



PREPARED: Tuesday, 30 April 2024

# 58 Finchampstead Road, Wokingham; Noise and Vibration Impact Assessment

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## LIST OF ATTACHMENTS

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|                                                  |                     |                                                                                                                                                                                |                                       |
|--------------------------------------------------|---------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Project Ref:                                     | AS13511             | Title:                                                                                                                                                                         | 58 Finchampstead Road, Wokingham      |
| Report Ref:                                      | AS13511.240419.NVIA | Title:                                                                                                                                                                         | Noise and vibration Impact Assessment |
| Client Name:                                     | Davis Planning Ltd  |                                                                                                                                                                                |                                       |
| Project Manager:                                 | Matt Sugden         |                                                                                                                                                                                |                                       |
| Report Author:                                   | Matt Sugden         |                                                                                                                                                                                |                                       |
| Clarke Saunders Acoustics<br>Winchester SO22 5BE |                     | This report has been prepared in response to the instructions of our client. It is not intended for and should not be relied upon by any other party or for any other purpose. |                                       |

## 1.0 INTRODUCTION

- 1.1 Planning approval is being sought for the demolition of an existing dwelling and redevelopment of land located at 58 Finchampstead Road. The redevelopment is to comprise 4 no. proposed residential dwellings with associated access and parking facilities.
- 1.2 A pre-planning application has been submitted to Wokingham Borough Council (WBC) and, in response, a noise impact assessment has been requested due to the Site's proximity to the railway line. This report has been prepared to support the respective planning application.
- 1.3 As requested by WBC, this report considers the acoustic design of the development, the construction noise impact on nearby receptors and the impact of the existing noise sources on the proposed dwellings internally and externally, with reference to BS8233: *Guidance on sound insulation and noise reduction for buildings*. This report also provides an assessment of the impact of vibration from railway activity on the proposed dwellings.

## 2.0 SITE DESCRIPTION

- 2.1 58 Finchampstead Road (the Site) is located in a residential/rural area to the south of Wokingham. The site is bordered by the Reading to Waterloo railway line to the north, an existing dwelling and apartment block to the west as shown in the attached site plan AS13511/SP1. Land to the south and east has been allocated as part of the South Wokingham Strategic Development Location. A number of planning applications have been submitted for development on this land.
- 2.2 The Site is currently occupied by an existing dwelling and associated outhouses all of which are to be demolished as part of the redevelopment. The planning application includes provision for 4 no. 5 bed detached residential units each with parking and garage facilities.
- 2.3 Three of the proposed dwellings are proposed to be approximately 30m from the railway line, with the fourth at approximately 18m from the railway line.
- 2.4 From review of timetables, it appears that, when operating at normal capacity, trains on the adjacent line operate approximately between the hours of 05:30 and 23:45 and, at their peak, around 8 trains per hour are expected to pass the site. It is noted that, during the nighttime period, between the hours of 23:00 and 07:00, approximately 10 trains pass by the Site.
- 2.5 Trains passing the site were observed to be travelling at relatively low speeds, either on approach to or departing Wokingham station.

## 3.0 RELEVANT GUIDANCE

### 3.1 BS 8233: 2014 AND WHO GUIDANCE

- 3.1.1 Reference to BS 8233:2014 *Guidance on sound insulation and noise reduction for buildings* has been requested with regards to the noise impact assessment on the proposed dwellings.
- 3.1.2 Guideline indoor ambient noise levels are shown in Table 4 from Section 7.7.2 of BS8233:2014 and is replicated in Table 3.1 below.

| ACTIVITY                   | LOCATION           | 07:00 – 23:00         | 23:00 - 07:00        |
|----------------------------|--------------------|-----------------------|----------------------|
| Resting                    | Living Room        | 35 dB $L_{Aeq, 16hr}$ | -                    |
| Dining                     | Dining room / area | 40 dB $L_{Aeq, 16hr}$ | -                    |
| Sleeping (daytime resting) | Bedroom            | 35 dB $L_{Aeq, 16hr}$ | 30 dB $L_{Aeq, 8hr}$ |

Table 3.1: BS8233:2014 – Table 4, Section 7.7.2

[dB ref. 20μPa]

*\*NOTE 2 The levels shown in Table 4 are based on the existing guidelines issued by the WHO and assume normal diurnal fluctuations in external noise. In cases where local conditions do not follow a typical diurnal pattern, for example on a road serving a port with high levels of traffic at certain times of the night, an appropriate alternative period, e.g. 1 hour, may be used, but the level should be selected to ensure consistency with the levels recommended in Table 4.*

*\*\*Note 4 Regular individual noise events (for example, scheduled aircraft or passing trains) can cause sleep disturbance. A guideline value may be set in terms of SEL or  $L_{Amax,F}$ , depending on the character and number of events per night. Sporadic noise events could require separate values.*

*\*\*\*NOTE 5 If relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level. If applicable, any room should have adequate ventilation (e.g. trickle ventilators should be open) during assessment.*

3.1.3 The World Health Organisation's Guidelines for Community Noise comments on night-time noise maxima, resulting in a typically adopted target of  $L_{AFmax}$  45dB not being exceeded in bedrooms more than 10-15 times per night.

## 3.2 BS 6472-1:2008

3.2.1 There are no set planning requirements for vibration levels. within residential buildings. Guidance can, however, be taken from BS 6472-1:2008 *Guide to evaluation of human exposure to vibration in buildings: Part 1: Vibration sources other than blasting*.

3.2.2 Perception thresholds for continuous whole-body vibration vary widely among individuals. The standards states that approximately half the people in a typical population, when standing or seated, can perceive a vertical weighted peak acceleration of  $0.015 \text{ ms}^{-2}$  where the weighting used is  $W_b$ . A quarter of the people would perceive a vibration of  $0.01 \text{ ms}^{-2}$  peak, but the least sensitive quarter would only be able to detect a vibration of  $0.02 \text{ ms}^{-2}$  peak or more. Perception thresholds are slightly higher for vibration duration of less than about 1 s.

3.2.3 The standard assesses the effect of building vibration on human comfort due to intermittent events using the vibration dose value (VDV) parameter which accounts for the magnitude and time exposed to the vibration. The probability of adverse comment rising from vibration in residential buildings is given in Table 1 of BS 6472-1:2008, replicated below.

| PLACE AND TIME                    | LOW<br>PROBABILITY OF<br>ADVERSE<br>COMMENT<br>$\text{ms}^{-1.75}$ | ADVERSE<br>COMMENT<br>POSSIBLE<br>$\text{ms}^{-1.75}$ | ADVERSE<br>COMMENT<br>PROBABLE<br>$\text{ms}^{-1.75}$ |
|-----------------------------------|--------------------------------------------------------------------|-------------------------------------------------------|-------------------------------------------------------|
| Residential buildings<br>16h day  | 0.2 to 0.4                                                         | 0.4 to 0.8                                            | 0.8 to 1.6                                            |
| Residential buildings<br>8h night | 0.1 to 0.2                                                         | 0.2 to 0.4                                            | 0.4 to 0.8                                            |

Table 3.2: BS 6472-1:2008 – Table 1, Section 6

3.2.4 BS 6472-1:2008 states that these values represent the best judgement currently available and may be used for both vertical and horizontal vibration, provided that they are correctly weighted.

3.2.5 The assessment and control measures, where necessary, will target the category “low probability of adverse comment” or below.

## 4.0 ENVIRONMENTAL NOISE AND VIBRATION SURVEY & EQUIPMENT

4.1 A survey of existing noise and vibrations levels was undertaken at locations representative of the proposed dwellings. The indicative location of the monitors, proposed dwellings and nearest affected receptors are presented in the attached site plan, AS13511/SP1. Noise monitoring was undertaken at locations LT1 and LT2 and vibration monitoring was undertaken solely at position LT2.

4.2 Measurements of consecutive 5-minute and 1-minute  $L_{Aeq}$ ,  $L_{Amax}$ , the  $L_{A10}$  and  $L_{A90}$  sound pressure levels were taken at 1.5m above ground level free-field locations LT1 and LT2, respectively, between 14:00 hours on Friday 12 April and 10:45 hours on Tuesday 16 April 2024. 1-minute measurements of VDV were recorded at Position LT2.

4.3 Monitoring position LT1 was identified as being located approximately 30m from the railway line, around the same distance as three of the dwellings will be from the railway. Position LT2 was located around 18m from the railway, approximately the same distance as the closest other dwelling.

4.4 The following equipment was used during the course of the survey:

- 1 no. Rion sound level meter type NL52 (LT1);
- 1 no. Svantek 958 analyser (LT2);
- 1 no. Rion sound level field calibrator type NC74;
- 1 no. Norsonic sound level field calibrator type 1251

4.5 The triaxial accelerometer of the Svantek 958 analyser was installed horizontally on an existing paving slab confirmed to have a firm coupling with the ground. The orientation of the accelerometer was such that the x-axis was perpendicular with the railway line and the y-axis was parallel with the tracks.

4.6 The calibration of the instrumentation was verified before and after use. No significant calibration drift was detected.

- 4.7 Measurements were made generally in accordance with BS 7445-2:1991 (ISO1996-2:1987) *Description and measurement of environmental noise – Part 2: Acquisition of data pertinent to land use.*
- 4.8 The weather during the survey was generally dry with occasional strong winds. It is not anticipated that the increased wind speeds affected the survey results to a significant extent.
- 4.9 The railway runs along an embankment as it passes the site. In order to ascertain variation in noise levels at elevation, i.e. at first floor window height, additional detailed measurements were undertaken during the site survey. 5-minute synchronised noise measurements were taken at a height of 4m above ground level at both monitoring locations LT1 and LT2.

## 5.0 RESULTS

### 5.1 NOISE

5.1.1 Figures AS13511/TH1-TH5 and AS13511/TH6-TH10 show the  $L_{Aeq}$ ,  $L_{Amax}$ ,  $L_{A10}$  and  $L_{A90}$  sound pressure levels as time histories at measurement positions LT1 and LT2, respectively.

5.1.2 The noise levels measured across the survey period are summarised in the table below.

| LOCATION            | PERIOD                      | NOISE LEVEL |                    |                     |
|---------------------|-----------------------------|-------------|--------------------|---------------------|
|                     |                             | $L_{Aeq,T}$ | Typical* $L_{A90}$ | Typical^ $L_{Amax}$ |
| LT1<br>(free-field) | Daytime<br>(07:00-23:00)    | 56 dB       | 38 dB              | n/a                 |
|                     | Night-time<br>(23:00-07:00) | 49 dB       | 29 dB              | 69 dB               |
| LT2<br>(free-field) | Daytime<br>(07:00-23:00)    | 54 dB       | 40 dB              | n/a                 |
|                     | Night-time<br>(23:00-07:00) | 51 dB       | 33 dB              | 61 dB               |

Table 5.1 – Results of environmental sound survey

[dB ref. 20μPa]

\* Typical defined as 10<sup>th</sup> percentile of  $L_{A90}$  dataset.

^ Typical defined as 90<sup>th</sup> percentile of  $L_{AFmax}$  dataset.

5.1.3 Analysis of the survey data at LT1 highlighted an increase of approximately 0.5 dB in the train passby  $L_{Amax}$  and  $L_{Aeq}$  levels at the elevated position. Consequently, levels measured at LT1 are deemed to be representative of levels experienced by the entire north facing façades of plots 1, 2 and 3.

- 5.1.4 Analysis of data measured at LT2 showed an increase of 2-3 dB in the passby  $L_{Amax}$  at the elevated position. A worst-case scenario of +3 dB has been used as a correction for external building calculations at first floor level of Plot 4.
- 5.1.5 A small difference in passby  $L_{Aeq}$  levels was measured at LT2. Owing to the presence of environmental noise from other sources, this increase in short-term level is not anticipated to significantly affect the longer-term 8- or 16-hour  $L_{Aeq}$  averages. No correction has, therefore, been included within the external building fabric calculation of these parameters.

## 5.2 VIBRATION

- 5.2.1 Monitoring position LT2 was considered a representative location to assess potential vibration impact from the railway line on the nearest proposed dwelling.
- 5.2.2 The range of Vibration Dose Value data from this monitoring position is summarised in Table 5.2 below. It should be noted that clearly spurious events have been removed from daytime and nighttime calculations:

| MONITORING POSITION AND DURATION | VDV ( $ms^{-1.75}$ ) Z-AXIS |
|----------------------------------|-----------------------------|
| LT2: VDV <sub>Day</sub>          | 0.035 – 0.051               |
| LT2: VDV <sub>Night</sub>        | 0.009 – 0.05                |

Table 5.2– Results of the environmental vibration survey

- 5.2.3 Additional vibration sample measurements were taken elsewhere around site. Measured values were found to be similar to those obtained at monitoring position LT2. Subjectively, no tactile or otherwise noticeable vibration was detected at any point across the Site.

## 6.0 ASSESSMENT

### 6.1 EXTERNAL BUILDING FABRIC

- 6.1.1 This review is based on the submitted site and dwelling layouts available at the time of writing, targeting the internal noise levels set in Section 3.1.
- 6.1.2 It has been assumed that non-glazed elements, i.e. traditional brick and block external walls and tiled roofs, will provide the following minimum sound insulation performances, when tested in accordance with ISO 10140-2:2021 or equivalent test standard.

| NON-GLAZED FACADE ELEMENT | SINGLE FIGURE WEIGHTED SOUND REDUCTION FIGURE |
|---------------------------|-----------------------------------------------|
| Masonry                   | $R_w$ 51 dB                                   |
| Roof                      | $R_w$ 31 dB                                   |

Table 6.1– Assumed minimum sound insulation performance of existing non-glazed elements of external building fabric

- 6.1.3 On the basis of the measured noise levels at the proposed building facades, the required minimum acoustic performance of glazing and ventilation units has been determined. This assessment has considered both the daytime and night-time average and typical maximum noise levels in habitable rooms.
- 6.1.4 Suitable internal noise levels in all noise-sensitive rooms can be achieved where all glazed and background ventilation elements meet the minimum sound insulation specifications shown below.

| NON-GLAZED FACADE ELEMENT                                       | GLAZING SPECIFICATION    | TRICKLE VENTILATION SPECIFICATION |
|-----------------------------------------------------------------|--------------------------|-----------------------------------|
| Plots 1,2,3,4 Bedrooms                                          | $R_w$ 30 dB              | $D_{n,ew}$ 27 dB                  |
| Plots 1,2,3,4<br>Kitchen/Living/Dining<br>Spaces and Games Room | No minimum specification | No minimum specification          |

Table 6.2 – Minimum sound insulation performance of proposed glazing and trickle ventilators

- 6.1.5 It is anticipated that these specifications will be met with thermal double-glazed windows and standard trickle ventilators of a suitable specification.
- 6.1.6 Where trickle ventilators are utilised for background ventilation, the above performance specification is denoted on the basis on of a single vent per room. If multiple vents are required, the individual performance requirement will increase by a value equal to  $+10\log(N)$ , with N being the total number of vents serving the room.
- 6.1.7 With regards to overheating, Approved Document O will require the developer to comply with the requirements to mitigate overheating as follows:

*“3.2 In locations where external noise may be an issue (for example, where the local planning authority considered external noise to be an issue at the planning stage), the overheating mitigation strategy should take account of the likelihood that windows will be closed during sleeping hours (11pm to 7am).”*

*3.3 Windows are likely to be closed during sleeping hours if noise within bedrooms exceeds the following limits.*

*a. 40dB  $L_{Aeq,T_1}$  averaged over 8 hours (between 11pm and 7am).*

*b. 55dB  $L_{AFmax}$ , more than 10 times a night (between 11pm and 7am).*

*3.4 Where in-situ noise measurements are used as evidence that these limits are not exceeded, measurements should be taken in accordance with the Association of Noise Consultants' Measurement of Sound Levels in Buildings with the overheating mitigation strategy in use.”*

- 6.1.8 Owing to the external average nighttime noise levels at the Site, largely determined by the evening and morning ‘shoulder’ periods, it is not appropriate to use the ‘Simplified Method’, as detailed in ADO. A dynamic thermal model (conducted by others) will be required for all bedrooms, the outcomes of which will likely allow partially open windows to form part of the overheating strategy, depending on detailed acoustic design.

- 6.1.9 It should be noted that, for bedrooms on the southern façades of the proposed dwellings, the ability to apply the Simplified Method is a borderline case and may be reviewed by the Building Control Body.

## 6.2 GROUNDBORNE NOISE AND VIBRATION

- 6.2.1 Results from the environmental vibration survey highlight that the vibration levels from the railway line adjacent to the site are lower than levels that pose a low probability of adverse comment at both daytime and nighttime periods.

- 6.2.2 No further mitigation is required.

## 6.3 GOOD ACOUSTIC DESIGN

- 6.3.1 Good acoustic design has been considered within this proposal, summarised in the following elements:

- Maximising Separation: Proposed dwellings are not positioned at the northern boundary, instead being set back and provided with a buffer zone to the railway line, as shown in site plan AS13511/SP1.
- Site Layout – External Amenity Spaces: External amenity spaces are situated to the rear of the properties and subsequently benefit from increased distance attenuation from train noise from the railway. This design also allows for building mass screening from the dwellings themselves to further reduce noise levels within the external amenity spaces.
- Site Layout – Orientation: Internal dwelling layouts are designed such that bedrooms are not situated on the second floor which has a greater line of sight to the railway line.
- Façade Insulation Design: Non-glazed building elements of suitable materials and mass have been proposed for dwellings across the site, where all facades are constructed from masonry, with casement double-glazed window units.

## 7.0 CONSTRUCTION AND VEHICLE NOISE

- 7.1 Construction noise impacts have been considered in relation to their effect on surrounding residential receptors.
- 7.2 There is potential for temporary adverse noise effects on the closest existing residential receptor during Site demolition and construction. Effects will be of greater significance where activities take place close to the western Site boundary, adjacent to the existing residential dwelling.
- 7.3 Mitigation and management of noise sources in the form of best site practice should be included in a Construction Environmental Management Plan, and submitted for approval, and appropriate site hoarding will result in these effects being sensitively managed. This will include elements such as:

#### 7.4 ATTITUDE TO THE SITE OPERATOR

- 7.4.1 In conjunction with effective communication of site activities and scheduling, liaison with local residents is essential in cultivating a positive attitude in the community. A dedicated telephone number and designated staff contact should be made available to respond to any complaints or queries, with a messaging service for out of hours enquiries. Information on current and forthcoming activities should be made as freely available as possible.

#### 7.5 NOISE CHARACTERISTICS

- 7.5.1 Some noisy activities are particularly intrusive due to tonal or impulsive characteristics which tend to draw more attention to their operation. Typical examples of this are piling noise and heavy-duty percussive breakers. Awareness of these issues is important in liaison with local residents.

#### 7.6 CONTRACTOR'S OBLIGATIONS

- 7.6.1 In order to minimise and manage noise and vibration impacts at neighbouring properties, the Contractor will;
- Erect an appropriate site hoarding around the site comprising a continuous and impermeate barrier material, ideally having minimum 8kg/m<sup>2</sup> superficial density;
  - Facilitate an early community involvement exercise with neighbours to establish and agree protected areas of their properties and then to continually update progress and forewarn of impending noisy works. A member of onsite staff should be designated as community relations manager to maintain good communications with neighbours;
  - At all times and subject to availability, select and use quietest plant, machinery and vehicles appropriate for the task being undertaken will be used at all times. All vehicles and mechanical plant used for the purpose of the works will be fitted with effective exhaust silencers, will be maintained in good and efficient working order and operated in such a manner as to minimise noise emissions;
  - Employ at all times the Best Practicable Means (BPM), as defined in Section 72 of the Control of Pollution Act 1974, to reduce noise (including vibration) to a minimum, with reference to the general principles contained in British Standard BS5228;
  - Adopt and adhere to agreed 'on' and 'off' times for noisy works and/or vibration sources;
  - Operate a 'considerate builder' type scheme in which a commitment is made, amongst others, to undertake proper maintenance of equipment, control use of radios on site, site equipment with due consideration to proximity of neighbours and ensure it is turned off when not in use.

- 7.7 Vibration from Site construction is not likely to result in significant effects.

## 8.0 OPERATIONAL NOISE

- 8.1 The new dwellings are single family residences and, as such, will create a typical domestic soundscape. Given the location of the Site, and upon consideration of the future development across the South Wokingham Strategic Development Location, such sounds will not be incompatible with the local acoustic environment.
- 8.2 Noise effects from the occupied development would be restricted to an increase in vehicle movements along the private access road leading from Finchampstead Road and within the driveways of the dwellings and closing of car doors. The proposed tarmac access road surface will serve to reduce vehicle noise in comparison to the likes of gravel or crushed stone.
- 8.3 It is anticipated that the impact of this increase in vehicular movements will be insignificant when considering the context of the local acoustic climate.

## 9.0 CONCLUSION

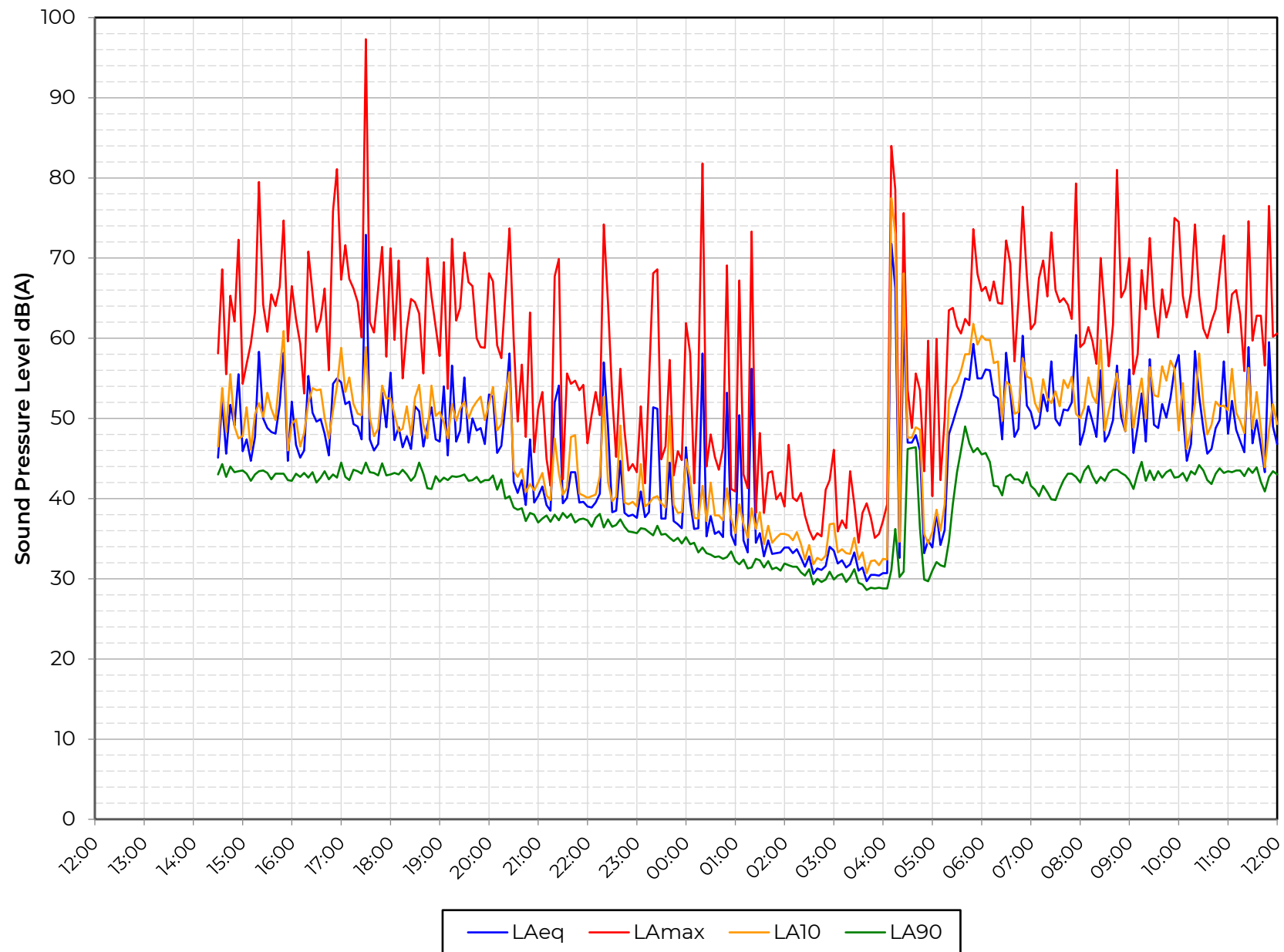
- 9.1 Planning approval is being sought for the demolition of an existing dwelling and redevelopment of land located at 58 Finchampstead Road. The redevelopment is to comprise 4 no. proposed residential dwellings with associated access and parking facilities.
- 9.2 Due to the Site's proximity to a railway line, Wokingham Borough Council has requested a noise impact assessment to support the planning application.
- 9.3 Sound reduction performances have been specified for glazing and passive background ventilators. Desirable internal ambient noise levels are expected to be achieved within the dwellings, where the acoustic performance specification is complied with.
- 9.4 Analysis of noise and vibration from the adjacent railway line has been undertaken. Measured survey data shows that levels of vibration are sufficiently low that they represent a low probability of adverse comment on the proposed residential dwellings.
- 9.5 The impact of construction and vehicle noise has been considered and adoption of an appropriate Construction Environmental Management Plan is recommended to minimise and manage impacts.

Matt Sugden

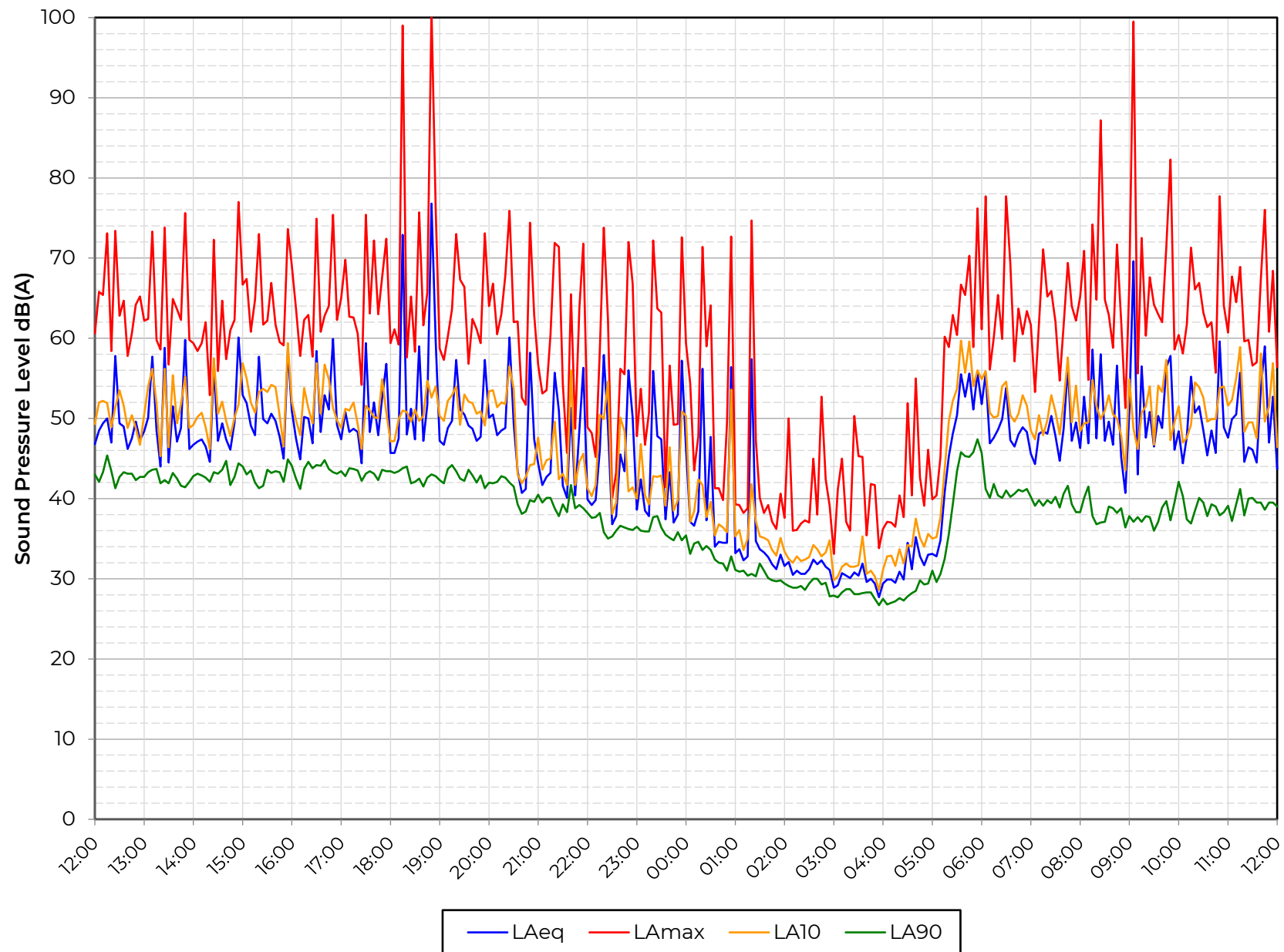
Matt Sugden MIOA  
CLARKE SAUNDERS ACOUSTICS



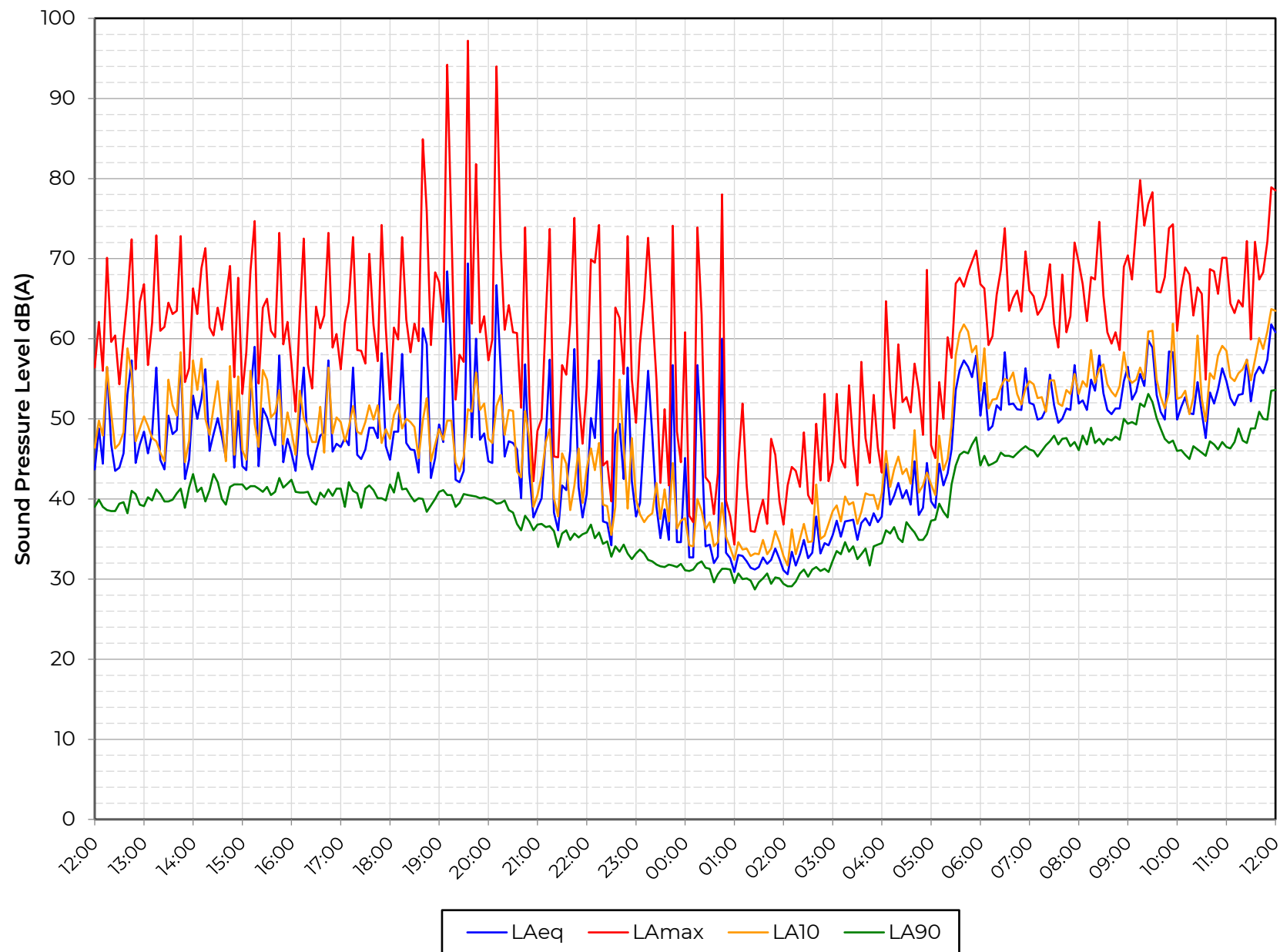
**Position LT1**



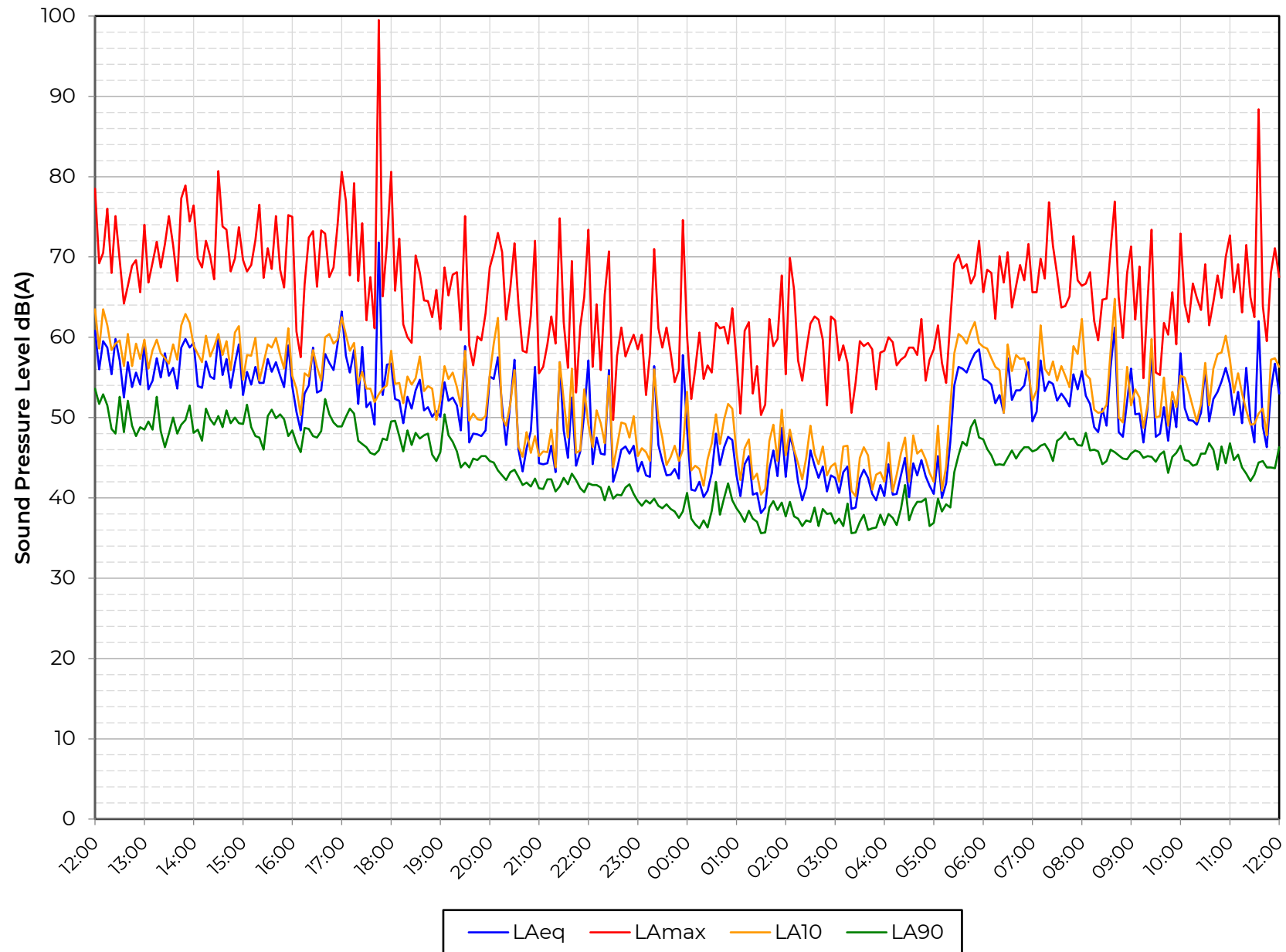
**Position LT1**



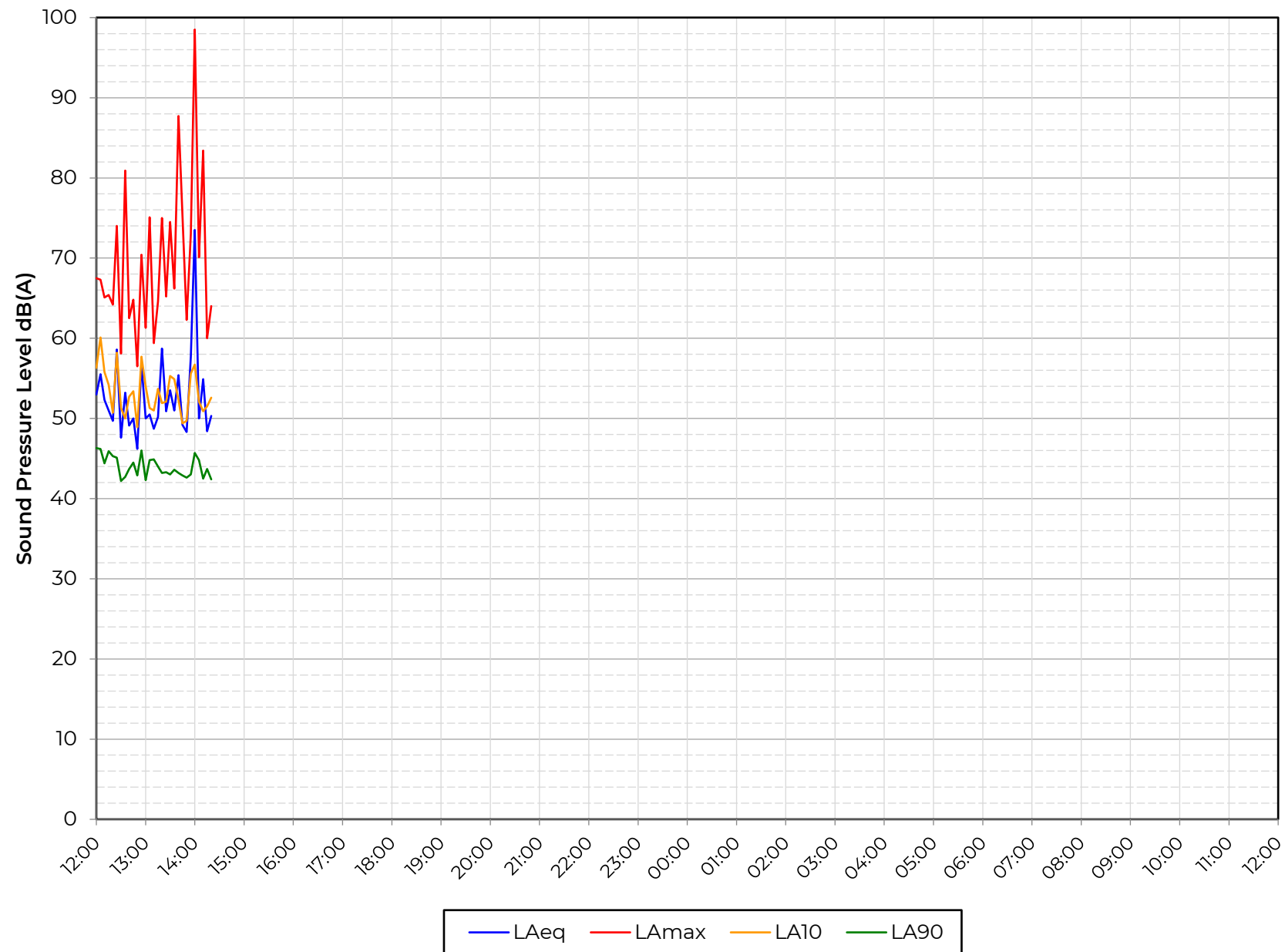
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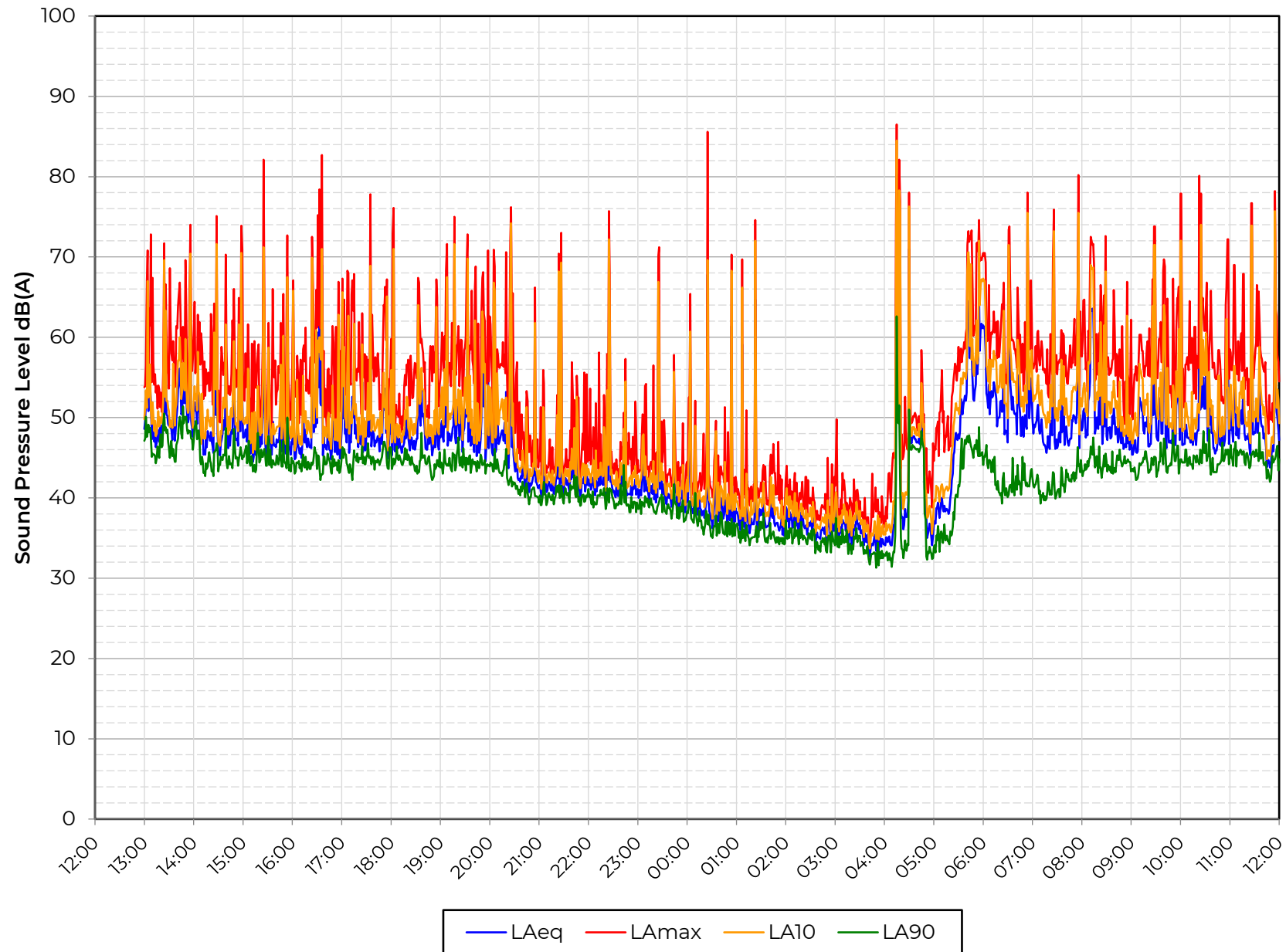
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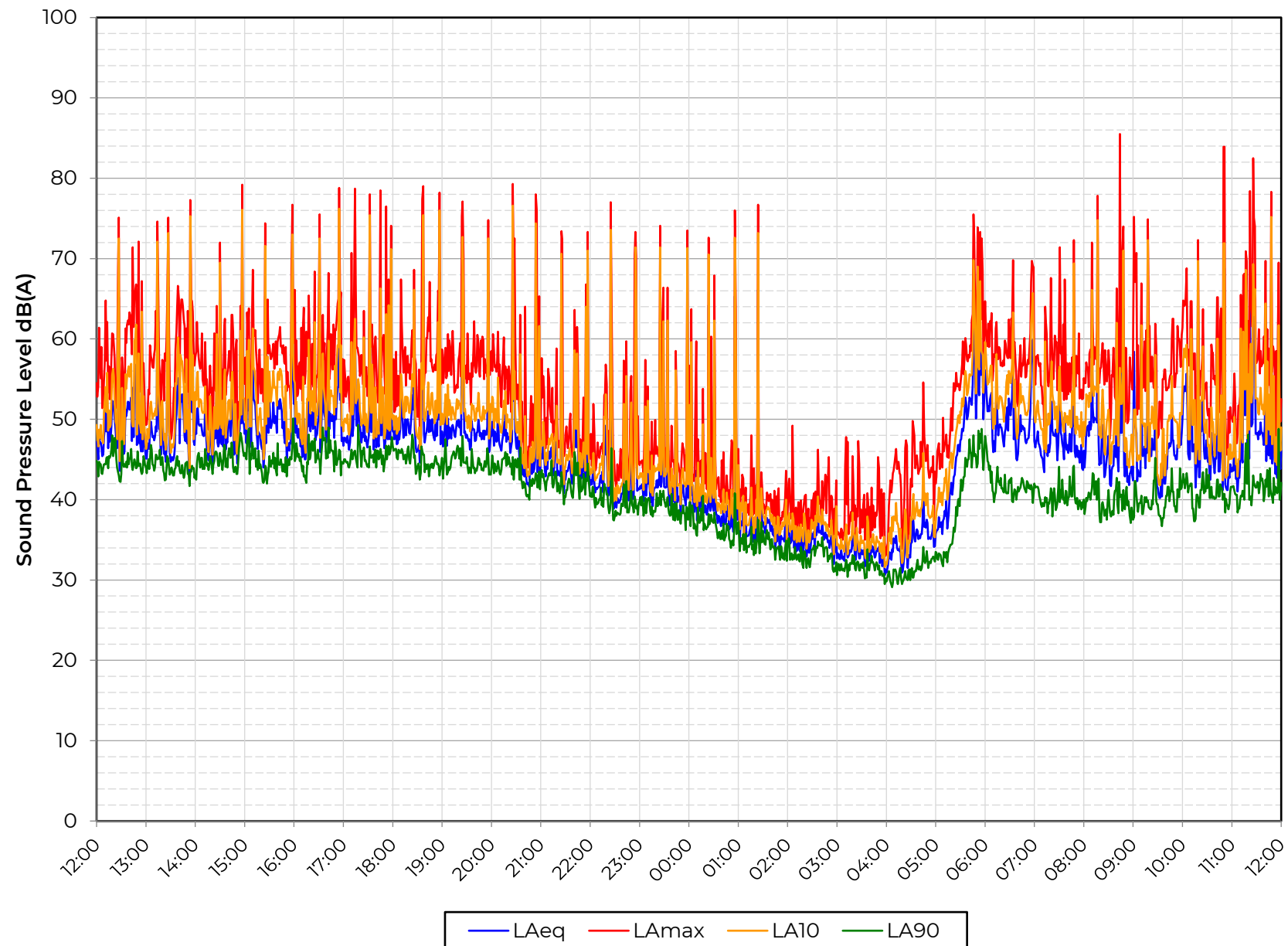
**Position LT1**



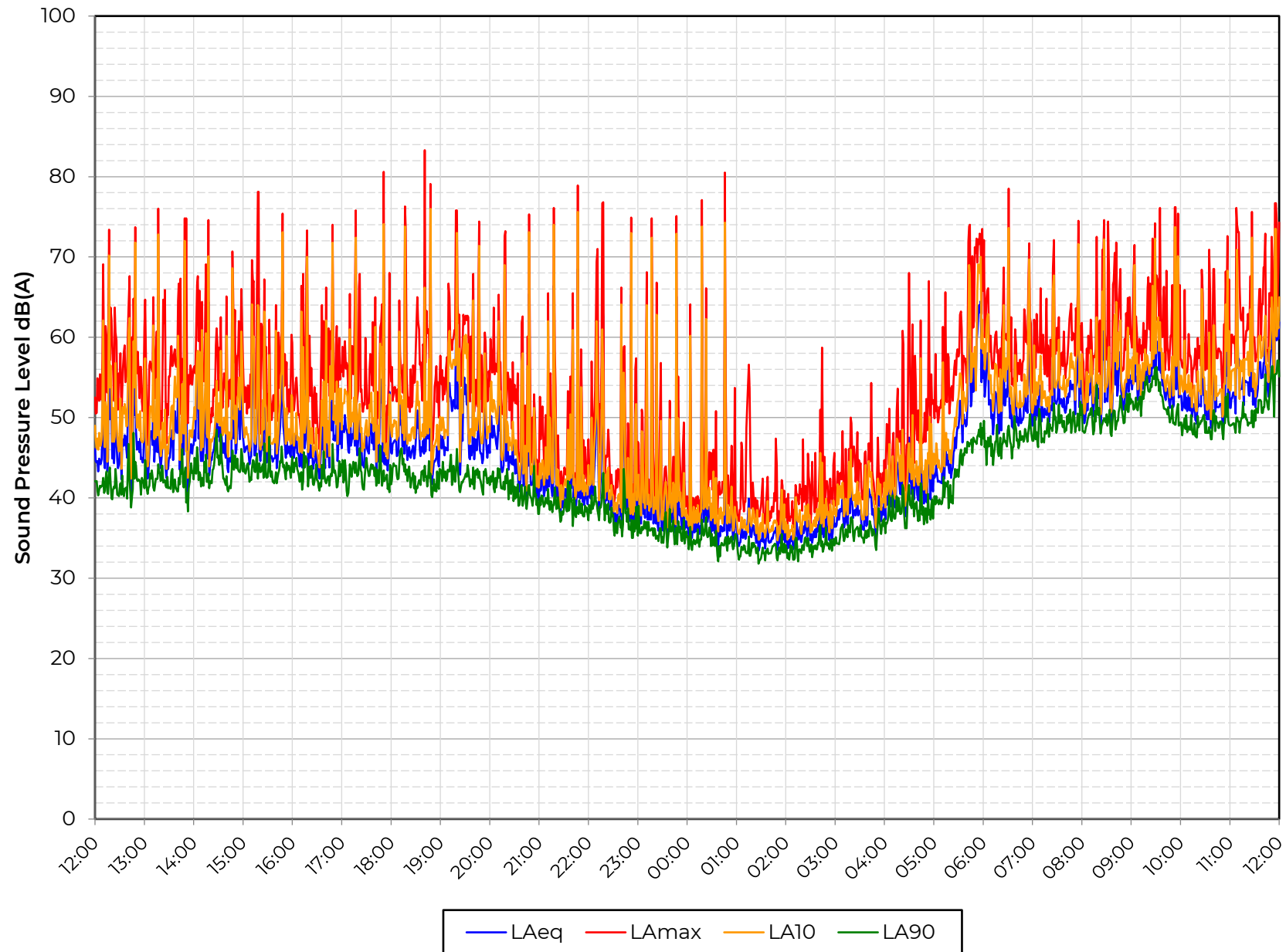
**Position LT2**



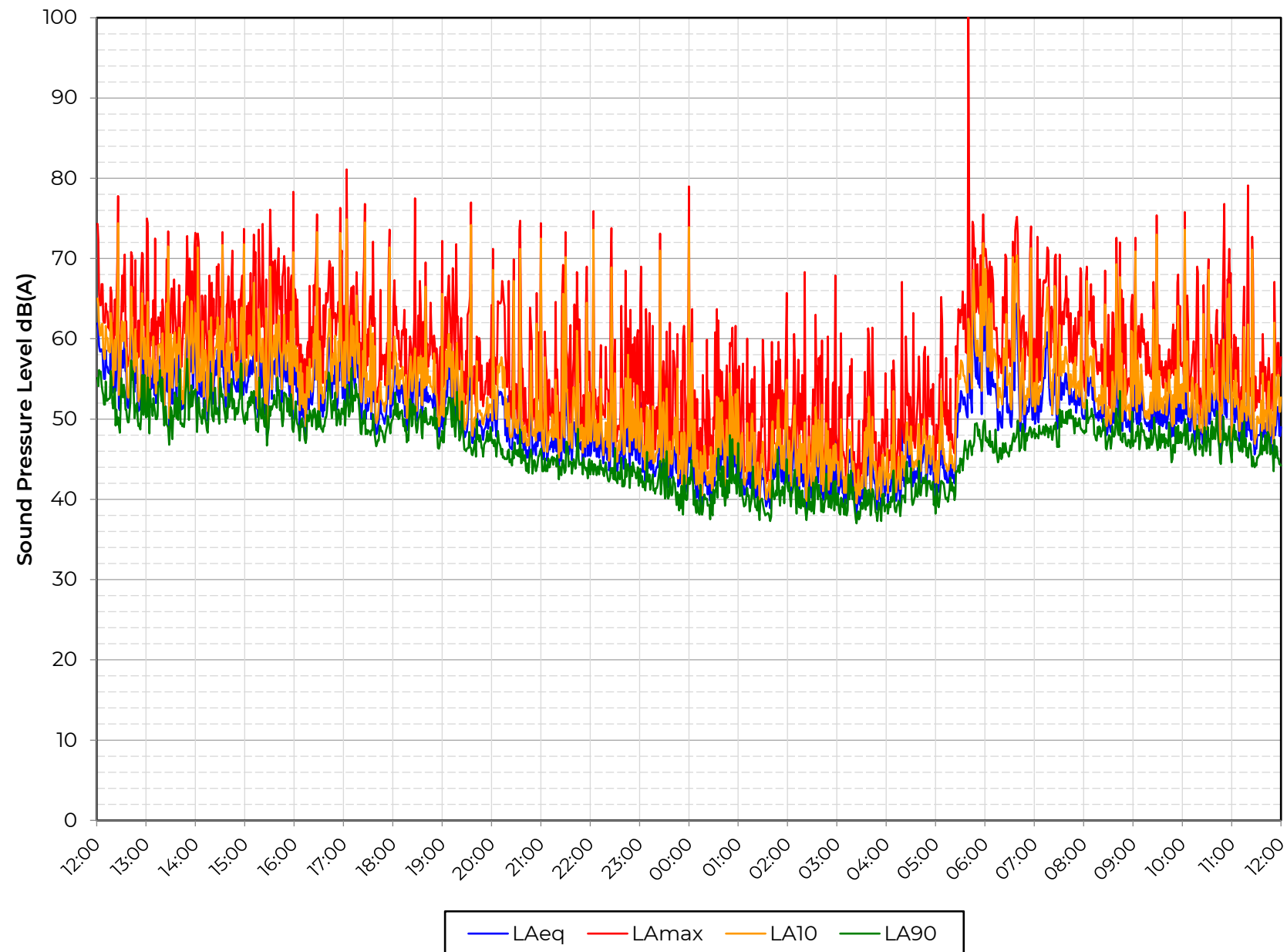
**Position LT2**



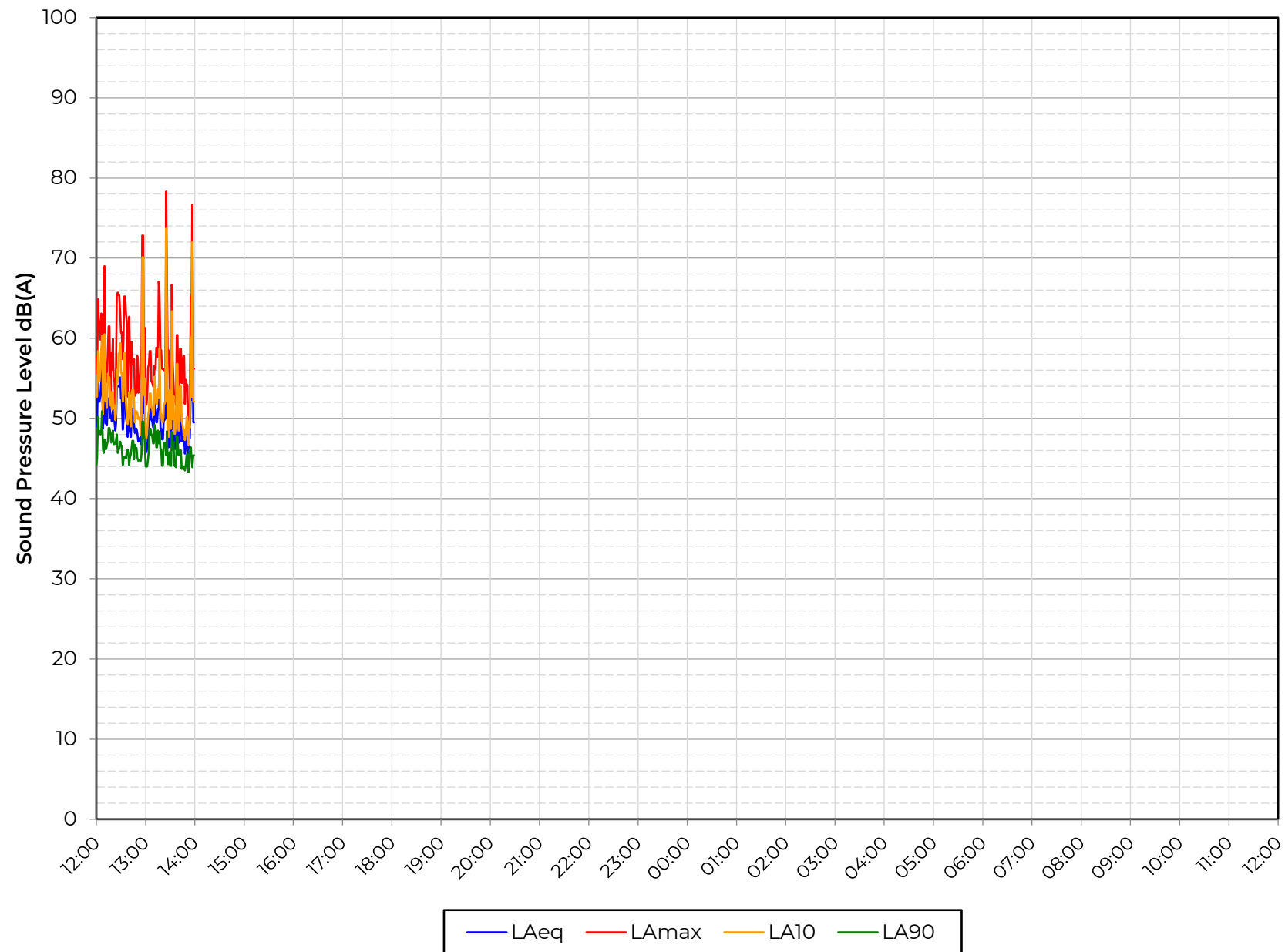
**Position LT2**



**Position LT2**



**Position LT2**



### Acoustic Terminology

The human impact of sounds is dependent upon many complex interrelated factors such as 'loudness', its frequency (or pitch) and variation in level. In order to have some objective measure of the annoyance, scales have been derived to allow for these subjective factors.

|                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Sound</b>                                          | Vibrations propagating through a medium (air, water, etc.) that are detectable by the auditory system.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Noise</b>                                          | Sound that is unwanted by or disturbing to the perceiver.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Frequency</b>                                      | The rate per second of vibration constituting a wave, measured in Hertz (Hz), where 1Hz = 1 vibration cycle per second. The human hearing can generally detect sound having frequencies in the range 20Hz to 20kHz. Frequency corresponds to the perception of 'pitch', with low frequencies producing low 'notes' and higher frequencies producing high 'notes'.                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>dB(A):</b>                                         | Human hearing is more susceptible to mid-frequency sounds than those at high and low frequencies. To take account of this in measurements and predictions, the 'A' weighting scale is used so that the level of sound corresponds roughly to the level as it is typically discerned by humans. The measured or calculated 'A' weighted sound level is designated as dB(A) or $L_A$ .                                                                                                                                                                                                                                                                                                                                                                                        |
| <b><math>L_{eq}</math>:</b>                           | <p>A notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (e.g. 8 hour, 1 hour, etc).</p> <p>The concept of <math>L_{eq}</math> (equivalent continuous sound level) has primarily been used in assessing noise from industry, although its use is becoming more widespread in defining many other types of sounds, such as from amplified music and environmental sources such as aircraft and construction.</p> <p>Because <math>L_{eq}</math> is effectively a summation of a number of events, it does not in itself limit the magnitude of any individual event, and this is frequently used in conjunction with an absolute sound limit.</p> |
| <b><math>L_{10}</math> &amp; <math>L_{90}</math>:</b> | <p>Statistical <math>L_n</math> indices are used to describe the level and the degree of fluctuation of non-steady sound. The term refers to the level exceeded for n% of the time. Hence, <math>L_{10}</math> is the level exceeded for 10% of the time and as such can be regarded as a typical maximum level. Similarly, <math>L_{90}</math> is the typical minimum level and is often used to describe background noise.</p> <p>It is common practice to use the <math>L_{10}</math> index to describe noise from traffic as, being a high average, it takes into account the increased annoyance that results from the non-steady nature of traffic flow.</p>                                                                                                          |
| <b><math>L_{max}</math>:</b>                          | The maximum sound pressure level recorded over a given period. $L_{max}$ is sometimes used in assessing environmental noise, where occasional loud events occur which might not be adequately represented by a time-averaged $L_{eq}$ value.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>NR</b>                                             | <i>Noise Rating</i> . A single figure noise level rating that takes into account the frequency content of an acoustic environment.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>R</b>                                              | <i>Sound Reduction Index</i> . Effectively the Level Difference of a building element when measured in an accredited laboratory test suite in accordance with the procedures laid down in BS EN ISO 10140-2:2010 and corrected for its size and the reverberant characteristics of the receive room.                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>D</b>                                              | The sound insulation performance of a construction is described in terms of the difference in sound level on either side of the construction in the presence of a sound source on one side and the reverberant characteristics of the adjoining 'receive' space. D is the arithmetic Level Difference in decibels between the                                                                                                                                                                                                                                                                                                                                                                                                                                               |

source and receive sound levels when filtered into frequency bands.

|                                                      |                                                                                                                                                                                                                                                                                                             |
|------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $D_{nT}$                                             | <i>Weighted Standardised Level Difference.</i> As defined in BS EN ISO 717-1, representing the Weighted Level Difference, when standardised for reference receiving room reverberant characteristics.                                                                                                       |
| $D_{n,e}$                                            | Normalised sound insulation of small building elements of fixed dimensions, such as vents, measured in an accredited laboratory test suite in accordance with the procedures laid down in BS EN ISO 10140-2:2010.                                                                                           |
| $D_{n,f}$                                            | Flanking sound insulation of lightweight elements, such as curtain wall mullions, measured in an accredited laboratory test suite in accordance with the procedures laid down in ISO 10848-2:2006                                                                                                           |
| $R_w$ $D_w$<br>$D_{nT,w}$ $D_{n,e,w}$<br>$D_{n,f,w}$ | Value of parameter, determined as above, but weighted in accordance with the procedures laid down in BS EN ISO 717-1 to provide a single-figure value.                                                                                                                                                      |
| $C, C_{tr}$                                          | Spectral adaptation terms to be added to a single number quantity such as $D_{nT,w}$ , to take account of the sound insulation within frequency ranges of particular interest.                                                                                                                              |
| $L'_{nT,w}$                                          | <i>Weighted Standardised Impact Sound Pressure Level</i> as defined in BS EN ISO 717-2, representing the level of sound pressure when measured within a space where the floor above is under excitation from a calibrated tapping machine, standardised for the receiving room reverberant characteristics. |
| $\Delta L_w$                                         | Change in impact sound pressure level when a floor is fitted with a 'soft' or resilient covering, as measured in an accredited laboratory test suite in accordance with the procedures laid down in BS EN ISO 10140-3:2010.                                                                                 |

## Octave Band Frequencies

In order to determine the way in which the energy of sound is distributed across the frequency range, the International Standards Organisation has agreed on "preferred" bands of frequency for sound measurement and analysis. The widest and most commonly used band for frequency measurement and analysis is the Octave Band.

In these bands, the upper frequency limit is twice the lower frequency limit, with the band being described by its "centre frequency" which is the average (geometric mean) of the upper and lower limits, e.g. 250 Hz octave band extends from 176 Hz to 353 Hz. The most commonly used octave bands are:

|                                    |    |     |     |     |      |      |      |      |
|------------------------------------|----|-----|-----|-----|------|------|------|------|
| Octave Band Centre<br>Frequency Hz | 63 | 125 | 250 | 500 | 1000 | 2000 | 4000 | 8000 |
|------------------------------------|----|-----|-----|-----|------|------|------|------|

## Human Perception of Broadband Noise

Because of the logarithmic nature of the decibel scale, it should be borne in mind that sound levels in dB(A) do not have a simple linear relationship. For example, 100dB(A) sound level is not twice as loud as 50dB(A). It has been found experimentally that changes in the average level of fluctuating sound, such as from traffic, need to be of the order of 3dB before becoming definitely perceptible to the human ear. Data from other experiments have indicated that a change in sound level of 10dB is perceived by the average listener as a doubling or halving of loudness. Using this information, a

# APPENDIX A

## ACOUSTIC TERMINOLOGY AND HUMAN RESPONSE TO BROADBAND SOUND

guide to the subjective interpretation of changes in environmental sound level can be given.

### INTERPRETATION

| Change in Sound Level dB | Subjective Impression                             | Human Response   |
|--------------------------|---------------------------------------------------|------------------|
| 0 to 2                   | Imperceptible change in loudness                  | Marginal         |
| 3 to 5                   | Perceptible change in loudness                    | Noticeable       |
| 6 to 10                  | Up to a doubling or halving of loudness           | Significant      |
| 11 to 15                 | More than a doubling or halving of loudness       | Substantial      |
| 16 to 20                 | Up to a quadrupling or quartering of loudness     | Substantial      |
| 21 or more               | More than a quadrupling or quartering of loudness | Very Substantial |

### Earth Bunds and Barriers - Effective Screen Height

When considering the reduction in sound level of a source provided by a barrier, it is necessary to establish the "effective screen height". For example if a tall barrier exists between a sound source and a listener, with the barrier close to the listener, the listener will perceive the sound as being louder if he climbs up a ladder (and is closer to the top of the barrier) than if he were standing at ground level. Equally if he sat on the ground the sound would seem quieter than if he were standing. This is explained by the fact that the "effective screen height" is changing with the three cases above. In general, the greater the effective screen height, the greater the perceived reduction in sound level.

Similarly, the attenuation provided by a barrier will be greater where it is aligned close to either the source or the listener than where the barrier is midway between the two.