
High Speed Rail (London-West Midlands)

Construction noise and vibration methodology report

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Department for Transport

High Speed Two (HS2) Limited has been tasked by the Department for Transport (DfT) with managing the delivery of a new national high speed rail network. It is a non-departmental public body wholly owned by the DfT.

High Speed Two (HS2) Limited,
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

Telephone: 08081 434 434

General email enquiries: HS2enquiries@hs2.org.uk

Website: www.gov.uk/hs2

A report prepared by Atkins on behalf of HS2 Ltd.

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Abbreviations and descriptions

1.1.1 The abbreviations, descriptions and project terminology used within this report can be found in the Project Dictionary (HS2-HS2-PM-GDE-000-000002).

Abbreviation / description	Meaning
Ambient sound	A description of the all-encompassing sound at a given location and time which will include sound from many sources near and far. Ambient sound can be quantified in terms of the equivalent continuous sound pressure level, $L_{pAeq,T}$
Decibel(s), or dB	Between the quietest audible sound and the loudest tolerable sound there is a million to one ratio in sound pressure (measured in Pascal (Pa)). Because of this wide range, a level scale called the decibel (dB) scale, based on a logarithmic ratio, is used in sound measurement. Audibility of sound covers a range of approximately 0-140dB.
Decibel(s) A-weighted, or dB(A)	The human ear system does not respond uniformly to sound across the detectable frequency range and consequently instrumentation used to measure sound is weighted to represent the performance of the ear. This is known as the 'A weighting' and is written as 'dB(A)'.
Equivalent continuous sound pressure level, or $L_{pAeq,T}$	An index used internationally for the assessment of environmental sound impacts. It is defined as the notional unchanging level that would, over a given period of time (T), deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating sound levels can be described in terms of an equivalent single figure value, typically expressed as a decibel level.
Peak particle velocity, or PPV	Instantaneous maximum velocity reached by a vibrating element as it oscillates about its rest position. The PPV is a simple indicator of perceptibility and risk of damage to structures due to vibration. It is usually measured in mm/s.
Sound pressure level	The parameter by which sound levels are measured in air. It is measured in decibels. The threshold of hearing has been set at 0dB, while the threshold of pain is approximately 120dB. Normal speech is approximately 60dB at a distance of 1 metre and a change of 3dB in a time varying sound signal is commonly regarded as being just detectable. A change of 10dB is subjectively twice, or half, as loud.
Vibration dose value, or VDV	An index used to evaluate human exposure to vibration in buildings. While the PPV provides information regarding the magnitude of single vibration events, the VDV provides a measure of the total vibration experienced over a specified period of time (typically 16h daytime and 8h night-time). It takes into account the magnitude, the number and the duration of vibration events and can be used to quantify exposure to continuous, impulsive, occasional and intermittent vibration. The vibration dose value is measured in $m/s^{1.75}$.

1 Introduction

- 1.1.1 The present report describes the methodology which will be adopted to monitor noise and vibration levels arising from construction activities, required for the completion of the High Speed 2 (HS2) project. Monthly noise and vibration monitoring reports will be published separately, presenting a summary of contractors' monitoring data from all HS2 worksites active during each calendar month of works. The present methodology report, together with the monthly monitoring reports, fulfils HS2 Limited's commitment detailed in the Environmental Minimum Requirements (EMRs), Annex 1, Code of Construction Practice.

2 Applicable standards and guidance

- 2.1.1 This section summarizes the relevant standards and guidance documents required for the monitoring and assessment of impacts associated with the proposed scheme. It also defines the impact assessment criteria used and includes the noise and vibration LOAELs and SOAELs specified in HS2 information paper E23.

2.2 Relevant legislation

Noise Policy Statement for England (NPSE)

- 2.2.1 NPSE seeks to clarify the underlying principles and aims in existing policy documents, legislation and guidance that relate to noise. The statement applies to all forms of noise, including environmental noise, neighbour noise and neighbourhood noise. The statement sets out the long term vision of the Government's noise policy, which is to "promote good health and a good quality of life through the effective management of noise within the context of policy on sustainable development".
- 2.2.2 The guidance promotes the effective management and control of noise, within the context of Government policy on sustainable development and thereby aims to:
- avoid significant adverse impacts on health and quality of life;
 - mitigate and minimise adverse impacts on health and quality of life; and
 - where possible, contribute to the improvements of health and quality of life.
- 2.2.3 The statement adopts established concepts from toxicology and applies and adapts them to identify how varying levels of noise impact may be classified in terms of their effect. The classification categories as detailed within the NPSE are as follows:
- No Observed Effect Level (NOEL) - the level below which no effect can be detected. Below this level no detectable effect on health and quality of life due to noise can be established;
 - Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse effects on health and quality of life can be detected; and
 - Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse effects on health and quality of life occur.

- 2.2.4 It is recognised that SOAEL does not have a single objective noise-based level that is applicable to all sources of noise in all situations and therefore the SOAEL is likely to be different for different sources, receptors and at different times of the day.

Planning Practice Guidance - Noise

- 2.2.5 Government's Planning Practice Guidance on noise (PPG) provides guidance on the effects of noise exposure, relating these to people's perception of noise, and linking them to the NOEL and, as exposure increases, the LOAEL and SOAEL.
- 2.2.6 As exposure increases above the LOAEL, the noise begins to have an adverse effect and consideration should be given to mitigating and minimising those effects, taking account of the economic and social benefits being derived from the activity causing the noise. As the noise exposure increases, it will then at some point cross the SOAEL boundary.
- 2.2.7 The LOAEL is described in PPG as the level above which "noise starts to cause 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".
- 2.2.8 PPG identifies the SOAEL as the level above which "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."

High Speed Rail (London - West Midlands) Act 2017

- 2.2.9 On 23 February 2017 Royal Assent was granted for Phase One of HS2. The High Speed Two Bill is now an Act of Parliament (law) i.e. High Speed Rail (London - West Midlands) Act 2017. The Environmental Minimum Requirements (EMRs) detailed in the Act set out the high level environmental and sustainability commitments and are contained in the EMR General Principles document supported by a series of papers:

Annex 1: Code of Construction Practice (see below)

Annex 2: Planning Memorandum

Annex 3: Heritage Memorandum

Annex 4: Environmental Memorandum

Environmental Minimum Requirements: General Principles

- 2.2.10 The Environmental Minimum Requirements - General Principles require that the controls to be implemented in delivering the scheme (including the EMRs, powers contained in the Act and Undertakings) will ensure that impacts which have been assessed in the ES will not be exceeded. If the significant adverse impacts identified in the ES are likely to be exceeded, all reasonable steps will be taken to minimise or eliminate those additional impacts.

- 2.2.11 The EMRs also require compliance with the undertakings and assurances.
- 2.2.12 Annex 1 to the EMRs comprises a Code of Construction Practice (CoCP), which shall be adopted and implemented by the nominated undertaker in delivering the works, the high level requirements of which are set out below.

Environmental Minimum Requirements Annex 1: Code of Construction Practice

- 2.2.13 The CoCP sets out the general control measures to be implemented and the standards to which the nominated undertaker and its contractors will comply in delivering the scheme. Its aim is to ensure that likely significant construction effects that are reported in the Environmental Statement will either be avoided or mitigated. Notwithstanding this, nominated undertaker will take all reasonable steps to design and construct the scheme so that noise and vibration from the construction does not give rise to adverse effects. Where it is not reasonably practicable to achieve this, noise and vibration from construction of the scheme will be reduced as far as is reasonably practicable. This approach is considered to align with the noise policy aims set out in the Noise Policy Statement for England and the principles of Best Practicable Means^{1 2}.
- 2.2.14 The general control measures and monitoring arrangements for noise and vibration identified in the CoCP have been considered in the development of the noise and vibration monitoring regime.

Information paper E23: Control of Construction Noise and Vibration

- 2.2.15 In addition to the Environmental Minimum Requirements themselves, HS2 have produced a number of information papers in order to explain the project commitments and how they will be applied to the design and construction of the scheme. In particular *Information Paper E23: Control of Construction Noise and Vibration* outlines measures that will be put in place to control the effects of noise and vibration that might otherwise arise from the construction of the scheme. This document also includes the HS2 Construction Noise and Vibration Policy which details LOAELs and SOAELs for construction noise and vibration.

HS2 Sustainability Policy

- 2.2.16 HS2's sustainability policy sets out HS2 Ltd's commitment to be an exemplar project. It states that HS2 Ltd "will promote high speed rail and balance community, environmental and economic issues". The key theme identified that relates to noise impact is "Environmental change: seek to avoid significant adverse effects on communities, business and the natural, historic and built environment. Minimise impacts where they occur and deliver enhancements as far as practicable to ensure there is no net loss to the natural environment." This reflects the Noise Policy Statement for England's three aims and the need to avoid the noise impact of a scheme being treated in isolation.

1 HM Government 1974, section 72 Control of Pollution Act 1974, The Stationery Office Limited

2 HM Government 1990, section 79 Environmental Protection Act 1990, The Stationery Office Limited

2.3 Relevant guidance

British Standard (BS) 7445-2: 1991 'Description and Measurement of Environmental Noise'

2.3.1 BS7445-2: 1991 defines parameters, procedures and instrumentation required for noise measurement and analysis.

BS5228: 2009+A1: 2014 'Code of practice for noise and vibration control on construction and open sites'

2.3.2 BS5228: 2009+A1: 2014 provides a 'best practice' guide for noise and vibration control, and includes sound power level (SWL) data for individual plant as well as a calculation method for noise from construction activities. Part 1 relates to noise and part 2 relates to vibration.

LOAELs and SOAELs for construction noise and vibration

2.3.3 The levels that are considered the LOAELs and SOAELs for construction noise and vibration are set out in Table 1 to Table 4 of the HS2 Construction Noise and Vibration Policy included within Information paper E23 and are re-produced in tables below.

2.3.4 Where baseline ambient noise or vibration levels exceed the LOAELs or SOAELs set out in tables, adverse effects on health and quality of life due to construction works are considered to arise when the specific construction noise or vibration level exceeds the baseline ambient level. Furthermore, in line with the code of practice for noise and vibration control on construction and open sites (BS5228-1), significant adverse effects on health and quality of life are considered to occur when SOAELs are exceeded for at least the following time periods as set out in Appendix B Paragraph 2 of E23:

- a period of 10 or more days of working in any 15 consecutive days during construction;
or
- for a total of 40 days or more in any 6 consecutive months during construction.

Table 1: Construction noise effect levels for permanent residential buildings (outdoor at the façade)

Day	Time (hours)	Averaging Period T	Lowest Observed Adverse Effect Level $L_{pAeq,T}$ (dB)	Significant Observed Adverse Effect Level $L_{pAeq,T}$ (dB)
Mondays to Fridays	0700 - 0800	1 hour	60	70
	0800 - 1800	10 hours	65	75
	1800 - 1900	1 hour	60	70
	1900 - 2200	1 hour	55	65
Saturdays	0700 - 0800	1 hour	60	70
	0800 - 1300	5 hours	65	75
	1300 - 1400	1 hour	60	70
	1400 - 2200	1 hour	55	65
Sundays & Public Holidays	0700 - 2200	1 hour	55	65
Any night	2200 - 0700	1 hour	45	55

Table 2: Ground-borne noise and vibration effect levels for permanent residential buildings (indoors near but not at the centre of any habitable room)

Ground-borne noise	Lowest Observed Adverse Effect Level	L_{pASmax} [dB]	35
	Significant Observed Adverse Effect Level	L_{pASmax} [dB]	45
Vibration	Lowest Observed Adverse Effect Level	VDVday [$m/s^{1.75}$]	0.2
		VDVnight [$m/s^{1.75}$]	0.1
	Significant Observed Adverse Effect Level	VDVday [$m/s^{1.75}$]	0.8
		VDVnight [$m/s^{1.75}$]	0.4

3 Measurement methodology

3.1 Measurement methodology and equipment

- 3.1.1 As far as reasonably practicable, long term noise monitoring installations will be deployed at locations which are considered to be representative of potential construction noise impacts upon sensitive receptors, taking into consideration the need for access, maintenance and power supply. Consultation will take place with the relevant local authority and other stakeholders regarding the selection of each location.
- 3.1.2 Noise monitors have been installed at a height of approximately 4m above ground level, approximating to first floor level, and are generally located in free-field locations in order to minimise the influence of reflections. Where noise monitors are not located in the free-field i.e. at distances less than 3.5m from a reflecting surface other than the ground or located at ground level 1.5m above ground, this is indicated in the relevant data table.
- 3.1.3 The noise monitoring equipment will be compliant with the requirements for a 'class 2' instrument or better as defined in BS EN 61672-1³ and BS EN 61672-2⁴ and microphones will be fitted with effective windshields. In addition, the calibration of each sound level meter will be checked and recorded at the start and end of each measurement using calibrators (Class 1) meeting the requirements of BS EN 60942 2003⁵. If a significant drift of more than 1.0 dB is observed, the data will be treated with caution.
- 3.1.4 The vibration monitoring equipment will be compliant with performance characteristics detailed in BS EN ISO 8041:2005⁶.
- 3.1.5 A range of statistical sound and vibration data will be logged continuously (over a 5 minute interval). Any data which has been collected under unsuitable weather conditions (for example during rainfall or wind speeds exceeding 5m/s), missing data or unusually high/low levels will be highlighted and treated with caution.

3.2 Presentation of results

- 3.2.1 The monthly monitoring report will present the noise and vibration data recorded over the month from all the installed monitoring equipment.
- 3.2.2 For construction noise, the $L_{Aeq,T}$ index is the relevant parameter. This is the A-weighted equivalent continuous sound pressure levels and is a notional steady level which, over a given period of time, T, would deliver the same sound energy as the actual time-varying sound over the same period. Data pertaining to the relevant time averaging periods, as identified in Table 1 (e.g. $L_{Aeq,10hr}$ for the 10hour period between 8am-6m during a weekday), will be presented in

³ BSI, BS EN 61672-1:2013 *Electroacoustics. Sound level meters. Specifications*, London: BSI, 2013.

⁴ BSI, BS EN 61672-2:2013 *Electroacoustics. Sound level meters. Pattern evaluation tests*, London: BSI, 2013.

⁵ BSI, BS EN 60942 2003 *Electroacoustics. Sound calibrators*, London: BSI, 2003.

⁶ BSI, BS EN ISO 8041:2005 *Human response to vibration — Measuring instrumentation, incorporating corrigendum November 2007*, London: BSI, 2009.

the main body of the report, whilst graphs showing the full $L_{Aeq,1hr}$ data set over the month will be presented in the Appendices. The monitored raw data will also be published

- 3.2.3 For construction vibration both the Vibration Dose Value (VDV) and the Peak Particle Velocity (PPV) will be presented. The VDV is a measure of the total vibration experienced over a specified period of time (typically 16h daytime and 8h night-time), and will be presented in table format in the main body of the report. The PPV gives an indication of the maximum vibration experienced within a certain time period, graphs showing the full PPV data set over the month will be presented in the Appendices.
- 3.2.4 The monthly monitoring reports will include information on any exceedance of the agreed trigger levels and received complaints, the cause of these, and action taken to remedy it and avoid a reoccurrence.
- 3.2.5 The monthly monitoring report will be published on the HS2 government website within one month from the end of the month to be reported and can be found at the following location www.gov.uk/government/publications/monitoring-noise-and-vibration-on-the-hs2-phase-one-route.

High Speed Two (HS2) Limited,
Two Snowhill
Snow Hill Queensway
Birmingham B4 6GA

www.gov.uk/hs2