



Project: J 02291
Rail Vibration Impact Assessment:
Residential Development, New Lane, Havant

Consultants: Sound Planning Ltd
48 Windermere Way
Farnham
Surrey
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Client: Airtight & NoiseCheck

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Signed:

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1.0 BACKGROUND

- 1.1 The proposal concerns the development of new residential dwellings on the A1 Recovery commercial site at 8 New Lane, Havant PO9 2JH.

See APPENDIX 2 – Site Location.

- 1.2 The site location is in close proximity to the Havant – Warblington, Havant – Rowlands Castle lines.

- 1.3 The site location falls under the jurisdiction of Havant Borough Council (HBC).

- 1.4 Sound Planning limited have been retained to conduct a vibration assessment and report in accordance with local and national planning requirements.

- 1.5 Relevant national standards and guidance should be referenced with regard to measurement methodology, measurement equipment and assessment criteria.

- 1.6 The measurement and assessment of vibration levels will be undertaken in accordance with BS 6472: 2008.

- 1.7 About the Author

1.7.1 Dan Thomas is a Member of the Institute of Acoustics (M.I.O.A) having attained appropriate qualifications in acoustics and experience within the workplace.

1.7.2 Dan has been working within the noise and vibration industry for ten years and has attained the following qualifications within the field of acoustics:

- Institute of Acoustics (IOA) Diploma
- Post Graduate Diploma in Applied Acoustics and Noise Control (University of Surrey)
- Masters Degree in Applied Acoustics and Noise Control (University of Surrey)



2.0 ASSESSMENT CRITERIA

The vibration assessment and acoustic report should be carried out in accordance with relevant standards and guidelines in conjunction with the Local Planning Authority's planning policies.

2.1 BS 6472-1:2008

2.1.1 *The way in which people perceive building vibration depends on various factors including the vibration frequency and direction. Different frequency weightings are required for different axes of motion... The weightings W_b (for vertical motion) and W_d (for horizontal motion) are defined in BS 6841¹.*

2.1.2 The effect of building vibration on the people within is assessed by finding the appropriate vibration dose. The Vibration Dose Value (VDV) is used to assess the acceptability of building vibration with respect to human response.

2.1.3 BS 6472 requires that the VDV be determined separately for the 16 hour daytime (0700 – 2300 hours) and 8 hour night time (2300 – 0700 hours).

2.1.4 VDV Calculation:

$$VDV_{b/d,day/night} = \left(\int_0^T a^4(t) dt \right)^{0.25}$$

Where:

$VDV_{b/d,day/night}$ is the vibration dose value (in $m \cdot s^{-1.75}$);

$a(t)$ is the frequency-weighted acceleration (in $m \cdot s^{-2}$), using W_b or W_d as appropriate;

T is the total period of the day or night (in s) during which vibration can occur.

¹ British Standard 6472: 2008 'Guide to evaluation of human exposure to vibration in buildings' supersedes the 1992 version of the standard.

2.1.5 The VDV is measured in each of the three whole-body orthogonal axes and the maximum from the three axes used. Where the vibration conditions are constant or regularly repeated only one representative period need be measured (or predicted) and the 16 hour daytime (or 8 hour night time) overall VDV level may be calculated from the shortened data.

2.1.6 Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings.

2.1.7 BS 6472 – Criteria Assessment Table

Place and time	² Low probability of adverse comment $\text{m}\cdot\text{s}^{-1.75}$	Adverse comment possible $\text{m}\cdot\text{s}^{-1.75}$	³ Adverse comment probable $\text{m}\cdot\text{s}^{-1.75}$
Residential buildings 16 hour day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8 hour night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

3.0 METHODOLOGY

3.1 Sound Planning conducted building vibration measurements in accordance with BS 6472: 2008.

3.2 Rail Vibration Assessment

3.2.1 Sound Planning conducted vibration measurements in accordance with BS 6472-1: 2008.

3.2.2 The Svantek Svan 958 (multi channel sound and vibration level meter) and Svan SV207 (Building Vibration Transducer Set) were securely fixed on a firm and level surface in a position representative of the nearest proposed residential dwelling (site boundary). Accelerations were measured and VDV calculated for daytime and night time human exposure based on the rail timetable.

² Below these ranges adverse comment is not expected.

³ Above these ranges adverse comment is very likely.



3.2.3 The total VDV for a defined period should be expressed:

$$[NV^4]^{0.25} = N^{0.25} \times V.$$

Where

$$V = VDV_{1 \text{ train}}$$

N = number of hours (or trains)

4.0 INSTRUMENTATION

4.1 Sound/Vibration Level Meters

Equipment	Make	Model	Class	Serial Number	Field Calibration
SLM	Svantek	958	1	23349	Yes
VLM	Svantek	SV207	1	22837	

4.2 Calibrators

Equipment	Make	Model	Class	Serial Number	UKAS Calibration
Field Calibrator	Casella	CEL 110/1	1	077948	U18561 (16/4/15)

The Sound Level Meter (SLM) was field calibrated before and after the on-site vibration measurements.

No deviation was detected (1kHz).

4.3 Other Equipment

Equipment	Make	Model	Class	Serial Number	UKAS Calibration
Environmental Tripod (1.5m)					
Laser Measurer	Leica	Disto A5		1073750838	
Digital Camera	Samsung				
Battery Kits					

5.0 RESULTS

5.1 Train Activity – Number of Trains (Tables 123, 156 & 165)

Operator	Direction			
	Easterly		Westerly	
	Day	Night	Day	Night
South West Trains	44	9	46	14
Southern Trains	30	3	25	4

5.2 Highest Vibration Levels

Operator	Direction	
	Easterly	Westerly
	VDV m/s ^{1.75}	VDV m/s ^{1.75}
South West Trains	0.03	0.03
Southern Trains	0.03	0.02



5.3 Calculated Vibration Levels

Operator	Direction – Total VDV m/s ^{1.75}			
	Easterly		Westerly	
	Day	Night	Day	Night
South West Trains	0.08	0.05	0.08	0.06
Southern Trains	0.07	0.04	0.04	0.03
Combined	0.09	0.05	0.08	0.06

5.4 Exposure Values (Easterly & Westerly Combined)

Daytime Exposure: 0.1 m/s^{-1.75}

Night Time Exposure: 0.07 m/s^{-1.75}

6.0 DISCUSSION

6.1 Freight Trains

Freight Liner – No current freight activity⁴

Direct Rail Services – No current freight activity⁵

6.2 Future Freight Train Activity

Due to no current activity, freight train vibration levels could not be measured; it would be advisable to reassess if the route becomes active again.

⁴ Reference – Freight Liner TEL: 02380 523902. Date 13 October 2015.

⁵ Reference Barry Earl – Direct Rail Services TEL: 01228 406600. Date 19 October 2015.



7.0 NOISE MITIGATION

7.1 Vibration Mitigation

7.1.1 BS 6472 – Assessment- *‘Adverse comment is not expected’*.

7.1.2 No mitigation measures are required.

7.1.3 Freight activity could not be assessed; it may be advisable for the foundations to be structural isolated from the ground in which it is situated in order to prevent future adverse comment if freight activity recommences.

7.1.4 Types of appropriate foundation isolation (GERB, Slyomer Range) can be found in APPENDIX 5.

8.0 CONCLUSIONS

8.1 Sound Planning has undertaken a building vibration assessment in accordance with BS 6472: 2008.

8.2 The current passenger train activity results in combined vibration levels to which *‘Adverse comment is not expected’* in accordance with assessment criteria within BS 6472: 2008.

8.3 No vibration mitigation measures are currently required.

8.4 At the time of this assessment there was no freight activity on this line; if freight activity is to recommence vibration levels should be re-assessed or appropriate foundation isolation should be constructed in order to prevent future vibration problems.



APPENDIX 1

Glossary of Acoustic Terms

The Decibel, dB

The unit used to describe the magnitude of sound is the decibel (dB) and the quantity measured is the sound pressure level. The decibel scale is logarithmic and it ascribes equal values to proportional changes in sound pressure, which is a characteristic of the ear. Use of a logarithmic scale has the added advantage that it compresses the very wide range of sound pressures to which the ear may typically be exposed to a more manageable range of numbers. The threshold of hearing occurs at approximately 0 dB (which corresponds to a reference sound pressure of 2×10^{-5} pascals) and the threshold of pain is around 120 dB. The sound energy radiated by a source can also be expressed in decibels. The sound power is a measure of the total sound energy radiated by a source per second, in watts. The sound power level, L_w is expressed in decibels, referenced to 10^{-12} watts.

Frequency, Hz

Frequency is analogous to musical pitch. It depends upon the rate of vibration of the air molecules that transmit the sound and is measure as the number of cycles per second or Hertz (Hz). The human ear is sensitive to sound in the range 20 Hz to 20,000 Hz (20 kHz). For acoustic engineering purposes, the frequency range is normally divided up into discrete bands. The most commonly used bands are octave bands, in which the upper limiting frequency for any band is twice the lower limiting frequency, and one-third octave bands, in which each octave band is divided into three. The bands are described by their centre frequency value and the ranges which are typically used for building acoustics purposes are 63 Hz to 4 kHz (octave bands) and 100 Hz to 3150 Hz (one-third octave bands).

Noise Rating

The Noise Rating (NR) system is a set of octave band sound pressure level curves used for specifying limiting values for building services noise. The Noise Criteria (NC) and Preferred Noise Criteria (PNC) systems are similar.

A-weighting

The sensitivity of the ear is frequency dependent. Sound level meters are fitted with a weighting network which approximates to this response and allows sound levels to be expressed as an overall single figure value, in dB(A).



Noise Descriptors

Where noise levels vary with time, it is necessary to express the results of a measurement over a period of time in statistical terms. Some commonly used descriptors follow.

$L_{Aeq, T}$ *The most widely applicable unit is the equivalent continuous A-weighted sound pressure level ($L_{Aeq, T}$). It is an energy average and is defined as the level of a notional sound which (over a defined period of time, T) would deliver the same A-weighted sound energy as the actual fluctuating sound.*

L_{AE} *Where the overall noise level over a given period is made up of individual noise events, the $L_{Aeq, T}$ can be predicted by measuring the noise of the individual noise events using the sound exposure level, L_{AE} (or SEL or L_{AX}). It is defined as the level that, if maintained constant for a period of one second, would deliver the same A-weighted sound energy as the actual noise event.*

L_{A10} *The level exceeded for 10% of the time is often used to describe road traffic noise.*

L_{A90} *The level exceeded for 90% of the time is normally used to describe background noise.*

Sound Transmission Descriptors

D_{nT} Standardised level difference

$D_{nT, w}$ Weighted standardised level difference

L_1 The average sound pressure level in the source room

L_2 The average sound pressure level in the receiving room

T Reverberation time (receiving room)

T_0 Reference reverberation time = 0.5s

C_{tr} Adaption spectrum which takes account for low to medium speed road/rail/air traffic; disco music; and factory noise (medium to low frequency noise).

C Adaptation spectrum which takes account of domestic activities including speech, music, radio and television.

R_{TRA} Traffic Noise Reduction



Frequency Analysis

Octave Band	<i>A band of frequencies the upper limit of which is twice the lower limit. They are known by their centre frequency, e.g., 63, 125, 250, 500, 1000, 2000 Hz...</i>
One Third Octave	<i>The logarithmic frequency interval between a lower frequency f_2, when f_2/f_1 equals $2^{1/3}$ apart. Frequencies include: 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000Hz.</i>

Sound Transmission in the Open Air

Most sources of sound can be characterised as a single point in space. The sound energy radiated is proportional to the surface area of a sphere centred on the point. The area of a sphere is proportional to the square of the radius, so the sound energy is inversely proportional to the square of the radius. This is the inverse square law.

In decibel terms, every time the distance from a point source is doubled, the sound pressure level is reduced by 6 dB. Road traffic noise is a notable exception to this rule, as it approximates to a line source, which is represented by the line of the road. The sound energy radiated is inversely proportional to the area of a cylinder centred on the line. In decibel terms, every time the distance from a line source is doubled, the sound pressure level is reduced by 3 dB.

Factors Affecting Sound Transmission in the Open Air

Reflection

When sound waves encounter a hard surface, such as concrete, brickwork, glass, timber or plasterboard, it is reflected from it. As a result, the sound pressure level measured immediately in front of a building façade is approximately 3 dB higher than it would be in the absence of the façade.

Screening and Diffraction

If a solid screen is introduced between a source and receiver, interrupting the sound path, a reduction in sound level is experienced. This reduction is limited, however, by diffraction of the sound energy at the edges of the screen. Screens can provide valuable noise attenuation however. For example, a timber boarded fence built next to a motorway can reduce noise levels on the land beyond, typically by around 10 dB(A). The best results are obtained when a screen is situated close to the source or close to the receiver.



Meteorological Effects

Temperature and wind gradients affect noise transmission, especially over large distances. The wind effects range from increasing the level by typically 2 dB downwind, to reducing it by typically 10 dB upwind – or even more in extreme conditions. Temperature and wind gradient are variable and difficult to predict.

APPENDIX 2

Site Location/Plans

Proposed Dwellings



Site Location/Plans



Proposed Dwellings Location



Site Location/Plans

Proposed Dwellings

3D Modelling



APPENDIX 3

Site Photographs



Vibration Monitoring Position (site boundary)



Vibration Monitoring Position (site boundary)

APPENDIX 4

Vibration Measurements

Test	Direction	Direction	Train Type	Vibration			Vibration			Notes
				VDV mm/s ²			VDV m/s ²			
				Ch1	Ch2	Ch3	Ch1	Ch2	Ch3	
204	Havant	West	Southern	2.4	2.2	18.6	0.00	0.00	0.02	
205	Warblington	East	SW	2.7	3.7	23.9	0.00	0.00	0.02	
206	Warblington	East	Southern	2.5	3.1	20.2	0.00	0.00	0.02	
207	Havant	West	SW	2.3	2.5	21.1	0.00	0.00	0.02	
208	Warblington	East	Southern	1.9	2.5	15.2	0.00	0.00	0.02	
209	Havant	West	Southern	2.4	2.2	18.3	0.00	0.00	0.02	
210	Havant	West	SW	2.3	2.5	22.1	0.00	0.00	0.02	
211	Warblington	East	Southern	2.1	3	19.3	0.00	0.00	0.02	
212	Havant	West	Southern	3.1	2.3	22.3	0.00	0.00	0.02	
213	Warblington	East	SW	4.2	5	32.9	0.00	0.01	0.03	
214	Warblington	East	SW	2.9	3.8	24.2	0.00	0.00	0.02	
215	Havant	West	Southern	3.2	2.2	19.6	0.00	0.00	0.02	
216	Warblington	East	Southern	3	3.3	24.2	0.00	0.00	0.02	
217	Havant	West	Southern	2.7	2.1	18.3	0.00	0.00	0.02	
218	Havant	West	SW	3.4	3	23.8	0.00	0.00	0.02	
219	Havant	West	SW	2.5	2.5	23.4	0.00	0.00	0.02	
220	Warblington	East	Southern	3.5	4.4	25.4	0.00	0.00	0.03	
221	Havant	West	Southern	2.8	2.2	19.7	0.00	0.00	0.02	
222	Warblington	East	SW	2.3	3.3	22	0.00	0.00	0.02	
223			n/a	1.1	1.2	3.5	0.00	0.00	0.00	Background 5 minutes
224	Warblington	East	SW	2.7	3.2	20.8	0.00	0.00	0.02	
225	Havant	West	SW	2.7	2.7	23.3	0.00	0.00	0.02	
226	Warblington	East	Southern	2.7	3.3	23	0.00	0.00	0.02	
227	Havant	West	Southern	3.3	2.8	22	0.00	0.00	0.02	
228	Havant	West	SW	2.4	2.5	24	0.00	0.00	0.02	
229	Warblington	East	Southern	2.6	3.3	19.4	0.00	0.00	0.02	
230	Havant	West	Southern	2.4	2.2	19.6	0.00	0.00	0.02	
231	Warblington	East	SW	2	3	21.1	0.00	0.00	0.02	
253	Warblington	East	SW	1.3	2.1	20.5	0.00	0.00	0.02	
254	Warblington	East	SW	1.3	2.3	20.3	0.00	0.00	0.02	
255	Havant	West	SW	1.3	2.1	26.3	0.00	0.00	0.03	
256	Warblington	East	Southern	1.6	2.8	25.6	0.00	0.00	0.03	
257	Havant	West	Southern	1.1	2.1	20.8	0.00	0.00	0.02	



258	Havant	West	SW	1.3	2.1	20.8	0.00	0.00	0.02	
259	Havant	West	Southern	1.1	1.7	20.2	0.00	0.00	0.02	
260	Warblington	East	Southern	1.4	2.3	20.7	0.00	0.00	0.02	
261	Warblington	East	SW	1.6	2.9	30	0.00	0.00	0.03	
262	Havant	West	Southern	1.2	1.8	19.2	0.00	0.00	0.02	
263	Havant	West	SW	1.6	2.4	28.5	0.00	0.00	0.03	
264	Warblington	East	SW	1.2	2.1	20.7	0.00	0.00	0.02	
265	Warblington	East	Southern	1.4	2.5	25.6	0.00	0.00	0.03	
266	Havant	West	Southern	1	1.4	16.6	0.00	0.00	0.02	
267	Havant	West	SW	1.2	1.9	19.5	0.00	0.00	0.02	
268	Warblington	East	Southern	1.3	2.4	22.3	0.00	0.00	0.02	
269	Warblington	East	SW	1.2	2.3	22.5	0.00	0.00	0.02	
270	Havant	West	Southern	1	1.7	19.3	0.00	0.00	0.02	
271	Warblington	East	Southern	1.4	2.3	21	0.00	0.00	0.02	
272	Havant	West	SW	1.3	2.1	21.8	0.00	0.00	0.02	
273	Warblington	East	Southern	1.4	2.7	23.8	0.00	0.00	0.02	
274	Havant	West	Southern	1.3	1.8	20	0.00	0.00	0.02	
275	Havant	West	SW	1.2	1.9	19.3	0.00	0.00	0.02	
276	Warblington	East	Southern	1.2	2	18.7	0.00	0.00	0.02	
277	Warblington	East	SW	1.4	2.3	23	0.00	0.00	0.02	
278	Havant	West	Southern	1	1.7	18.1	0.00	0.00	0.02	
279	Warblington	East	SW	1.6	2.9	32	0.00	0.00	0.03	
280	Havant	West	SW	1.7	2.7	29.4	0.00	0.00	0.03	
281	Warblington	East	Southern	1.5	2.7	22.1	0.00	0.00	0.02	

APPENDIX 5

Vibration Isolation

GERB

GERB

Vibration Isolation of Buildings

Attractive sites in central and convenient locations sometimes have one disappointing disadvantage – vibrations or structure borne noise, caused by

- a subway or other railway lines,
- heavy truck traffic on uneven roads or neighbouring bridges,
- heavy machinery in neighbouring industrial facilities.

Vibrations and noise limit the general value of such properties.

The extent of these vibrations when measured on the subsoil is at the beginning often underestimated.

Only in the finished building, the consequences are fully felt with floors vibrating, and walls and floors being the radiating surface of secondary noise. Countermeasures are then nearly not at all possible any more or will require a lot of time and money.

It is therefore the responsibility of building owners and architects to investigate this problem early to avoid subsequent problems.

Conventional foundations cannot prevent the transmission of disturbing vibrations into the building. Measures at the vibration source are often not possible or not sufficient. Structural measures in the building are in most cases not successful and may furthermore limit the creativity of the architect.

Special measures on foundation level may become necessary to preserve chances for the erection of a residential or office building, a hotel or senior home, a concert hall, a conference center or a modern facility with vibration sensitive production without risks for people, machines or the buildings themselves.

Base isolation by spring support offers this chance.



Prestressable spring unit for vibration isolation of buildings

Vibration Isolation

GERB

Vibration Isolation Systems for Buildings

Elastic support systems designed by GERB for buildings result in vertical system natural frequencies of 3 to 5 Hz, for special applications even down to 2 Hz. Corresponding to the natural frequencies is the efficiency of isolation starting at frequencies as low as 5 Hz or even less.

This does not only very efficiently eliminate the transmission of structure borne noise, but also 80 % of vibrations and more with frequencies of 10 – 20 Hz, which are often found near railway lines and which are amplified especially on floors inside the building, and well perceived especially on higher floors. For higher frequencies the efficiency of isolation is even higher.

The system keeps vibration levels safely below the limits according to DIN 4150, Part 2 even under difficult conditions.

The GERB base isolation system consists of spring units containing coil steel springs. It has been used worldwide for decades in vibration isolation of heavy machinery with high static and dynamic loads.



The worldwide first residential building spring supported for vibration isolation, 4 Hz – Berlin, Germany 1986

Since 1985 the GERB system has been successfully used for base isolation of buildings including the application for seismic protection. Before that time, spring systems had already been installed in more than 500 cases to protect buildings against differential settlement in subsidence areas.

For earthquake protection, too, GERB spring units combined with Viscodampers® are in use in different countries.



Spring supported building PSA Peugeot Citroën – Poissy, France

Vibration Isolation

GERB



Complex of buildings above an underground line
on 5 Hz spring units – Berlin, Germany

System Design and Installation



Non-prestressable spring unit

The design of a base isolation system is usually done on the results of a preceding vibration survey. Types and numbers of spring units are defined in cooperation between architect, structural engineer and GERB.

A large list of standardized spring units with different load capacities is available to choose from which makes it easy to adapt the spring system to the actual static loads.

GERB spring units are available in prestressable versions allowing easy load adjustment of the springs and even – whenever this should become necessary – the replacement of complete elements.

GERB spring units for base isolation are designed to take high loads. They accept wind loads without any additional bracing of the building.

GERB spring units are simply fixed with adhesive pads on top and bottom sides without bolts.

Vibration isolation of a townhouse
above metro line – Berlin, Germany



Adjusting a spring unit –
Shanghai, China

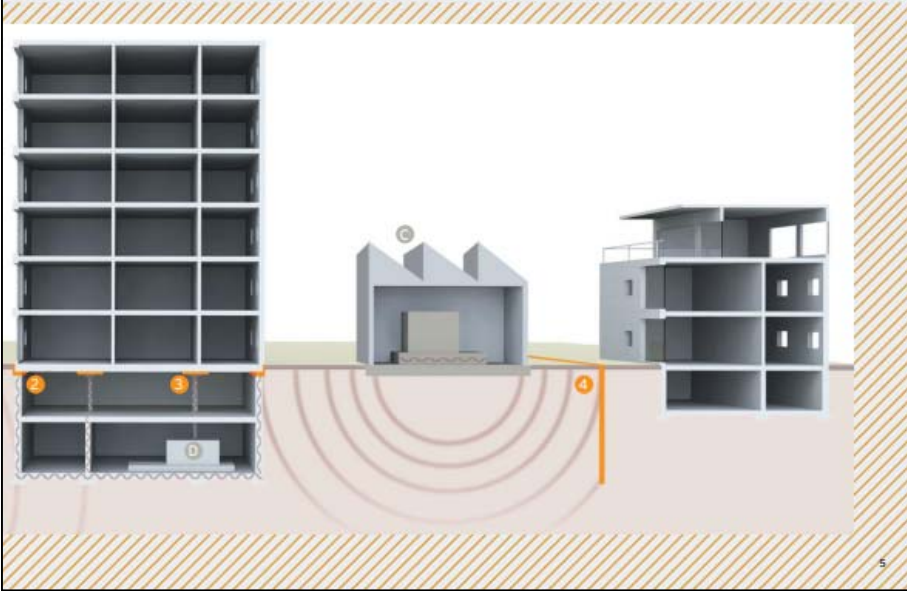
Vibration Isolation

Slyomer Range



Drachen Centre Basle: Full-surface bearings for buildings

Anti-vibration measures for recipient	Sources	Result
1 Full-surface bearings for buildings using side mats 2 Strip bearing of buildings or structures 3 Discrete bearing of buildings or structures 4 Slot wall between existing source and recipient	- A Rail traffic, light railways, trams, etc. - B Underground rail traffic - C Industrial complexes, machinery, etc. - D Building service installations	- Greater usage potential - Greater comfort in the building - Increases market value of buildings and land



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