



BEROL QUARTER

Vibration Impact Assessment

WSP

BEROL QUARTER LIMITED

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Berol Quarter Limited

BEROL QUARTER

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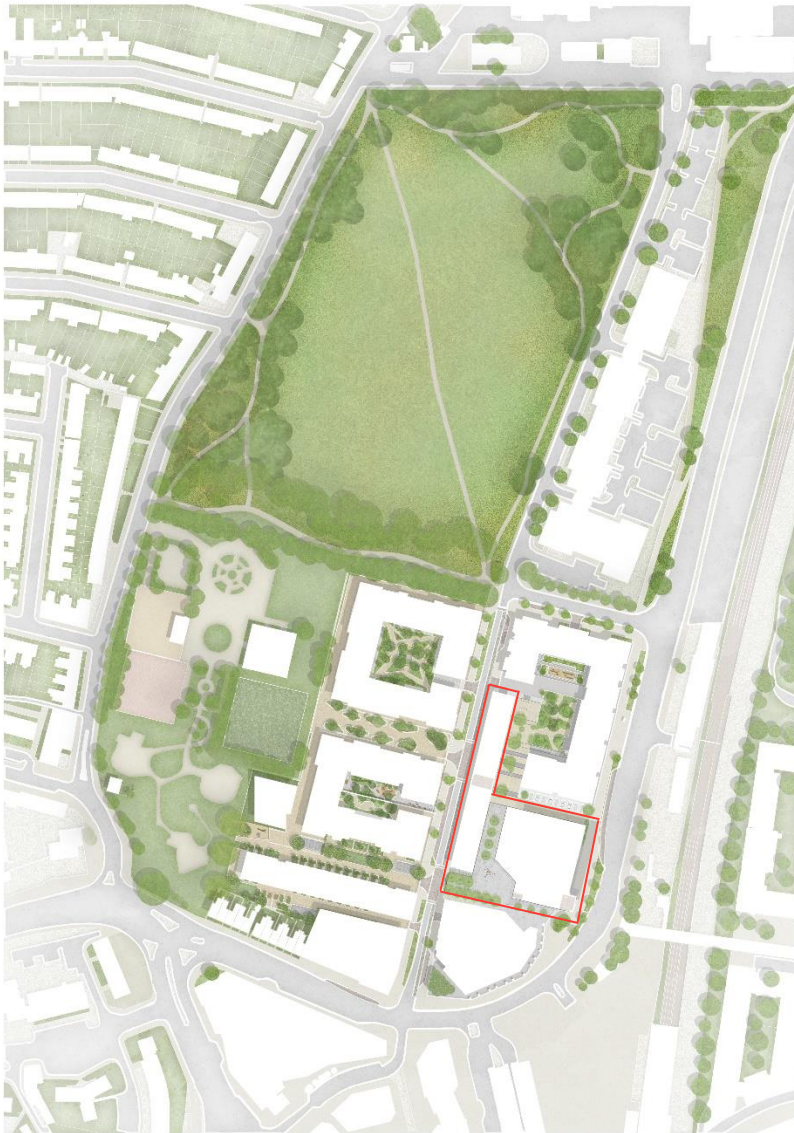
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ACOUSTICS GLOSSARY

1 INTRODUCTION

- 1.1.1. WSP has been commissioned by Berol Quarter Limited (the ‘Applicant’) to carry out a Vibration Impact Assessment for the proposed mixed-use development at Berol Quarter, Ashley Road, Tottenham Hale. The site falls under the jurisdiction of the London Borough of Haringey (LBH).
- 1.1.2. The site is bounded by Watermead Way to the east with the Greater Anglia railway line approximately 55m from the site boundary, a newly constructed residential building called The Gessner to the north-east, Cannon Factory to the north which has planning permission for new homes, Ashley Road to the west, and a construction site to the south for the Tottenham Hale Centre development. The nearest existing and future sensitive receptors to the site include The Gessner to the north-east, the Cannon Factory to the north, and the development plots of Ashley Gardens, Ashley House and Ashley Park to the west on the opposite side of Ashley Road. The location of the site is illustrated on Figure 1-1.

Figure 1-1 – Site location plan



- 1.1.3. This report is intended to support the full planning application to LBH for the refurbishment and extension of Berol House to include Use Class E floorspace and the development of 2 Berol Yard to provide new residential homes, Use Class E floorspace and associated landscaping, public realm improvements, car and cycle parking and other associated works.
- 1.1.4. This report presents the results of the baseline vibration survey undertaken to establish the existing vibration climate at the site. The results have been used to assess the suitability of the site for the proposed residential use within 2 Berol Yard in accordance with the relevant criteria.
- 1.1.5. A glossary of terms used in this report is provided in Appendix A.

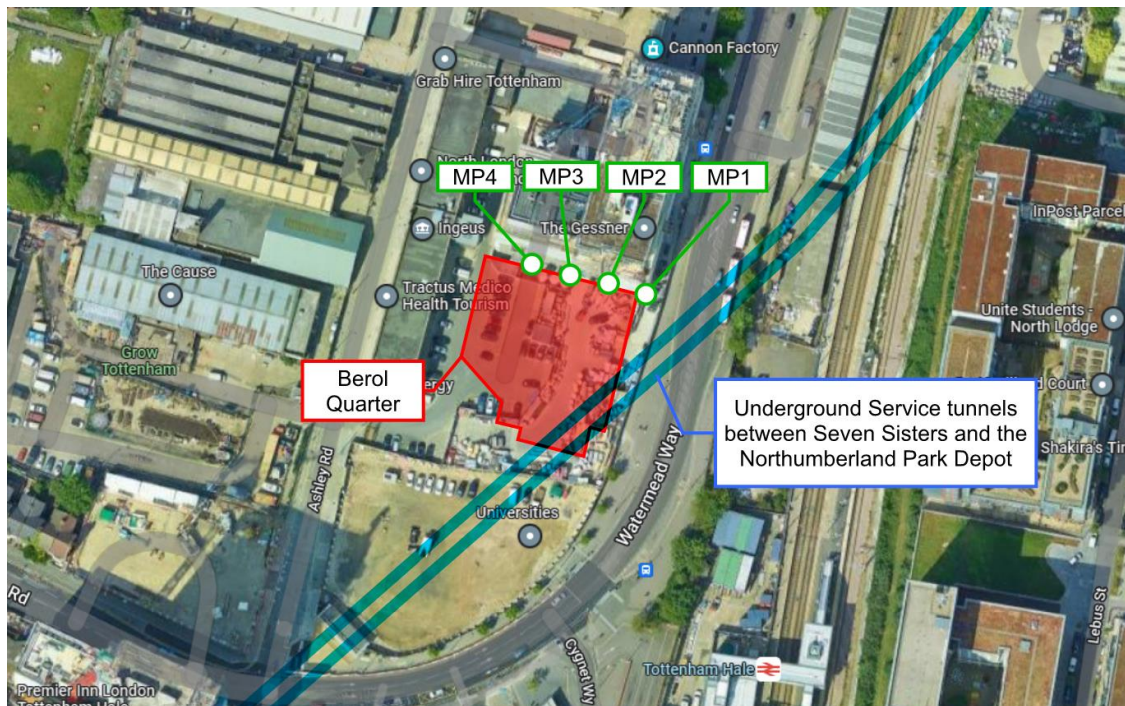
2 METHODOLOGY

- 2.1.1. Railway operations often give rise to high levels of vibration, which have the potential to be transmitted through the ground to nearby buildings. This type of vibration has the ability to travel throughout the building in floorplates and walls, causing plate-like structural elements to radiate noise into sensitive spaces. This can give rise to general annoyance, discomfort, potential sleep disturbance, and interference with specific activities.
- 2.1.2. The degree to which rail-induced vibration levels impact on the building occupants is mainly a function of the building design, construction type and distance between the rail tunnel and the foundation of the building. Modern construction tends to rely on complex lightweight structures centred on stronger, more lightly damped, materials (e.g. pre-stressed concrete, steel frames and fewer joints) raising the building's responsiveness.
- 2.1.3. Countermeasures may turn out to be highly complex, often incurring significant additional costs to the development, not only financially, but also in terms of design impact, constructability and maintenance.
- 2.1.4. To effectively assess the rail-induced vibration impact, WSP breaks down the assessment into two stages:
 - 1 **General Assessment** – a high-level assessment which aims to identify sensitive areas which may be under the influence of adverse effects from rail-induced vibration. For this assessment stage, the methodology relies on site measurements coupled with generic transfer functions empirically established. In order to ensure that potential affected buildings will be considered for the detailed stage this assessment adopts a slightly conservative approach (i.e. transfer functions will be selected to overpredict the rail-induced vibration effects).
 - 2 **Detailed Assessment** – to enhance the assessment's accuracy and to examine the extent of the vibration effects, the "detail assessment" recommends to investigate the expected vibration climate at the proposed building by considering all relevant structural elements of the building's design.
- 2.1.5. The current Vibration Impact Assessment is a **General Assessment** for the proposed development at Berol Quarter.

2.1 SURVEY PROCEDURE

- 2.1.1. In order to quantify and characterise the vibration caused by train pass-by events at Berol Quarter, a measurement survey was conducted on-site between 10:50-14:30 on 26 October 2022.
- 2.1.2. Tri-axial vibration time-history measurements were taken at the four positions shown in Figure 2-1, using an 01dB Metravib db04 V01 multi-channel analyser and Sinus triaxial geophone.
- 2.1.3. In total, 20 train pass-by events were recorded during the survey – this satisfies ISO 14837-31 recommendation that at-least 5 train pass-bys are recorded to obtain a representative recording.

Figure 2-1 – Vibration measurement positions (green), in approximate relation to development site (red) and the underground service tunnels (blue)



2.2 BUILDING DESIGN

- 2.2.1. As shown in Figure 2-2, the new building will be a multi-storey tower (comprised of GF plus 30 storeys and lift overrun within core). The building does not feature a basement level.
- 2.2.2. The internal floors are poured concrete, with unknown span. It has been conservatively assumed that, being for residential use, individual floor spans will be small – this was found to yield a conservative outcome.
- 2.2.3. The building is to be constructed on piled foundations, however the locations of the piles themselves are currently unknown. It has, therefore, been assumed that each measurement has been conducted in very close locality to a piled foundation and, hence, the measured vibration levels at each position are equivalent to those exerted on the building foundation – i.e. no corrections have been applied to measurements to account for any propagation effects through the soil between the surveyed locations and piled foundations.

Figure 2-2 – Berol Quarter building design



2.3 VIBRATION SOURCES

- 2.3.1. The dominant vibration source affecting the new development is expected to be rail operation on the underground service tunnel between Seven Sisters and the Northumberland Park Depot. The relevant details of this excitation are specified in Table 3-1.
- 2.3.2. Following consultation with Transport for London, it is understood trains do not operate to a timetable in this underground service tunnel. Up-to nine trains were identified in a one-hour period during a pre-scoping survey – on the assumption that this is representative of a typical hour, it has been deduced that there are approximately 144 train events during a typical daytime period (07:00 – 23:00) and 72 train events during a typical night-time period (23:00 – 07:00).
- 2.3.3. The duration of a typical train pass-by is assumed to be 40 seconds, based upon the measured vibration data.

Table 3-1 – Details of vibration source used within analysis

Source	Train Pass-Bys (Day: 07:00-23:00)	Train Pass-Bys (Night: 07:00-23:00)	Average Duration of Train Pass-By
Underground service tunnel between Seven Sisters and the Northumberland Park Depot	144 (Assumed)	72 (Assumed)	40 (Assumed)

2.4 ANALYSIS PROCEDURE

- 2.4.1. As per the BS 6472-1:2008 guidance relating to human exposure to vibration, results should be presented as a vibration dose value (VDV). Frequency weighting has been applied to the vibration measurements, such that the results correspond to the frequency response of the human body. BS 6472-1:2008 requires W_b frequency-weighting for vertical motion for occupants within buildings – as defined in BS 6841:1987.
- 2.4.2. As VDV's are dictated primarily by the magnitude of vibration, rather than the duration or number of occurrences, a conservative assessment was obtained by analysing the “worst-case” train pass-by event at each measurement location – this artificial extreme result was generated by extracting the maximum vibration level at each 1/3 octave frequency band across all measured train pass-by events at the location.
- 2.4.3. For regularly repeated and consistent excitation, as is expected to be the case for the current rail excitation, an equivalent VDV can be estimated for periods extending beyond the measurement duration (e.g. day-time and night-time) – this is calculated by extrapolating individual measurements to all train pass-by events within the given period. In the current analysis, eVDVs (i.e. VDV computed from data given in the frequency domain) were calculated for the day-time and night-time periods, based on the details provided in Table 3-1.
- 2.4.4. The dynamic response of the new building was predicted by undertaking calculations based upon: a representative event belonging to the worst-case set of vibration events; the relative positioning of the measurement equipment, foundations and rail; the ground make-up; foundation and structure design; and generic structural dynamic trends described in scientific publications¹.
- 2.4.5. This enabled the ground-borne tactile vibration (given as VDV) and noise (given as L_{ASmax}) to be predicted on the ground floor and first-floor level (first suspended floor level which is taken to be the most affected level). The following corrections were applied to subsequent building levels, accounting for attenuation within building structure²:
 - **Ground-borne vibration (eVDV):** Reduce by 45% for second and third suspended floors and 30% for each further level.
 - **Ground-borne noise (L_{ASmax}):** Reduce by 2.5 dB per floor for second and third suspended floors 1.5 dB for each further level.

¹ Such publications include: Saurenman and Nelson (A Prediction Procedure for Transportation Groundborne Noise and Vibration, Transport Research Record 1143, USFTA) and Villot et al (Procedures to Predict Exposure in Buildings and Estimate Annoyance, a report from the RIVAS (Railway Induced Vibration Abatement Solutions) collaborative project).

² Whilst the applied corrections are considered to provide an appropriate approximation of vibration attenuation in the current structure, further accuracy could be obtained with detailed simulation and/or measurement within the final structure. WSP can provide further details and/or quotation for these extended scopes, if required.

2.5 ASSESSMENT CRITERIA

- 2.5.1. WSP is not aware of any specific ground-borne vibration requirements within the associated Planning Policy documents. Hence, typical assessment criteria have been applied.

GROUND-BORNE VIBRATION

- 2.5.2. BS 6472-1:2008 contains VDV ranges for multiple sensitive spaces that might result in various probabilities of adverse comment (i.e. complaint), as provided in Table 3-2 and Table 3-3. The guidance relates to vibration measured at the point of entry into the human body, which is usually taken to mean the ground surface or at a point mid-span of an upper storey floor, rather than the point of entry into the building (e.g. a foundation element). In WSP's experience, disturbance or annoyance from vibration in residential situations is likely to arise when the magnitude of vibration is only slightly in excess of the threshold of perception.

Table 3-2 – VDV day (16h) ranges which might result in various probabilities of adverse comment

Sensitivity Classification	Complaint Improbable ($\text{ms}^{-1.75}$) ³	Complaint Possible ($\text{ms}^{-1.75}$)	Complaint Probable ($\text{ms}^{-1.75}$) ⁴
High (e.g. Residential)	0.20 to 0.40	0.40 to 0.80	0.80 to 1.60
Mid (e.g. Office)	0.40 to 0.80	0.80 to 1.60	1.60 to 3.20
Low (e.g. Retail)	0.80 to 1.60	1.60 to 3.20	3.20 to 6.40

Table 3-3 – VDV night (8h) ranges which might result in various probabilities of adverse comment

Sensitivity Classification	Complaint Improbable ($\text{ms}^{-1.75}$) ³	Complaint Possible ($\text{ms}^{-1.75}$)	Complaint Probable ($\text{ms}^{-1.75}$) ⁴
High (e.g. Residential)	0.10 to 0.20	0.20 to 0.40	0.40 to 0.80

³ Below these ranges adverse comment is not expected.

⁴ Above these ranges adverse comment is very likely.

GROUND-BORNE NOISE

- 2.5.3. The ANC Guidelines recommend using the criteria adopted by the US Federal Transit Administration (USFTA) “Transit Noise and Vibration Impact Assessment”. According to the USFTA guidelines, the human response to different levels of ground-borne noise is dependent on the spectral characteristics of the vibration. The corresponding limits are provided in Table 3-4.

Table 3-4 – USFTA Ground-borne Noise Guidelines

Human Response	Noise Level (L_{ASmax})	
	Low Frequency ⁵	Mid Frequency ⁶
Threshold of Perception Low frequency sound usually inaudible, mid frequency sound excessive for quiet sleeping areas.	25 dB	40 dB
Barely Perceptible Many people find transit vibration at this level unacceptable. Low frequency noise acceptable for sleeping areas, mid frequency noise annoying in most quiet occupied areas.	35 dB	50 dB
Distinctly Perceptible Low frequency noise unacceptable for sleeping areas, mid frequency noise unacceptable even for infrequent events with institutional land uses such as schools and churches.	45 dB	60 dB

- 2.5.4. The USFTA limits have been adopted by many rail operators and bodies in the UK, including London Underground, Crossrail, the Channel Tunnel Rail Link and some London local authorities.
- 2.5.5. The values quoted in Table 3-4 are designed to protect sensitive land uses such as residential accommodation, schools and places of worship. The following limits of perceptibility are usually set:
- **Residential:** Usually set at 35 to 40 dB L_{ASmax} . Most London Boroughs suggest a limit of 35 dB, whilst some rail operators opt for 40 dB.
 - **Office:** Most rail operators have adopted a limit of 40 dB L_{ASmax} .
 - **Retail:** It might be considered that limits could be relaxed beyond 40 dB L_{ASmax} .

⁵ Approximate noise level when peak in vibration spectrum is near 30 Hz.

⁶ Approximate noise level when peak in vibration spectrum is near 60 Hz.

2.6 ASSUMPTIONS

2.6.1. Where information was unavailable, WSP have applied the following assumptions:

- 1 The four measurement positions are each in very close locality a piled foundation and, therefore, the measured vibration levels at each position are equivalent to that transferred to the 2 Berol Yard building foundation.
- 2 The internal floors are concrete and of small span.
- 3 The dynamic response of the building will be that of a large masonry building, with typical attenuation².
- 4 144 train events occur during a typical daytime period (07:00 – 23:00) and 72 train events during a typical night-time period (23:00 – 07:00), with an average duration of 40 seconds.

3 GENERAL ASSESSMENT

- 3.1.1. WSP is not aware of any specific ground-borne vibration requirements within the Planning Policy. In order to determine suitable vibration assessment limits, the most sensitive use-case for each building level were determined. The corresponding assessment limits adopted within the current analysis are provided in Table 3-1.
- 3.1.2. In total, 20 train pass-bys were measured across the four surveyed positions. The “worst-case” train pass-by excitation and corresponding eVDVs calculated, assuming that the excitation occurs 144 times in day-time and 72 times in night-time. The vibration and structure-borne noise levels at each building level were then predicted, as provided in Table 3-2.
- 3.1.3. The analysis predicts that train pass-bys will be on the lower limit of perceptibility at residential properties on Level 01 and Level 02, where there is a low probability of adverse comment due to tactile vibration from Level 01 tenants during the day-time and the radiated noise may be perceptible on Level 01 and Level 02.
- 3.1.4. Ground-borne vibration and noise is predicted to be imperceptible on all other levels.
- 3.1.5. WSP do not consider these results to be overly concerning at this stage. In the first instance, it is recommended that the assumptions utilised within the current analysis are reviewed – as specified in Section 2.6. If required, a Detailed Assessment could be performed to more accurately predict the vibration response throughout the building and investigate possible isolation measures.

Table 3-1 – Assessment limits

Level	Most Sensitive Use-Case	Day-time Vibration eVDV day ($\text{ms}^{-1.75}$)	Night-time Vibration eVDV night ($\text{ms}^{-1.75}$)	Noise L_{ASmax} (dB)
Levels 01-30	Residential	0.20 to 0.40 Complaint Improbable	0.10 to 0.20 Complaint Improbable	35 Perceptible
Ground Floor	Retail	0.40 to 0.80 Complaint Improbable	N/A ⁷	~40 Perceptible

Table 3-2 – Predicted ground-borne vibration and noise levels

Level	Most Sensitive Use-Case	Day-time Vibration eVDV day ($\text{ms}^{-1.75}$)	Night-time Vibration eVDV night ($\text{ms}^{-1.75}$)	Noise L_{ASmax} (dB)
Levels 04-30	Residential	Level below $x0.7$ Acceptable	Level below $x0.7$ Acceptable	Level below -1.5 Acceptable
Level 03	Residential	0.05 Acceptable	0.02 Acceptable	34.7 Acceptable
Level 02	Residential	0.12 Acceptable	0.04 Acceptable	37.2 Perceptible
Level 01	Residential	0.21 Complaint Improbable	0.06 Acceptable	39.7 Perceptible
Ground Floor	Retail	0.05 Acceptable	0.06 Acceptable	30.5 Acceptable

⁷ Retail settings would be expected to be unoccupied during the night-time and, hence, specific vibration limits are not required.

4 CONCLUSIONS AND RECOMMENDATIONS

- 4.1.1. WSP has been commissioned by Berol Quarter Limited to undertake a vibration survey and assessment for the proposed mixed-use development at Berol Quarter.
- 4.1.2. A measurement survey was undertaken to assess ground-borne vibration caused by train pass-bys on the underground service tunnel between Seven Sisters and the Northumberland Park Depot. In total, 20 train pass-bys were measured across four surveyed positions.
- 4.1.3. The tactile vibration and re-radiated noise levels were calculated for each building level of 2 Berol Yard.
- 4.1.4. WSP is not aware of any specific ground-borne vibration requirements within the Planning Policy and, hence, appropriate assessment criteria have been applied – specifically, the ground-borne vibration and noise have been assessed against BS 6472-1:2008 and USFTA respectively.
- 4.1.5. The results indicate that train pass-bys could be on the lower limit of perceptibility at residential properties on Level 01 and Level 02, and imperceptible on all other levels.
- 4.1.6. WSP do not consider the current results to be overly concerning at this stage.
- 4.1.7. The following is recommended:
 - 1 The assumptions (as specified in Section 2.6) are regularly reviewed.
 - 2 For greater certainty or if concerns arise, a Detailed Assessment could be performed to more accurately predict the vibration response throughout the building and investigate possible isolation measures.

Appendix A

ACOUSTICS GLOSSARY



ACOUSTIC TERMINOLOGY

Table A1: Acoustic Glossary

Terminology	Description
Attenuation	A general term used to indicate the reduction of noise or vibration, or the amount (in decibels) by which it is reduced.
A-Weighting, dB(A)	The unit of sound level, weighted according to the A-scale, which takes into account the increased sensitivity of the human ear at some frequencies.
Damping	A general term used to describe the attenuation of sound or vibration via the material properties of the substance through which the sound or vibration is transmitted.
Decibel (dB)	A scale for comparing the ratios of two quantities, including sound pressure and sound power. The difference in level between two sounds s_1 and s_2 is given by $20 \log_{10} (s_1 / s_2)$. The decibel can also be used to measure absolute quantities by specifying a reference value that fixes one point on the scale. For sound pressure, the reference value is $20\mu\text{Pa}$.
Displacement, Acceleration and Velocity	Vibration is an oscillatory motion. The magnitude of vibration can be defined in terms of displacement (how far from the equilibrium position that something moves), velocity (how fast something moves), or acceleration (the rate of change of velocity). When describing vibration, one must specify whether peak values are used (i.e. the maximum displacement or maximum velocity) or r.m.s. values (effectively an average value) are used. Standards for the assessment of building damage are usually given in terms of peak velocity, whilst human response to vibration is often described in terms of r.m.s. acceleration.
Estimated Vibration Dose Value (eVDV)	An estimated value of the VDV, calculated according to a procedure defined in BS6472-1. The eVDV is often used as an approximation to the VDV in situations where there are regular occurrences of vibration, which are intermittent in nature but similar in magnitude, as would be the case for railway vibration.
Frequency (Hz), Frequency Spectrum	Sound and vibration from trains will occur over a range of frequencies (cycles per second, or Hz), referred to as the frequency spectrum. The range of human hearing can extend as low as 20Hz and as high as 16kHz. However, in the case of re-radiated noise from underground railways, the low frequencies (20 to 250Hz) are most significant. These low frequencies are usually perceived as a 'rumbling' sound.
Re-Radiated Noise (Structure-borne Noise, Ground-borne Noise)	These terms are used inter-changeably. When building elements or other structures are caused to vibrate, they can radiate noise. In the context of this report, re-radiated noise refers to the noise that may be heard from the vibrating building elements rather than any airborne noise from train movements. The terms re-radiated noise, structure-borne noise and ground-borne noise are often used interchangeably.
Root Mean Square (r.m.s.)	The r.m.s. value of a set of numbers is the square root of the average of the squares of the numbers. For a sound or vibration waveform, the r.m.s. value over a given time period is the square root of the average value of the square of the waveform over that time period.

Transfer Function	...of a vibrating system is the ratio of the output or response of the system to the input excitation, usually expressed as a complex function of frequency.
Vibration Dose Value (VDV)	This is a measure of the amount of vibration that is experienced over a specified period and has been defined so as to quantify the human response to vibration in terms of comfort and annoyance. The Vibration Dose Value is used to assess the likely levels of adverse comment about vibration and is defined mathematically as the fourth root of the time integral of the fourth power of the acceleration, after it has been frequency weighted to take into account the frequency response of the human body to a vibration stimulus. Measured in units of $\text{ms}^{-1.75}$.
Vibration Isolation	The reduction of vibration and structure borne sound by the use of resilient materials inserted in the transmission path between source and receiver.



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