8233 gives recommendations for the control of noise in and around buildings, and suggests appropriate limits and criteria for different situations. The criteria and limits are intended to guide the design of new buildings, and refurbished buildings undergoing a change of use.

4.2 It sets similar internal noise guidelines to the World Health Organisation, i.e. 35 dB $L_{Aeq,\ 16\ hour}$ for the daytime (living rooms and bedrooms) and 30 dB $L_{Aeq,\ 8\ hour}$ at night (bedrooms). For dining rooms a higher guideline value of 40 dB $L_{Aeq,\ 16\ hour}$ is set. Where development is considered necessary or desirable, despite external noise levels above WHO guidelines, the internal target levels may be relaxed by up to 5 dB and reasonable internal conditions still achieved.

4.3 BS 8233 notes that regular individual noise events (for example passing trains) can cause sleep disturbance and may require a guideline value in terms of SEL or $L_{Amax,fast}$ depending on the character and number of events at night.

4.4 If relying on closed windows to meet the guide values, there needs to be appropriate alternative ventilation that does not compromise the facade insulation or the resulting noise level.

4.5 For traditional external areas that are used for amenity space, such as gardens and patios, according to BS 8233 it is desirable that the external noise level does not exceed 50 dB L_{Aeq}, with an upper guideline value of 55 dB L_{Aeq} 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.

5. GROUND VIBRATION CRITERIA

5.1 Guidelines for the measurement and assessment of groundborne noise and vibration published by the Association of Noise Consultants (ANC) in 2001, and revised in 2012, have been followed for this assessment. They include reference to BS 6472: 2008 which is the British Standard concerned with the likelihood of complaints due to groundborne vibration affecting residential buildings. BS 6472 defines levels of vibration dose value VDV, reaching the occupants of a building, at which there is a low probability of adverse comment as follows:

Day 7 am to 11 pm	0.2 to 0.4 $ms^{-1.75}$ VDV
Night 11 pm to 7 am	0.1 to 0.2 $ms^{-1.75}$ VDV

5.2 Excitation of a building structure by groundborne vibration will also cause noise to be radiated inside a building (this is normally referred to as groundborne noise). The assessment of adverse comment in BS 6472 does not take account of this, so a separate consideration of this effect is needed. There are no relevant UK or international standards, but recent major railway infrastructure projects (the Jubilee Line extension, Thameslink, HS1 and Crossrail) have all adopted a design criterion for groundborne noise in residential properties of 40 dB $L_{Amax, slow}$.

6. ProPG: PLANNING AND NOISE

6.1 Professional practice guidance on planning and noise was published jointly by the Association of Noise Consultants, the Institute of Acoustics and the Chartered Institute of Environmental Health in May 2017. It has been produced to provide practitioners with guidance on a recommended approach to the management of noise within the planning system in England, where new residential development is exposed to noise that is predominantly from transport sources.

6.2 The recommended approach has two stages. The first is an initial risk assessment of the proposed development site. The second is a full assessment taking in the following elements:

Element 1 – Good Acoustic Design Process
Element 2 – Internal Noise Level Assessment
Element 3 – External amenity area noise assessment
Element 4 – Assessment of other relevant issues

6.3 The process leads to a choice of one of four possible recommendations which are to grant without conditions, to grant with conditions, to refuse due to significant adverse effects unless there are other over-riding planning reasons to grant permission, or to prevent due to unacceptable adverse effects.

6.4 The approach is underpinned by the preparation of an Acoustic Design Statement, which is set out in the following sections of this report.

7. SITE SURVEY – AIRBORNE NOISE

7.1 A survey has been carried out of the noise levels at the site caused by the passing trains, over a 24 hour period commencing at noon on Monday 26th November 2018. Weather conditions were suitable, being cloudy with a light wind of less than 10 mph from the north.

7.2 The measurement position was at the edge of the roof of one of the garages currently situated on the site, as marked on the site plan in Figure 1. This happens to be one of the garages which is to remain under the proposed scheme, chosen because it was not in use. It is a similar distance from the railway as the garages which are to be replaced by housing. A list of instrumentation used in the survey is at Appendix 1. The equipment has its calibration checked annually, traceable to national reference standards.

7.3 The L_{Aeq} noise levels were measured on an hour-by-hour basis and are listed in Table 1. The hourly L_{Aeq} noise levels have been used to calculate the overall day (7 a.m. to 11 p.m.) and night (11 p.m. to 7 a.m.) L_{Aeq} noise levels. Additional data is listed stating the instantaneous maximum noise levels ($L_{Amax,\ fast}$) and the statistical noise levels L_{A10}, L_{A50} and L_{A90} (respectively the values exceeded for 10%, 50% and 90% of the time) for each hour. Also, in Figures 2a to 2c the instantaneous maximum noise levels $L_{Amax,\ fast}$ are plotted second by second for the night time.

7.4 At the measurement position the free field daytime noise level is 69.8 dB $L_{Aeq,\ 16\ hour}$ and the free field noise level at night is 65.6 dB $L_{Aeq,\ 8\ hour}$.

7.5 According to the ProPG guidance the assessment of the $L_{Amax,\ fast}$ noise levels affecting bedrooms at night should be based on the level not exceeded more than ten times in a night. From Figures 2a to 2c it is apparent that this is 90 dB $L_{Amax,\ fast}$ free field at the measurement position.

7.6 These airborne noise levels are high enough to require mitigation, which is considered in section 9 of this report.

8. SITE SURVEY – GROUND VIBRATION

8.1 Vibration levels were measured on the floor of the same garage that was used for the noise survey (see Figure 1). The vibration sensor (accelerometer) was stud-mounted to a steel block which was in turn secured with Araldite adhesive to the concrete garage floor. It was located alongside the back wall of the garage, i.e. the wall nearest the railway.

8.2 Weighted acceleration levels (b and d weightings as defined in BS 6472) were measured in three mutually perpendicular planes, using a high sensitivity triaxial accelerometer stud-mounted onto a steel block, attached by adhesive to an existing concrete ground slab. The instrumentation is listed at Appendix 1. It measures the actual vibration dose vales VDV_b and VDV_d as defined in the current edition of the standard by filtering and integration of the vibration signal, as distinct from using estimation methods which were permitted by past editions of the standard.

8.3 The vibration dose value (VDV) was measured for individual trains as they passed. The total VDV for the whole day and night periods has then been calculated by taking the VDV for each train and factoring it up according to the number of trains passing in the full day and night periods. The numbers of trains have been counted from the detailed second by second records from the noise survey.

8.4 The vibration dose values for each train that was measured (taking the highest of the three measurement directions), and the calculation of the overall vibration dose values for the whole day and night periods, are set out in Table 1. The overall vibration dose values are 0.118 $m/s^{1.75}$ VDV during the day and 0.075 $m/s^{1.75}$ VDV during the night. These are just short of the levels at which BS 6472 indicates a low probability of adverse comment, which are 0.2 $m/s^{1.75}$ VDV during the day and 0.1 $m/s^{1.75}$ VDV during the night.

8.5 These calculations of vibration dose value are based on the measured vibration on the garage floor, at the closest position of the proposed buildings to the railway. A masonry building would have greater mass and therefore would vibrate less than the garage floor that was measured. Also the building's exposure to vibration will be lower at the parts of its foundations that are further from the track than the measurement position. Offset against this there will be amplification due to resonances in the building structure which can add around 5 dB for a well-damped masonry construction, for the vibration reaching the internal floors of the building. So on balance the measured ground vibration values are representative of the vibration expected in the building but with some uncertainty introduced by the possible variations of the soil / foundation interaction and building response.

8.6 Groundborne noise levels were predicted by integrating the vibration signal to give vibration velocity, then A-weighting the signal, and finally applying the empirical formula taken from the ANC guidelines:

$$L_p = L_v - 32 \text{ dB}$$

where L_p is the sound pressure level and L_v is the rms vibration velocity in dB relative to 10^{-9} m/s. The resulting values are included in Table 2.

8.7 The groundborne noise levels were typically 39 to 46 dB $L_{Amax, slow}$ for most trains. The two worst trains out of the 32 that were measured had levels just above 50 dB $L_{Amax, slow}$. It is apparent that the 40 dB $L_{Amax,slow}$ design criterion for groundborne noise at night will be exceeded by most trains. This is high enough to require mitigation, which is considered in section 10 of this report.

9. MITIGATION MEASURES – AIRBORNE NOISE

9.1 External noise levels in the garden / amenity areas to the sides of the proposed houses have been calculated using Soundplan, which is proprietary computer software for calculating noise transmission implementing the Department for Transport “Calculation of Railway Noise 1995” method. The computer model has been calibrated to correspond with the measured noise level in the site survey, and then extrapolates that value across the full site taking into account the shielding effect of the proposed buildings, and the proposed wall along the boundary of each garden to the railway.

9.2 It is proposed that each garden wall to the railway will be 2.5 metres high, and that it will be continued along the east boundary of the site at 2 metres high as far as the front elevation of the existing neighbouring house.

9.3 The result of this calculation is at Figure 3. The proposed barriers achieve noise levels that comply with the 55 dB $L_{Aeq,\ 16\ hour}$ upper guideline value for garden / amenity areas over more than half of the garden of each house. Only the rearmost part of the garden nearest the railway exceeds the criterion, by no more than 2 dB.

9.4 With regard to internal noise, the design targets set by British Standard BS 8233:2014 and the WHO guidelines depend on the use of the room are summarised as follows:

35 dB $L_{Aeq,\ 16\ hour}$ daytime in living rooms and bedrooms
40 dB $L_{Aeq,\ 16\ hour}$ daytime in dining rooms
30 dB $L_{Aeq,\ 8\ hour}$ and 45 dB $L_{Amax,\ fast}$ in bedrooms at night

9.5 The external daytime $L_{Aeq,\ 16\ hour}$ noise levels at the façades of the houses, at ground and first floor window height, have been calculated using the Soundplan model and are shown in Figure 4. The $L_{Aeq,\ 8\ hour}$ noise levels at night will be 4.2 dB lower than these values. Instantaneous maximum $L_{Amax,\ fast}$ noise levels at night have also been calculated, for the first floor window height, and these are shown in Figure 5.

9.6 The houses have been designed without any windows on the façade directly facing the railway. The highest noise level at a noise-sensitive window is the bedroom 2 window in Plots 1 to 4 with a sideways aspect to the railway, where the noise level is in the range 67.8 to 68.2 dB $L_{Aeq,\ 16\ hour}$.

9.7 Table 3 indicates how the required sound insulation might be achieved for the living room of Plot 4 (the others are similar). The glazed doors to the garden are quite well shielded by the rear garden wall, and as a result standard double glazing is adequate.

9.8 Tables 4a and 4b indicate how the required sound insulation might be achieved for bedroom 2 which is the nearest to the railway in each plot. The calculation uses Plot 4 as an example and Plots 1 to 3 are similar. Plot 5 has no window at the side so is less critical for noise. The requirements are driven by the 45 dB $L_{Amax,\ fast}$ criterion, rather than 30 dB $L_{Aeq,\ 8\ hour}$ which is less stringent in the circumstances at this site.

9.9 For bedroom 2 the following indicative measures are arrived at:

- An acoustic grade of glazing for the side window comprising a Pilkington Optiphon unit of 8.8 mm Optiphon and 12.8 mm Pilkington Optiphon separated by a 16 mm argon gap. A data sheet for Pilkington Optiphon is at Appendix 3.
- An acoustic lining such as Gyproc GypLyner IWL to the rear external cavity wall.

- For the roof and ceiling above the bedroom, a ceiling comprising a triple layer of 15 mm Gyproc SoundBloc or other similar high-density plasterboard with staggered joints, at least 100mm of mineral wool laid above the ceiling, and a tiled roof.

9.10 The noise from the railway is such that all the windows of living rooms and bedrooms need to be closed, to achieve the WHO guideline for the noise level outside an open bedroom window at night. So a ventilation system is required that does not rely on opening windows. This could be either System 3 (MEV - mechanical extract ventilation) or System 4 (MVHR - mechanical ventilation with heat recovery) in Approved Document F of the Building Regulations.

9.11 MEV has continuously running low rate fan extraction from kitchens and bathrooms, with higher speeds selectable by the residents as required. Intake air is drawn through passive ventilation slots normally of size 2500 mm^2 in the window frames of each living room and bedroom. These ventilation slots will need to be in the front windows of each room, not the side or the rear facing the railway. The ingress of sound through these slots is included in the sound insulation calculations of Tables 3, 4a and 4b.

9.12 MVHR has separate supply and extract fans both contained within a loft or cupboard-mounted unit which includes a heat exchanger, to transfer warmth from the extracted air to the incoming air. The heat exchanger is bypassed in summer when unheated incoming air is desirable. The extraction is ducted from the kitchen and bathrooms, and the incoming air is ducted to the living rooms and bedrooms. Normally silencers are need in the intake ducts to control the level of fan noise reaching the living rooms and bedrooms. Some manufacturers such as Nuaire (see Appendix 3) offer systems that have the silencers built-in.

10. MITIGATION MEASURES – GROUND VIBRATION

10.1 Most of the trains passing at night, of which there were 43 between 23:00 and 07:00 hours during the survey, are likely to cause groundborne noise levels above the 40 dB $L_{Amax,slow}$ design criterion with the worst case predicted to exceed this by just over 10 dB. This would be likely to cause sleep disturbance and it is therefore necessary to isolate the building from the ground vibration by supporting it on resilient bearings.

10.2 The requirement for this mitigation also comes about to a lesser extent by the analysis of vibration dose value in the building. The measured values are just short of the level at which adverse comment might be triggered, but with some uncertainty introduced by the possible variations of the soil / foundation interaction and building response. The vibration dose value alone would be marginal for requiring the use of resilient structural bearings but in combination with the $L_{Amax, slow}$ values at night the need is clear.

10.3 The isolation of buildings from ground vibration has been used as a construction method for about 40 years. The selection of elastomeric bearings for vibration isolation of buildings was formalised by a British Standard, BS 6177, as long ago as 1982. It is a well-established technique. Tico CV/M structural bearings are suited to this type of application, and manufacturer's data is reproduced at Appendix 4 of this report.

10.4 On the fifth page of the Tico data sheets there is a graph showing the transmissibility of the CV/M bearings. This graph is the result of analysing the combination of a mass (i.e. the building) sitting on a spring (the resilient structural bearing) as a simple single-degree-of-freedom vibration system and serves to illustrate the principles behind vibration isolation.

10.5 The natural frequency F_n of the building on its resilient bearings is determined by the relationship

$$F_n = {}^{1}/_{2\pi} \sqrt{k/m}$$

where k is the stiffness of the bearing and m is the mass of the building. Typically in a case of railway vibration the bearings will be selected to give a natural frequency F_n of about 15 Hz.

10.6 The ground vibration measured at this site peaked at frequencies around 30 to 50 Hz. At this vibration frequency an isolation system with a 15 Hz natural frequency will, from the single-degree-of-freedom model, attenuate the vibration by 10 to 20 dB. This amount of isolation would bring the groundborne noise inside the building to within the 40 dB $L_{Amax,slow}$ design criterion.

11. SUMMARY

11.1 The railway noise and vibration levels affecting the proposed building are sufficiently high that mitigation is required. The anticipated mitigation measures comprise a 2.5 metre solid wall at the rear of each garden to the railway, a 2 metre wall at the east boundary, an acoustic grade of glazing for bedroom windows with a sideways aspect to the railway (none directly face it), an acoustic lining to the bedroom walls on the railway side of the building, and an acoustic grade of roof / ceiling above the top floor rooms. Mechanical ventilation is required as the sound insulation scheme relies on windows being closed. If this includes passive intake ventilation slots they shall be at the front of the building facing away from the railway.

11.2 With regard to vibration, the building needs to be isolated from the ground using resilient structural bearings.

11.3 It is concluded that, subject to these mitigation measures which could be secured by planning conditions, the railway noise and vibration levels would be acceptable for the proposed residential development.

FIGURE 1: Site location plan, and measurement position for noise and vibration

Based on the site survey by OSP Architecture.

FIGURE 2a: Night LAmax noise levels

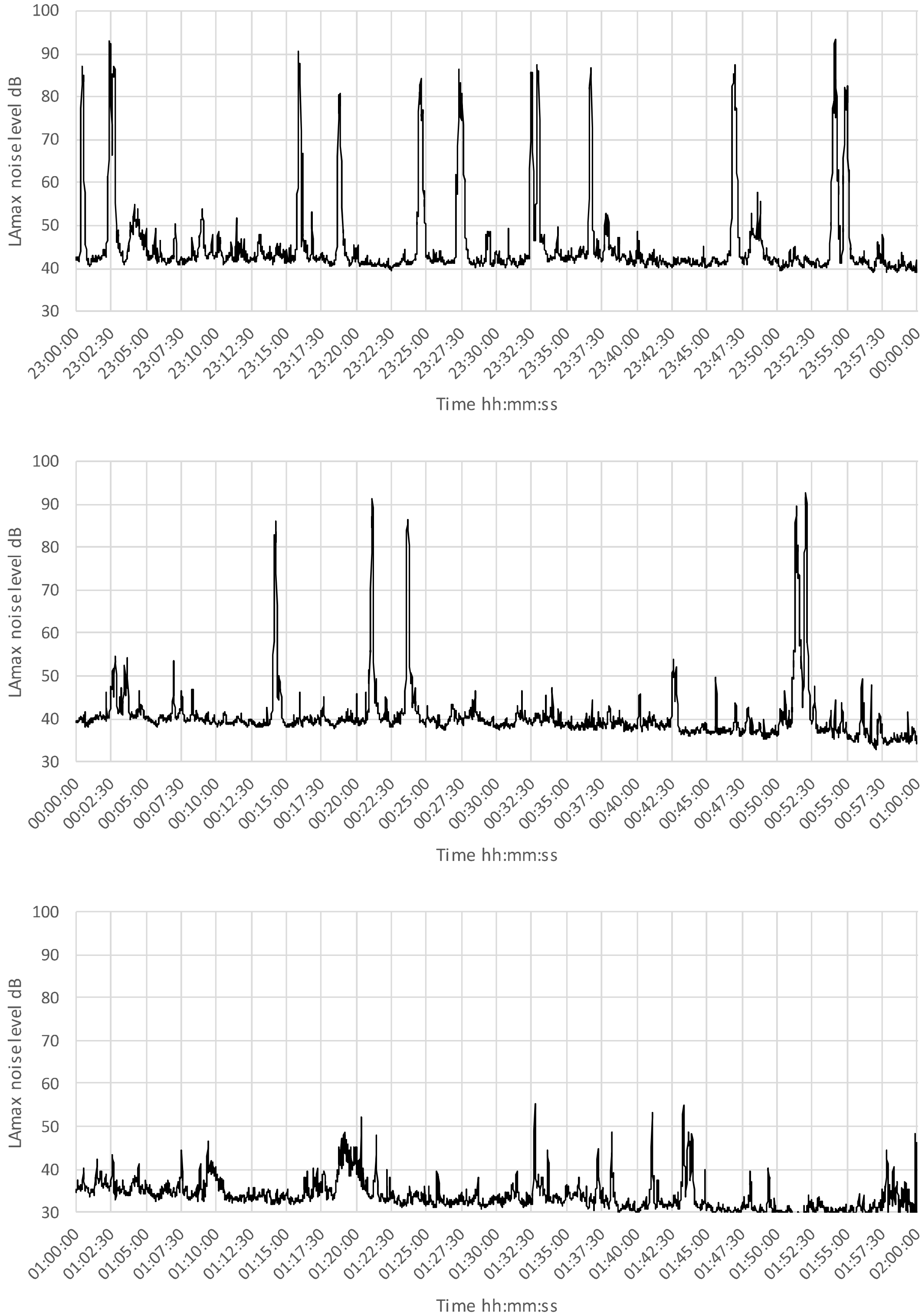


FIGURE 2b: Night LAmax noise levels

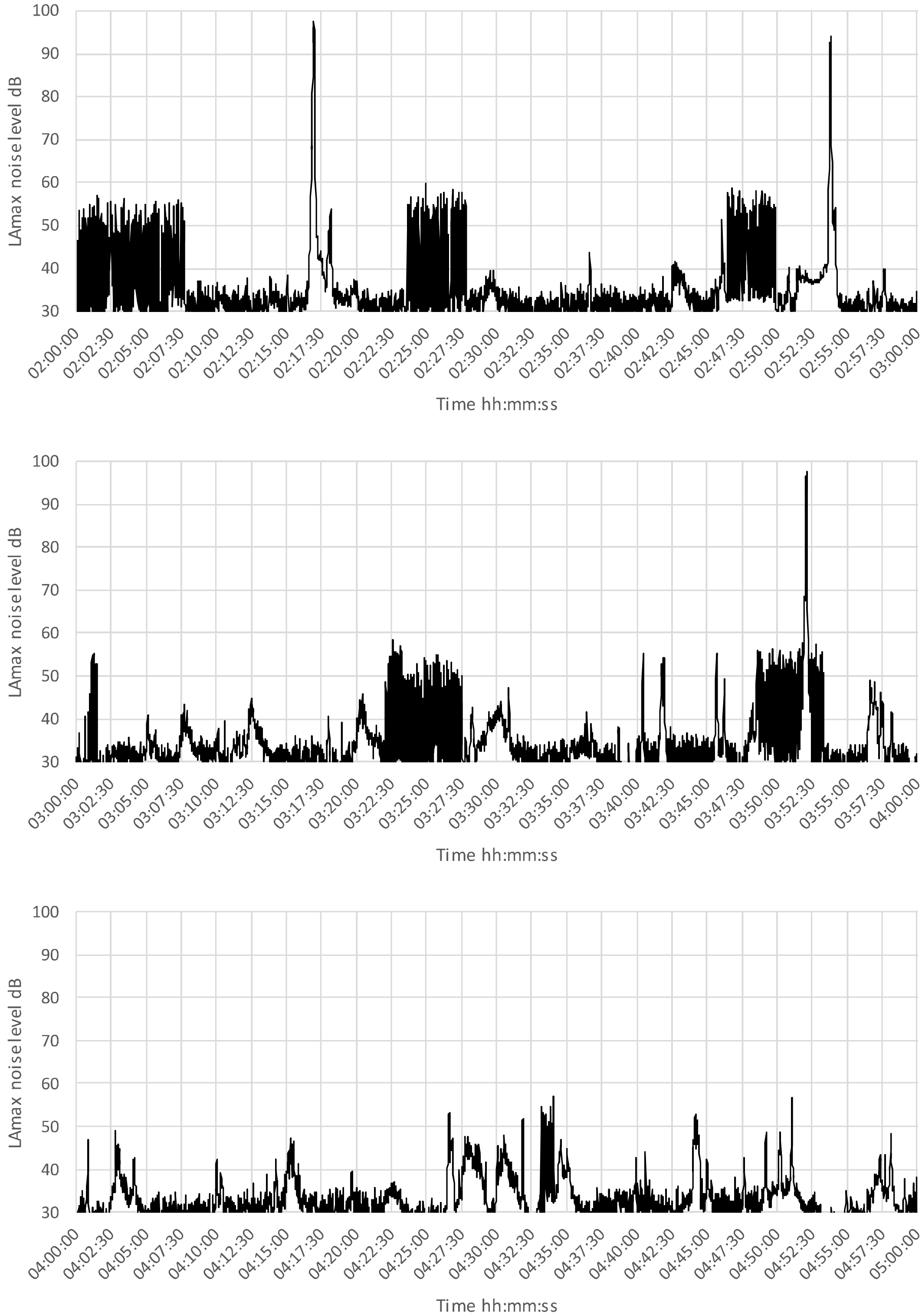
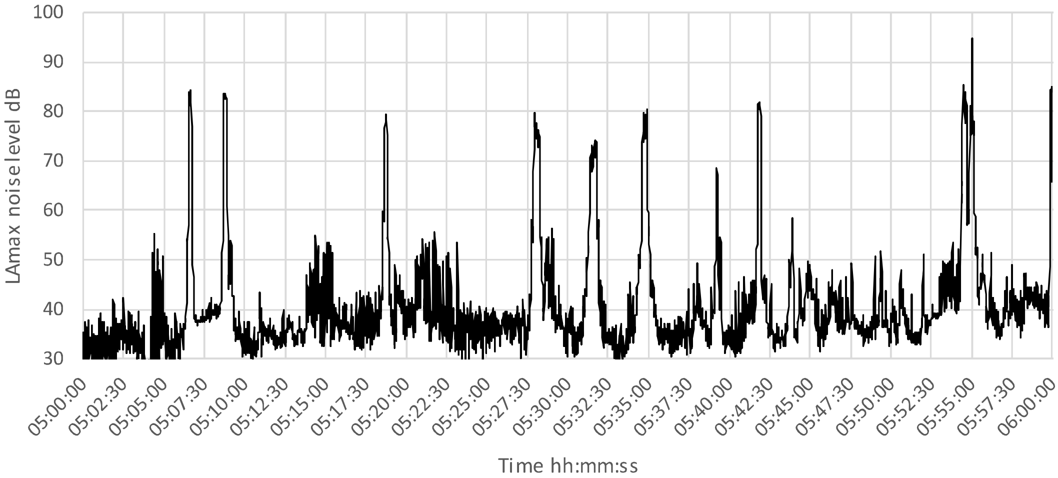
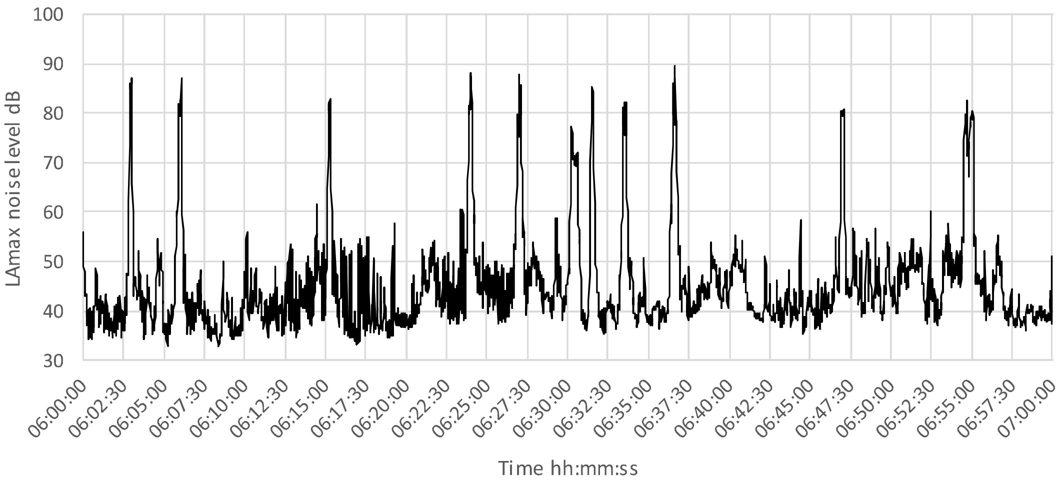


FIGURE 2c: Night LAmax noise levels





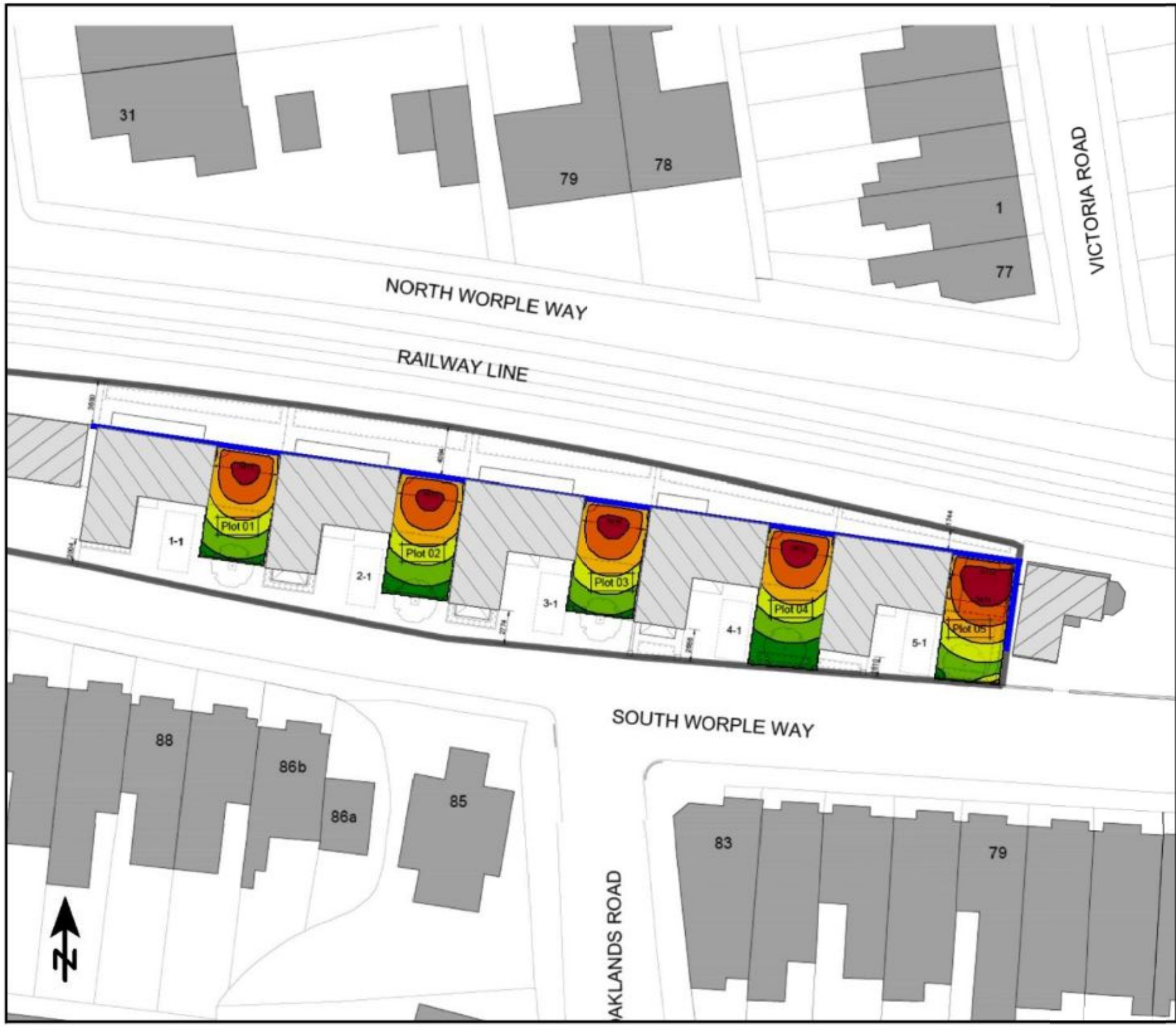


FIGURE 3: Daytime noise levels in garden / amenity areas

Daytime free field LAeq, 16 hour
at 1.5 metres above ground

2.5 metre wall at rear boundary facing railway
2 metre wall at east boundary

Signs and symbols

Wall

Building

Levels in dB(A)

<= 52
52 - 53
53 - 54
54 - 55
55 - 56
56 - 57
> 57

0 2.5 5 10 15 20 m

FIGURE 4: Daytime noise levels at house facades

Daytime facade LAeq, 16 hour
at ground and first floor window height

2.5 metre wall at rear boundary facing railway
2 metre wall at east boundary

Signs and symbols

- Wall
- Building
- Receiver at building
- Level tables

0 2.5 5 10 15 20 m

FIGURE 5: Night LAmax noise levels at house facades

Night LAmax,fast
at first floor window height

2.5 metre wall at rear boundary facing railway
2 metre wall at east boundary

Signs and symbols

- Wall
- Building
- Receiver at building
- Level tables

0 2.5 5 10 15 20 m

TABLE 1: Railway noise measurements

Date	Start time (hh:mm)	LAeq dB	LAmax dB	LA10 dB	LA50 dB	LA90 dB
26-Nov-18	12:00	69.0	94.1	60.0	50.0	46.9
26-Nov-18	13:00	69.5	100.8	59.0	50.3	46.9
26-Nov-18	14:00	65.6	88.8	54.9	49.7	46.0
26-Nov-18	15:00	70.2	93.5	58.7	50.0	47.3
26-Nov-18	16:00	70.0	93.6	57.7	48.6	45.4
26-Nov-18	17:00	71.2	92.5	64.9	48.7	45.7
26-Nov-18	18:00	70.5	92.7	65.1	48.5	45.4
26-Nov-18	19:00	71.8	97.4	61.0	46.8	43.9
26-Nov-18	20:00	69.2	90.7	57.0	45.2	41.7
26-Nov-18	21:00	68.5	91.1	58.0	45.6	41.8
26-Nov-18	22:00	71.5	104.3	60.6	45.7	42.0
26-Nov-18	23:00	69.4	93.5	49.5	41.7	40.2
27-Nov-18	00:00	65.3	92.6	42.3	38.7	36.1
27-Nov-18	01:00	35.0	55.4	36.8	32.5	29.8
27-Nov-18	02:00	67.2	97.7	40.3	30.7	28.0
27-Nov-18	03:00	65.6	97.7	39.5	30.2	26.3
27-Nov-18	04:00	35.7	57.2	37.9	30.0	26.2
27-Nov-18	05:00	65.3	94.9	47.6	35.7	31.0
27-Nov-18	06:00	66.4	89.4	52.1	40.4	35.9
27-Nov-18	07:00	69.4	93.5	61.4	44.8	39.5
27-Nov-18	08:00	69.7	88.4	70.0	50.1	44.3
27-Nov-18	09:00	67.8	88.3	58.9	47.4	42.9
27-Nov-18	10:00	69.0	97.2	59.5	48.9	44.8
27-Nov-18	11:00	70.2	95.1	60.6	49.6	46.2

Overall LAeq values

Day	07:00 to 23:00	69.8
Night	23:00 to 07:00	65.6

TABLE 2: Vibration from trains

Time	Comments	VDV $ms^{-1.75}$	Groundborne noise dB(A)
1146	2 trains	0.0217	44.0
1148		0.0185	42.7
1154	2 trains	0.0187	41.5
1200		0.0211	38.8
1209		0.0295	43.6
1213		0.0319	46.4
1216		0.0129	41.3
1217		0.0369	46.1
1221		0.0277	42.7
1224		0.0247	39.3
1229		0.0344	47.0
1230		0.0339	44.0
1241		0.0274	44.1
1249		0.0198	42.0
1251		0.0265	39.6
1252		0.0388	50.1
1255		0.0145	36.7
1259		0.0161	41.4
1300		0.0216	40.2
1309		0.0510	50.8
1311		0.0339	48.3
1317		0.0271	43.0
1319		0.0195	40.3
1321		0.0340	46.5
1324		0.0262	44.9
1327	2 trains	0.0201	41.9
1330		0.0174	39.3
1345		0.0282	40.2
1354		0.0124	34.8

Vibration per train

Average VDV per train	0.0292

Overall vibration day

Total VDV (269 trains)	0.118

Overall vibration night

Total VDV (43 trains)	0.075

TABLE 3: Sound Insulation Calculation - living room LAeq day

Based on BS 8233:2014 Table G.2
Input data is in bold text, standard reference data in plain text, calculated values in italics

Non frequency-dependent data

	Term	Value m^2
Rear facade area	S_f	**8.3**
Side façade area		**9.9**
Front glazed area	S_{wi}	**2.4**
Side glazed area		**4.8**
S_f - S_{wi} rear	S_{ew}	*8.3*
S_f - S_{wi} side		*5.1*
Area of roof/ceiling	S_{rr}	**15.5**
S_f + S_{rr}	S	*33.7*
Receiving room volume	V	**35.6**
Reference absorption area	A_0	10

Frequency-dependent data and calculations

	Term from equation	Ref. letter	Octave band centre frequency				
			125 Hz	250 Hz	500 Hz	1 kHz	2 kHz
External free field noise level at rear	$L_{Aeq,ff}$	A	**67.2**	**66.2**	**67.1**	**65.4**	**61.6**
Front ventilator 2500 mm^2		B	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - front glazing	R_{wi}		**20**	**18**	**28**	**38**	**34**
Additional screening			**22**	**22**	**22**	**22**	**22**
6/16/6 standard double glazing	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C1	*0.00000*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - side glazing	R_{wi}		**20**	**18**	**28**	**38**	**34**
Additional screening			**14.2**	**14.2**	**14.2**	**14.2**	**14.2**
6/16/6 standard double glazing	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C2	*0.00005*	*0.00009*	*0.00001*	*0.00000*	*0.00000*
Sound reduction index - rear wall	R_{ew}		**35**	**41**	**49**	**58**	**67**
Standard cavity masonry	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D1	*0.00008*	*0.00002*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - side wall	R_{ew}		**35**	**41**	**49**	**58**	**67**
Additional screening			**14.2**	**14.2**	**14.2**	**14.2**	**14.2**
Standard cavity masonry	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D2	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - roof/ceiling	R_{rr}						
Not applicable	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	E					
10 $\log_{10}$ (B+C1+C2+D1+D2+E)		F	*-38.6*	*-39.4*	*-48.9*	*-57.5*	*-55.4*
Receiving room reverberation time	T		0.5	0.5	0.5	0.5	0.5
Receiving room absorptive area A	0.16 V/T		*11.4*	*11.4*	*11.4*	*11.4*	*11.4*
10 log S/A		G	*4.7*	*4.7*	*4.7*	*4.7*	*4.7*
$L_{Aeq,2}$ = A+F+G+3			*36.3*	*34.5*	*25.9*	*15.7*	*13.9*
A-weighting dB			-16.1	-8.6	-3.2	0	1.2
$L_{Aeq,2}$ + A-weighting			*20.2*	*25.9*	*22.7*	*15.7*	*15.1*

Overall $L_{Aeq,ff}$ *69.3*

Overall $L_{Aeq,2}$ *28.7*

TABLE 4a: Sound Insulation Calculation - bedroom 2 LAeq night

Based on BS 8233:2014 Table G.2
Input data is in bold text, standard reference data in plain text, calculated values in italics

Non frequency-dependent data

	Term	Value m^2
Rear facade area	S_f	**6.4**
Side façade area		**9.9**
Front glazed area	S_{wi}	**1.7**
Side glazed area		**1.7**
S_f - S_{wi} rear	S_{ew}	*6.4*
S_f - S_{wi} side		*8.2*
Area of roof/ceiling	S_{rr}	**12.0**
S_f + S_{rr}	S	*28.4*
Receiving room volume	V	**27.7**
Reference absorption area	A_0	10

Frequency-dependent data and calculations

	Term from equation	Ref. letter	Octave band centre frequency 125 Hz	250 Hz	500 Hz	1 kHz	2 kHz
External free field noise level at rear	$L_{Aeq,ff}$	A	**63.0**	**62**	**62.9**	**61.2**	**57.4**
Front ventilator 2500 mm^2		B	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - front glazing	R_{wi}		**20**	**18**	**28**	**38**	**34**
Additional screening			**21.7**	**21.7**	**21.7**	**21.7**	**21.7**
6/16/6 standard double glazing	$\frac{S_{wi}}{S}\,10^{\frac{-R_{wi}}{10}}$	C1	*0.00000*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - side glazing	R_{wi}		**28**	**36**	**45**	**53**	**56**
Additional screening			**3.8**	**3.8**	**3.8**	**3.8**	**3.8**
8.8/16/12.8 Pilkington Optiphon	$\frac{S_{wi}}{S}\,10^{\frac{-R_{wi}}{10}}$	C2	*0.00004*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - rear wall	R_{ew}		**42**	**47**	**57**	**65**	**68**
Cavity masonry with inner acoustic lining	$\frac{S_{ew}}{S}\,10^{\frac{-R_{ew}}{10}}$	D1	*0.00001*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - side wall	R_{ew}		**37**	**42**	**52**	**60**	**63**
Additional screening			**3.8**	**3.8**	**3.8**	**3.8**	**3.8**
Standard cavity masonry	$\frac{S_{ew}}{S}\,10^{\frac{-R_{ew}}{10}}$	D2	*0.00002*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - roof/ceiling	R_{rr}		**34**	**44**	**50**	**55**	**59**
Additional screening			**6**	**6**	**6**	**6**	**6**
Tiled roof with 3 x 15mm plasterboard ceiling, mineral wool insulation	$\frac{S_{rr}}{S}\,10^{\frac{-R_{rr}}{10}}$	E	*0.00004*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
10 $\log_{10}$ (B+C1+C2+D1+D2+E)		F	*-39.0*	*-45.3*	*-53.7*	*-58.8*	*-59.8*
Receiving room reverberation time	T		0.5	0.5	0.5	0.5	0.5
Receiving room absorptive area A	0.16 V/T		*8.9*	*8.9*	*8.9*	*8.9*	*8.9*
10 log S/A		G	*5.1*	*5.1*	*5.1*	*5.1*	*5.1*
$L_{Aeq,2}$ = A+F+G+3			*32.0*	*24.8*	*17.3*	*10.4*	*5.7*
A-weighting dB			-16.1	-8.6	-3.2	0	1.2
$L_{Aeq,2}$ + A-weighting			*15.9*	*16.2*	*14.1*	*10.4*	*6.9*

Overall $L_{Aeq,ff}$ *65.1*

Overall $L_{Aeq,2}$ *20.9*

TABLE 4b: Sound Insulation Calculation - bedroom 2 LAmax night

Based on BS 8233:2014 Table G.2

Input data is in bold text, standard reference data in plain text, calculated values in italics

Non frequency-dependent data

	Term	Value m^2
Rear facade area	S_f	**6.4**
Side façade area		**9.9**
Front glazed area	S_{wi}	**1.7**
Side glazed area		**1.7**
S_f - S_{wi} rear	S_{ew}	*6.4*
S_f - S_{wi} side		*8.2*
Area of roof/ceiling	S_{rr}	**12.0**
S_f + S_{rr}	S	*28.4*
Receiving room volume	V	**27.7**
Reference absorption area	A_0	10

Frequency-dependent data and calculations

	Term from equation	Ref. letter	Octave band centre frequency				
			125 Hz	250 Hz	500 Hz	1 kHz	2 kHz
External free field noise level at rear	$L_{Aeq,ff}$	A	**83.8**	**87.1**	**88.4**	**84.4**	**79.5**
Front ventilator 2500 mm^2		B	*0.00000*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - front glazing	R_{wi}		**20**	**18**	**28**	**38**	**34**
Additional screening			**21.7**	**21.7**	**21.7**	**21.7**	**21.7**
6/16/6 standard double glazing	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C1	*0.00000*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - side glazing	R_{wi}		**28**	**36**	**45**	**53**	**56**
Additional screening			**3.8**	**3.8**	**3.8**	**3.8**	**3.8**
8.8/16/12.8 Pilkington Optiphon	$\frac{S_{wi}}{S}10^{\frac{-R_{wi}}{10}}$	C2	*0.00004*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - rear wall	R_{ew}		**42**	**47**	**57**	**65**	**68**
Cavity masonry with inner acoustic lining	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D1	*0.00001*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - side wall	R_{ew}		**37**	**42**	**52**	**60**	**63**
Additional screening			**3.8**	**3.8**	**3.8**	**3.8**	**3.8**
Standard cavity masonry	$\frac{S_{ew}}{S}10^{\frac{-R_{ew}}{10}}$	D2	*0.00002*	*0.00001*	*0.00000*	*0.00000*	*0.00000*
Sound reduction index - roof/ceiling	R_{rr}		**34**	**44**	**50**	**55**	**59**
Additional screening			**6**	**6**	**6**	**6**	**6**
Tiled roof with 3 x 15mm plasterboard ceiling, mineral wool insulation	$\frac{S_{rr}}{S}10^{\frac{-R_{rr}}{10}}$	E	*0.00004*	*0.00000*	*0.00000*	*0.00000*	*0.00000*
10 $\log_{10}$ (B+C1+C2+D1+D2+E)		F	*-39.0*	*-45.3*	*-53.7*	*-58.8*	*-59.8*
Receiving room reverberation time	T		0.5	0.5	0.5	0.5	0.5
Receiving room absorptive area A	0.16 V/T		*8.9*	*8.9*	*8.9*	*8.9*	*8.9*
10 log S/A		G	*5.1*	*5.1*	*5.1*	*5.1*	*5.1*
$L_{Aeq,2}$ = A+F+G+3			*52.8*	*49.9*	*42.8*	*33.6*	*27.8*
A-weighting dB			-16.1	-8.6	-3.2	0	1.2
$L_{Aeq,2}$ + A-weighting			*36.7*	*41.3*	*39.6*	*33.6*	*29.0*

Overall $L_{Aeq,ff}$ *89.0*

Overall $L_{Aeq,2}$ *44.8*

APPENDIX 1: Instrumentation

Sound level meter - Norsonic NOR 140, serial no. 1403645

Microphone - Norsonic NOR 1225, serial no. 103278, with NOR 1217 weather protection

Acoustic calibrator - Norsonic NOR 1251, serial no. 31230

Accelerometer – PCB high sensitivity triaxial type 356B18, serial no. 72919

Accelerometer calibrator - Bruel & Kjaer type 4294, serial no. 2678037

Computer interface – National Instruments type 9234, serial no. 137EC95

Analysis software – National Instruments Sound & Vibration Measurement Suite version 6

APPENDIX 2: Pilkington Optiphon data sheet

Pilkington **Optiphon**™
Laminated glass for superior noise insulation

Pilkington **Optiphon**™ is the ideal choice of glass in situations where there is excess noise from road, rail or air traffic, or various other sources, such as factories, nightclubs or neighbours.

Pilkington **Optiphon**™ is a high quality acoustic laminated glass incorporating a special PVB (PolyVinyl Butyral) interlayer. It offers excellent noise reduction without compromising on light transmittance or impact performance.

The desired acoustic performance can be achieved through combining various thicknesses of glass with a PVB interlayer. With a large variety of product combinations, Pilkington **Optiphon**™ offers the opportunity to achieve specific noise reduction requirements.

Note: Pilkington **Optiphon**™ can also be manufactured with other products, including coated glass

Benefits

- Special PVB interlayer for enhanced sound insulation performance
- A thinner and lighter glass for the equivalent acoustic performance
- Available in jumbo and LES sizes
- All products achieve safety class 1(B)1 (EN 12600) and are available to meet security classes in accordance with EN 356
- A high acoustic performance can be achieved when used in Insulating Glass Units (IGUs)
- Can also be used to improve noise insulation in a triple glazing construction

As well as reducing intrusive noise, Pilkington **Optiphon**™ can be combined with other Pilkington products for a multi-functional glazing solution with additional benefits, such as:

- Thermal insulation with Pilkington **K Glass**™ / Pilkington **Optitherm**™ (coating in position 3 in IGU)
- Solar control with Pilkington **Suncool**™ (coating in position 2 in IGU)
- Self-cleaning with Pilkington **Activ**™ (coating in position 1 in IGU)

Sound insulation data for Pilkington **Optiphon™**

Glass	Sound reduction index (dB)									
	Octaveband Centre Frequency (Hz)						R_w (C; C_{tr})	R_w	R_w+C	R_w+C_{tr}
	125	250	500	1000	2000	4000				
Single glazing										
6.8 mm Pilkington **Optiphon™**	22	26	31	37	40	40	36 (-1; -4)	36	35	32
8.8 mm Pilkington **Optiphon™**	27	29	34	38	40	43	37 (0; -2)	37	37	35
10.8 mm Pilkington **Optiphon™**	26	30	35	39	40	46	38 (-1; -3)	38	37	35
12.8 mm Pilkington **Optiphon™**	29	32	36	41	42	51	40 (-1; -3)	40	39	37
16.8 mm Pilkington **Optiphon™**	31	33	38	41	43	54	41 (-1; -3)	41	40	38
Insulating glass units										
6 mm / 16 mm argon / 6.8 mm Pilkington **Optiphon™**	21	28	37	48	48	54	40 (-2; -6)	40	38	34
6 mm / 16 mm argon / 8.8 mm Pilkington **Optiphon™**	25	27	38	48	47	55	41 (-2; -6)	41	39	35
8 mm / 16 mm argon / 8.8 mm Pilkington **Optiphon™**	21	30	39	47	50	55	42 (-3; -8)	42	39	34
10 mm / 16 mm argon / 8.8 mm Pilkington **Optiphon™**	28	31	42	45	50	58	44 (-2; -6)	44	42	38
10 mm / 20 mm argon / 8.8 mm Pilkington **Optiphon™**	28	36	43	47	49	58	46 (-2; -6)	46	44	40
8.8 mm Pilkington **Optiphon™** / 16 mm argon / 12.8 mm Pilkington **Optiphon™**	28	36	45	53	56	64	48 (-2; -7)	48	46	41
10.8 mm Pilkington **Optiphon™** / 24 mm argon / 16.8 mm Pilkington **Optiphon™**	35	41	48	53	55	65	52 (-2; -6)	52	50	46
12.8 mm Pilkington **Optiphon™** / 20 mm argon / 16.8 mm Pilkington **Optiphon™**	35	45	49	50	54	65	51 (-1; -4)	51	50	47

Measurements undertaken in accordance with BS EN ISO 10140 and Rw (C; C_{tr}) determined in accordance with BS EN ISO 717-1.
For insulating glass units, there is little difference in the sound insulation for cavity widths in the range 6 to 16 mm.
To calculate performance data for Pilkington products, please use our Spectrum online calculator at https://spectrum.pilkington.com/
For glass combinations to achieve an R_w value higher than 52 dB, please contact us for more details.

APPENDIX 3: Product data for Nuaire MVHR unit

MRXBOXAB-ECO3 MRXBOX-ECO3

and Opposite Handed versions

ACHIEVES 100% DUTY IN BYPASS MODE

The MRXBOXAB-ECO3 has been designed with automatic 100% bypass as listed on the SAP Product Characteristics Database (PCDB).

Due to its intelligent and smart design, there will be no reduction in airflow when operating in bypass mode resulting in enhanced performance.

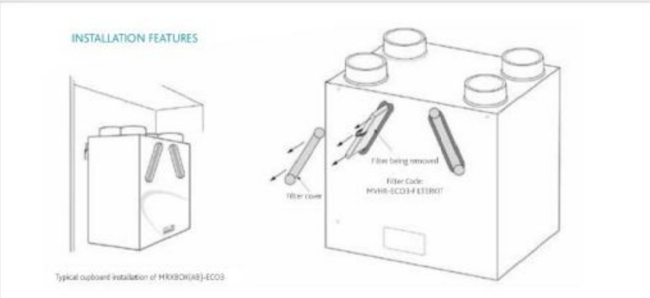
Both the MRXBOXAB-ECO3 and the MRXBOX-ECO3 are designed to provide optimised balanced (supply and extract) mechanical ventilation with heat recovery and both listed on the PCDB.

The units operate by continuously extracting moisture-laden air from wet rooms within the property and at the same time drawing in fresh supply air from outside. The heat from the extracted stale air is recovered via a heat exchanger inside the heat recovery unit which becomes tempered then filtered before supplying into the habitable rooms creating comfortable and well ventilated homes.

The heat exchanger block within these units can recover up to 95% of the normally wasted heat. The two independent fans have full speed control for background and boost ventilation rates.

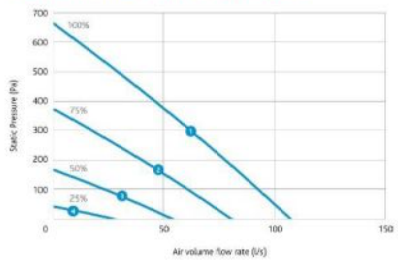
The MRXBOXAB-ECO3 has a summer bypass function. This feature activates automatically and attempts to maintain the home at a comfortable temperature. For example, if the outside temperature is warmer than the inside, the unit will continue to draw air through the heat exchanger. If the house is warmer than outside, the unit will bypass the heat exchanger and draw air in directly from outside.

Typical Installation



Typical cupboard installation of MRXBOX(AB)-ECO3

Performance - MRXBOX(AB)-ECO3



CODE DESCRIPTION

MRXBOXAB-ECO3
Wall mounted unit with 100% bypass and integral humidistat.

MRXBOX-ECO3
Wall mounted unit.

MRXBOXAB-ECO3-OH
Opposite handed configuration wall mounted unit with 100% bypass and integral humidistat.

MRXBOX-ECO3-OH
Opposite handed configuration wall mounted unit.

Electrical & Sound

	Maximum power consumption		Sound Power Levels dB re 1pW (Frequency Hz)								dBA @3m
Curve	(Watts)		63	125	250	500	1k	2k	4k	8k	
1	156	Open inlet	48	57	60	53	49	44	33	24	
		Open outlet	57	67	63	64	61	61	52	45	
		Breakout	65	59	58	57	50	46	36	26	40
2	67	Open inlet	43	52	56	48	46	40	30	18	
		Open outlet	54	62	59	62	58	58	48	40	
		Breakout	54	55	52	51	44	42	28	<16	34
3	20	Open inlet	38	44	47	39	36	29	16	<16	
		Open outlet	46	53	49	52	46	44	33	21	
		Breakout	47	46	44	42	34	29	16	<16	25
4	7	Open inlet	33	27	26	16	<16	<16	<16	<16	
		Open outlet	39	34	31	32	22	<16	<16	<16	
		Breakout	41	29	27	20	<16	<16	<16	<16	<16

The maximum power consumption shown above (Watts) is consumed on units running continuously, not taking into account any heat recovery saving and based on SAP Product Characteristic Database (PCDB) testing. The breakout case-radiated dBA values are given for Hemispherical free field radiation at 3m - to obtain the Spherical radiated data, subtract 3 dBA.

Please note: Sound data is provided at a particular duty point for 25%, 50%, 75% and 100%. For accurate sound data at a specific speed duty, please use Nuaires fan selector or call the office on 029 2085 8500.

MRXBOX-SIL3 (Silencer)
MRXBOX-FF3 (First Fix Plenum Chamber)
Acoustic Solution System

For Wall / Cupboard Mounted MRXBOX(AB)-ECO3 Units

Installation and Maintenance

The EMC Directive 2014/30/EU
The Low Voltage Directive 2014/35/EU

1.0 Introduction

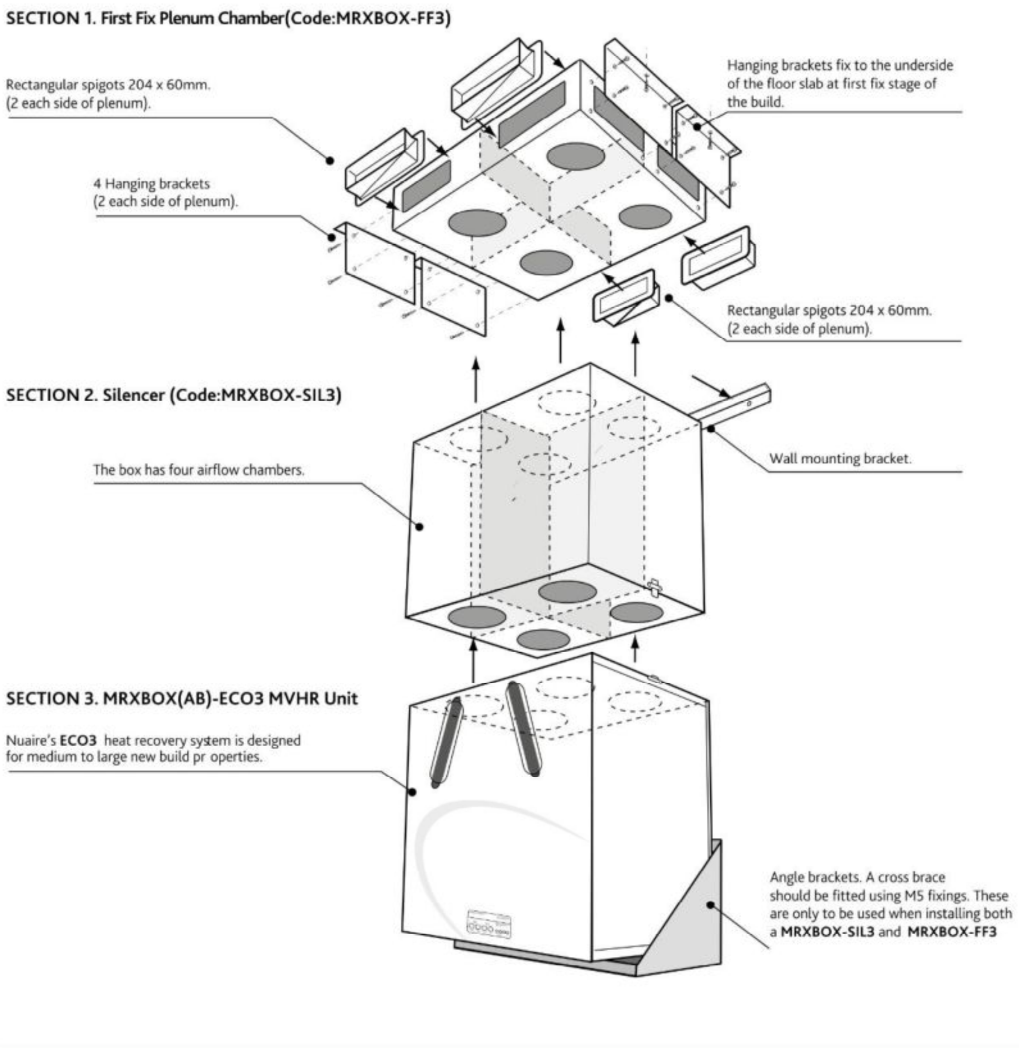
Nuaires First Fix and Acoustic Solution system is designed to not only significantly reduce noise but to improve the installation when wall or cupboard mounting the MRXBOX(AB)-ECO3 MVHR Units.

Offering a complete MVHR acoustic and first fix solution to overcome both noise and ease the installation of heat recovery units.

Nuaires system addresses both duct and breakout noise; provides an aesthetically pleasing cupboard installation for the home occupant and reduces installation errors and time.

Note: Information shown refers to complete system, not all parts will be relevant if part of system is fitted.

Figure 1. Units and components required to create the Acoustic Solution and Ducting for Wall Mounted MRXBOX(AB)-ECO3 MVHR Units.



3.0 Dimensions

Figure 10. MRXBOX-SIL3.

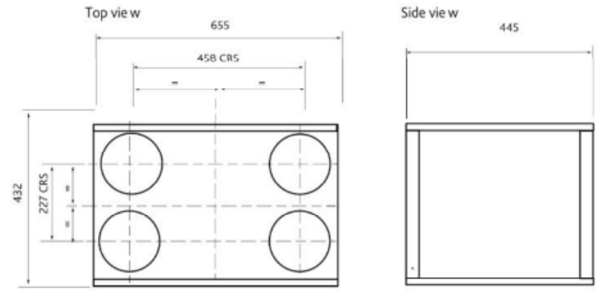


Figure 11. MRXBOX-FF3.

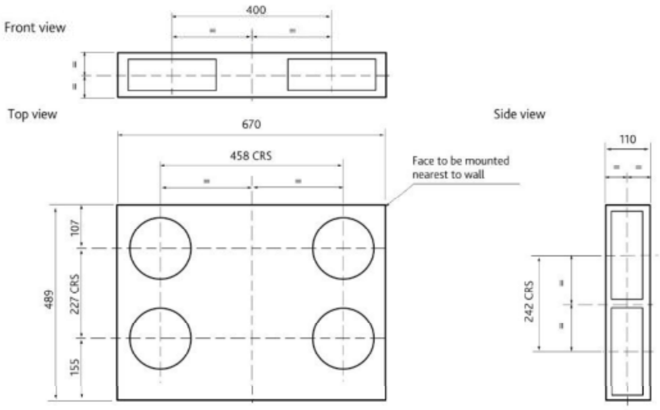
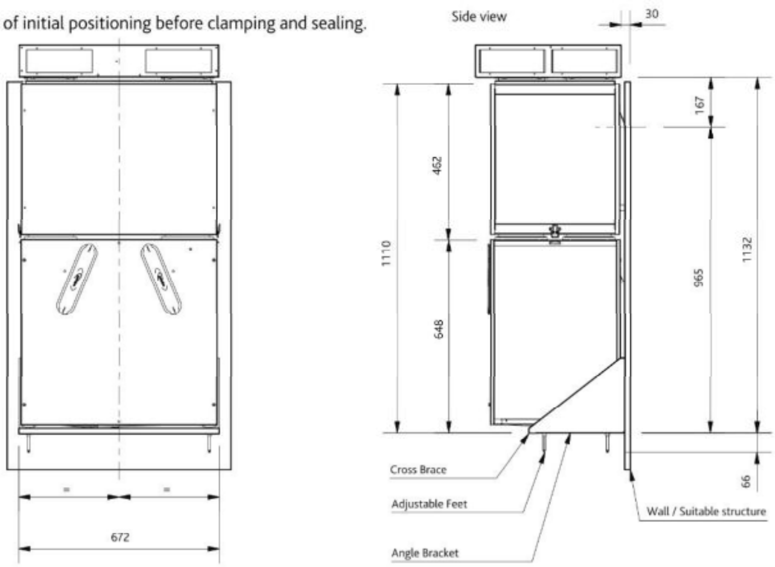


Figure 12. Front view of initial positioning before clamping and sealing.



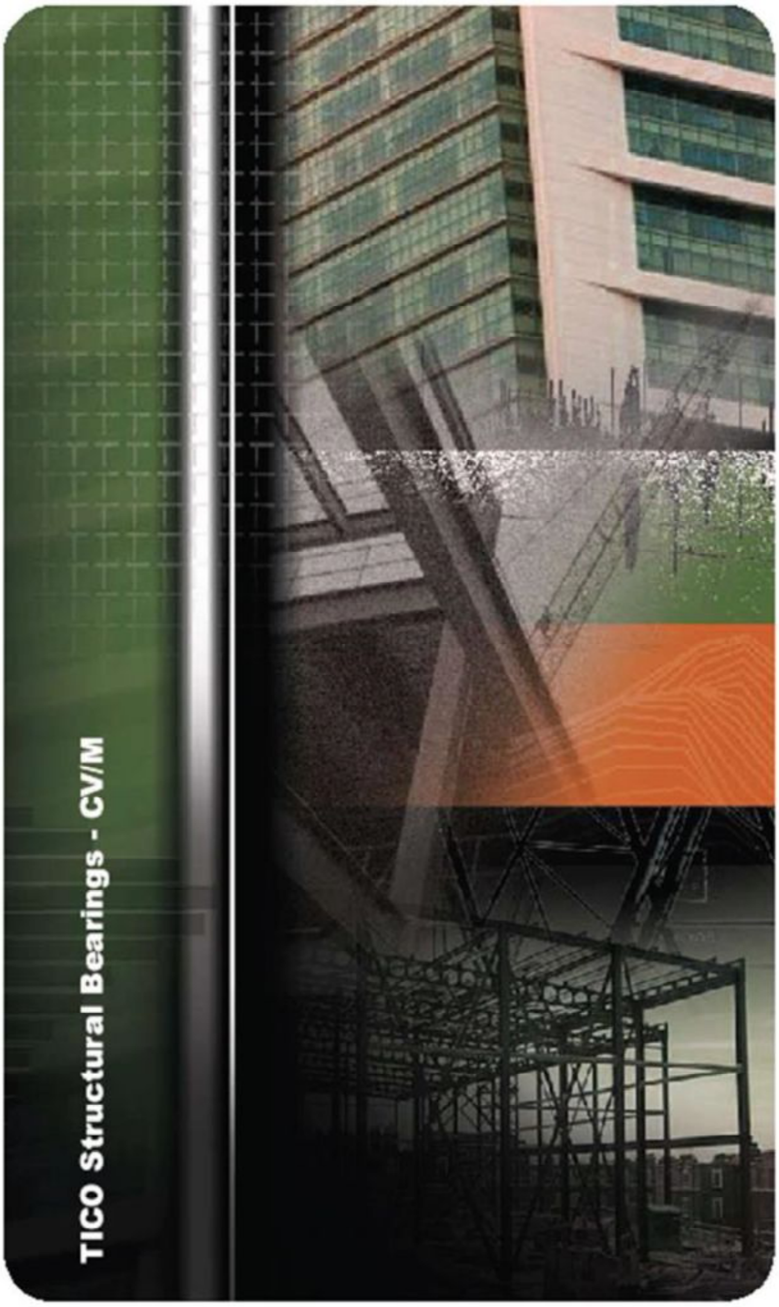
Silencer Corrections

SIL Corrections	Open Inlet	-8	-10	-9	-10	-22	-24	-16	-13
	Open Outlet	-11	-10	-9	-14	-23	-26	-20	-15
	Breakout	0	0	0	0	0	0	0	0

FF Corrections	Open Inlet	-4	-7	-5	-6	-7	-7	-6	-4
	Open Outlet	-8	-5	-4	-7	-7	-7	-6	-6
	Breakout	0	0	0	0	0	0	0	0

FF+SIL Corrections	Open Inlet	-12	-20	-15	-16	-22	-24	-19	-16
	Open Outlet	-18	-18	-18	-25	-30	-35	-28	-26
	Breakout	0	0	0	0	0	0	0	0

APPENDIX 4: Tico CV/M Structural Bearings data sheet



Tiflex

TICO CV/M - Medium Stress Bearing

TICO CV/M is a medium load structural bearing material, engineered to reduce the transmission of ground borne and structure borne noise and vibration, for example vibrations transmitted into and through buildings from nearby public transport systems or road networks. TICO CV/M has a maximum recommended working stress of 1400 kN/m² making it suitable for a wide variety of applications.

To achieve a major reduction in structural noise transmission it is necessary to separate one structure from another, or to isolate the complete structure itself from its foundation, depending on the source of vibration and amount of reduction required. Typical examples of TICO CV/M applications include isolation of cinemas, lightweight oil-rig modules, control rooms and floating floors.

TICO CV/M structural bearings can be used in a number of different configurations from modular pad arrangements on pile caps to continuous strip footings. In suitable configurations, isolation systems based around TICO CV/M structural bearings can achieve natural frequencies of less than 10 Hz.

TICO CV/M bearings are dimensionally stable under widely varying atmospheric conditions and should provide acceptable vibration attenuation properties for 50 years or more - the high quality constituents used in manufacture will render them durable and age resistant over many decades with a total load bearing life expectancy well in excess of the normal working life of the building.

TICO CV/M bearings have been designed and tested to meet and exceed the requirements of BS6177:1982 'Guide to selection and use of elastomeric bearings for vibration isolation of buildings'.

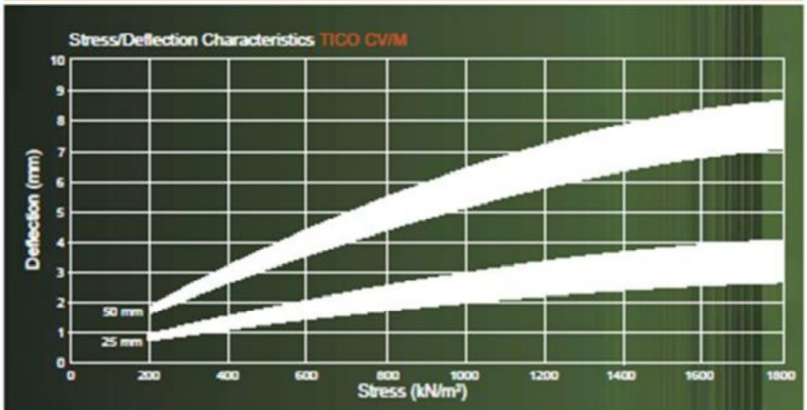
Physical Properties

TICO CV/M is formulated from the highest quality neoprene which has been modified by the inclusion of cellular cork particles. Thicker pads may be reinforced with a central layer, or layers, of high tensile fabric.

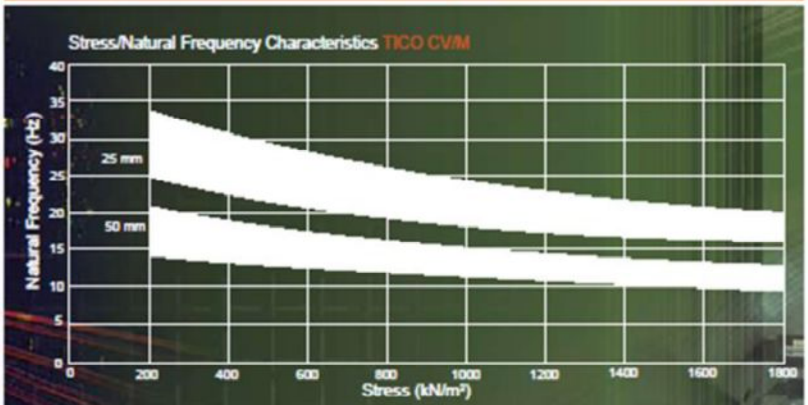
Maximum Recommended Working Stress	1400 kN/m²
Working Stress Range	1000-1400 kN/m²
Breakdown	In excess of 3 times the maximum recommended working stress (in accordance with BS6177)
Hardness (IRHD)	50 ± 5
Density (Typical)	1100 kg/m³
Temperature Range	-30 to +70°C Performance of bearing may be impaired at extremes of durable temperature range.
Typical Damping Ratio	0.065 to 0.085
Thermal Conductivity	0.251 W/m.K

TICO

Bearing Stress vs Static Deflection

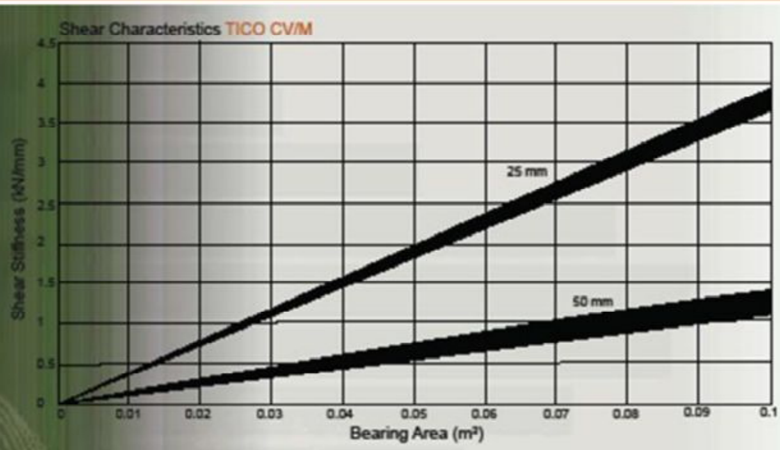


Bearing Stress vs Natural Frequency

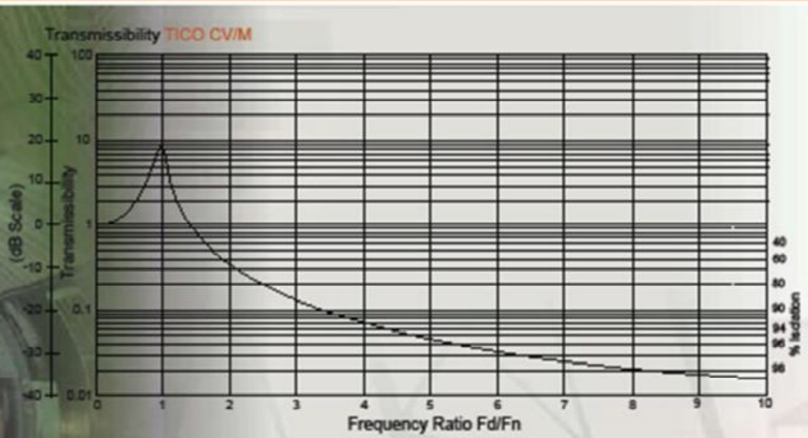


These graphs have been prepared from the results of extensive testing over many years. Where appropriate, data has been presented in the form of a shadow graph to illustrate the effect of shape factor on performance of the pads. All data is presented for guidance only.

Shear Stiffness



Transmissibility



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Design Considerations

Because of the wide range of applications for which TICO CV/M is suitable, and the variation of material properties under different operating conditions it is difficult to provide a simple design guide.

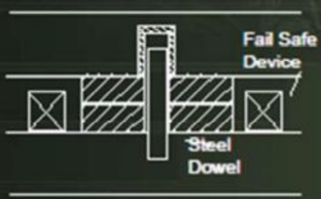
Key parameters in the specification of TICO CV/M bearing are:

- ☐ Operating loads (dead and live loads)
- ☐ Available space to incorporate bearings
- ☐ Required natural frequency of isolating system (bearings)
- ☐ Disturbing frequency of vibration to be isolated (if known)

The load and available area will largely determine the plan dimensions and configuration of bearings, whereas the required natural frequency or disturbing frequency will strongly influence the bearing thickness. The interdependence of these parameters is indicated in the graphs in the previous section.

It is recommended that bearings are employed in modules of the order of 200 - 300 mm square to offset the reduced deflection and increased natural frequency which occurs due to shape factor when employing larger bearing sizes.

TICO CV/M bearings can be employed in thicknesses in multiples of 25 mm to provide the required natural frequency for a specific project. When a low natural frequency dictates that a very thick bearing is required, it may be necessary to provide some form of horizontal restraint, e.g. dowels or side restraint bearings.



It is also advisable to include some form of fail safe such as a steel or concrete upstand in the foundation design to support the structure should failure of the bearings occur through a major fire or other exceptional circumstance. Any block fail safe system needs to be carefully designed to take into account the natural deflection (creep) of the bearings over long periods of time.

The incorporation of resilient structural bearings into a structure has to be considered at an early design stage to enable a safe, effective and economical system to be engineered. Detailing such systems late in the construction process can cause major complications and in some instances may simply not be feasible. It is Tiflex' custom to work closely with consultants, engineers and other authorised bodies throughout the design and build process to ensure that we provide a bearing solution best suited to each individual application.

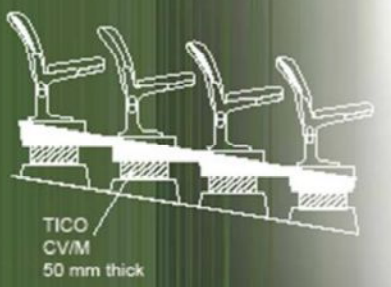
When incorporating bearings into a building, where possible and relevant, the guidance and recommendations of BS6177:1982 'Guide to selection and use of elastomeric bearings for vibration isolation of buildings' should be observed.

Installation

Installation of TICO CV/M structural bearings will vary from application to application and also depend on the design and arrangement of the bearings.

For plain bearings, pads or strips should be securely fixed in position with Tiflex Marine Epoxy Adhesive. The instructions for use of this adhesive should be followed carefully. Pre-cast units can be placed directly on the top of the bearing without any further bonding.

If the bearing surface is sloping or very irregular, a small level plinth can sometimes be cast to support the bearing as in the following diagram.



Good surface preparation is essential for a strong and durable bond. Surfaces onto which the bearing is to be placed, and surfaces mating with the upper surface of the pad, should be clean and as level as possible. Although TICO CV/M bearings are designed to take up some surface irregularity, out of plane mating surfaces can produce excessive stresses on the pads and impair their performance. Where possible the guidance of BS6177:1982 should be followed, in particular section 4.6 regarding bearing support surfaces.

Storage and Handling

On arrival on site, TICO Structural Bearings should be stored away from direct sunlight, excessive heat, chemicals or any liquid media. They should be kept in a safe, secure location where they are unlikely to be damaged or tampered with, become immersed in water, or have other building materials stacked on top of them.

Bearings should be handled with care during installation to ensure that they are not dropped or in any other way damaged. Damaged bearings should never be incorporated in the works and should be brought to the attention of an engineer or consultant.

On no account should welding be carried out on, or next to, a bearing either during or after manufacture.

Safe Handling data sheets are available for TICO CV/M bearings on request.

TICO

Supply Details

TICO CV/M is manufactured in sheet form up to a maximum sheet size of 1200 x 1000 mm. However, it is more common and advisable to employ this material in modular or strip form for the best performance.

Typically supplied bearing sizes and load bearing capacities are given in the following table.

Length (mm)	Width (mm)	Maximum Recommended Load (kN)
125	125	21
150	150	31
175	175	42
200	200	56
225	225	70
250	250	87
275	275	105
300	300	126

Tiflex recognises that in civil applications bearings often have to custom sized to meet the project requirements and thus we are happy to supply custom sizes up to the maximum sheet size available.

Standard thicknesses of TICO CV/M bearing material are 25, 50 and 75 mm, although other thicknesses are available on request.

For severe environments, bearing edges can be protected with a hypalon based coating applied during manufacture.

In major installations where fire protection is required, Tiflex are able to supply a protective ceramic fibre blanket and environmental shrouding.

Tiflex also offer a post installation bearing inspection service where required, to ensure that the bearings perform adequately over long periods of time.

Please contact our customer services department with full details of your requirements for a free written quotation. Our Technical Department will also be pleased to assist you in determining your exact bearing requirements.

All TICO materials are manufactured in accordance with BS EN ISO 9001: 2000

Uniclass L31:N14	EPIC C215
CI/SfB (29) X	

Tiflex

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