

Control of ground-borne noise and vibration

This factsheet describes the application of the aims set out in the Noise Policy Statement for England that relate to ground-borne noise and vibration from the operation of both the temporary and permanent railways. It outlines the objectives which are expected to be adopted and the measures that are expected to be put in place to control the effects of ground-borne noise and vibration that might otherwise arise from the operation of the temporary and permanent railways.

1 Introduction

- 1.1.1. High Speed Two (HS2) is the Government's proposal for a new, high speed north-south railway. The proposal is being taken forward in phases. Phase One will connect London with Birmingham and the West Midlands. Phase 2a will extend the route to Crewe. The Western Leg of Phase 2b comprises an extension of the network to Manchester and a connection to the West Coast Main Line at Golborne, and is referred to as the Western Leg hybrid Bill. The Eastern Leg of Phase 2b currently comprises an extension of the network from the West Midlands through the East Midlands to Leeds.
- 1.1.2. HS2 Ltd is the non-departmental public body responsible for developing and promoting these proposals. The company works to a Development Agreement made with the Secretary of State for Transport.
- 1.1.3. The construction and operation of Phase One of HS2 is authorised by the High Speed Rail (London – West Midlands) Act (2017). In July 2017, the Government introduced a hybrid Bill to Parliament to seek powers for the construction and operation of Phase 2a.
- 1.1.4. In February 2020, the Government announced its intention to draw up an Integrated Rail Plan. This will recommend a way forward on scoping, phasing and sequencing the delivery of HS2 Phase 2b, Northern Powerhouse Rail, Midlands Rail Hub and other proposed rail investments across the north. At the same time, the Government asked HS2 Ltd to prepare the Western Leg hybrid Bill, provided it does not prejudice any recommendations or decisions that will be taken in this plan, which will be published by the end of the year.
- 1.1.5. It is intended to deposit a Western Leg hybrid Bill seeking powers to construct and operate this phase in Parliament in early 2022 or sooner if possible (the Proposed Scheme). The work to produce the Bill will include an Environmental Impact Assessment (EIA), the results of which will then be reported in an Environmental Statement (ES). The ES would be submitted alongside the Bill when it is introduced to Parliament. As was the case with Phase One and Phase 2a, when the Bill is introduced to Parliament the Secretary of State will also publish draft Environmental Minimum Requirements (EMRs). The EMRs will set out the environmental and sustainability commitments that will be observed in the construction of the Proposed Scheme.
- 1.1.6. A series of information papers were produced for the Phase One and Phase 2a hybrid Bills, explaining the commitments made in those Bills and EMRs. It is the Secretary of State's intention to follow a similar process for the Western Leg Bill. These information papers will be used to provide

information about the Proposed Scheme itself, the powers contained in the Bill and how decisions on the Proposed Scheme have been reached. It is currently proposed that these information papers for the Western Leg of Phase 2b will be published at the time the Bill is introduced in Parliament.

- 1.1.7. The Secretary of State for Transport will be ‘the Promoter’ of the Western Leg Bill. The Promoter will also eventually appoint a body responsible for delivering the Proposed Scheme under the powers to be granted by the Bill. This body will be known as the ‘nominated undertaker’. There may well be more than one nominated undertaker. However, any and all nominated undertakers will be bound by the obligations contained in the Bill, the policies established in the Western Leg EMRs and any commitments provided in the Western Leg information papers.
- 1.1.8. These Western Leg factsheets have been produced to provide information on the emerging proposals for measures to manage the design process for the Proposed Scheme and to control impacts which may arise from the construction and operation of the Proposed Scheme. These measures may then be applied to the Western Leg as commitments made through the eventual Bill, EMRs or information papers.

2 Overview

- 2.1.1. This factsheet describes the application of the aims set out in the Noise Policy Statement for England¹ that relate to ground-borne noise and vibration from the operation of both the temporary² and permanent railways. It outlines the objectives which are expected to be adopted and the measures that are expected to be put in place to control the effects of ground-borne noise and vibration that might otherwise arise from the operation of the temporary and permanent railways.
- 2.1.2. Vibration from the temporary and permanent railways may propagate through the ground to surrounding buildings where it may result in the vibration of floors, walls and ceilings, which could also be heard as a low frequency ‘rumbling’ sound; the latter is referred to as ground-borne noise.

3 Objectives

- 3.1.1. The nominated undertaker would design the temporary and permanent railways such that the level of ground-borne noise and vibration predicted in

¹ The methodology for the assessment of likely significant noise and vibration effects is consistent with Scottish Government noise policy, planning policy and EIA Regulation. Please see Scottish Government (2011) Planning Advice Note (PAN) 1 /2011 Planning and Noise. Available online at: <https://www2.gov.scot/resource/doc/343210/0114180.pdf>

² Temporary railway is required for tunnelling activities during construction.

all reasonably foreseeable circumstances does not exceed the significant observed adverse effect levels given in Table 1 in Appendix B.

- 3.1.2. The nominated undertaker would take all reasonably practicable steps to construct, operate and maintain the temporary and permanent railways so that the design objective is fulfilled.
- 3.1.3. In addition, the nominated undertaker would take all reasonable steps to design, construct, operate and maintain the temporary and permanent railways such that, in all reasonably foreseeable circumstances, ground-borne noise and vibration does not exceed the lowest observed adverse effect levels given in Table 1 in Appendix B.
- 3.1.4. The nominated undertaker would reduce ground-borne noise and vibration from the temporary and permanent railways as far as is reasonably practicable.
- 3.1.5. In addition to the effects on people inside residential dwellings, it is recognised that impacts can also occur on people and activities in noise sensitive non-residential locations.
- 3.1.6. The nominated undertaker would design the temporary and permanent railways such that the level of ground-borne noise and vibration predicted in all reasonably foreseeable circumstances does not exceed the impact levels given in Tables 2 and 3 in Appendix B. The nominated undertaker would take all reasonably practicable steps to construct, operate and maintain the temporary and permanent railways so that this design objective is fulfilled.
- 3.1.7. For detail on the Operational Ground-borne Noise and Vibration Policy which is expected to be adopted for the Proposed Scheme see Appendix A.

4 Control measures

- 4.1.1. The likely ground-borne noise and vibration impact of the temporary and permanent railways will be assessed and the findings will be reported in the ES.
- 4.1.2. Ground-borne noise and vibration from the temporary and permanent railways will be controlled by the design and maintenance of the train and track.
- 4.1.3. To control ground-borne noise and vibration from the temporary and permanent railways, the nominated undertaker would be required to do the following in relation to the track systems:

- at design stage, predict, through the use of appropriate modelling, the engineering requirements of the track system that will fulfil the objectives;
- design a standard track form with the objective of meeting as many of those engineering requirements identified in the previous bullet as can reasonably be achieved by such a standard track system;
- design an enhanced track form for locations where it is predicted that the standard track system will not meet the engineering requirements or to discharge other project commitments and undertakings;
- translate the engineering requirements into contract specifications for the track systems; and
- procure, install and maintain the track systems to meet the contract specifications established above.

4.1.4. To ensure that the measures to control ground-borne noise and vibration are reasonable, the nominated undertaker would take account of the set of shared UK principles that underpin the Government's sustainable development strategy³.

5 More information

5.1.1. Further factsheets and details on the Proposed Scheme can be found at: www.hs2.org.uk/phase2b

³ TSO (The Stationery Office) (2005), Securing the future: delivering UK sustainable development strategy, London.

Appendix A

The Proposed Scheme Airborne Noise Policy for altered roads and the operational railway⁴

The Noise Policy Statement for England (2010)

1. The aims set out in the Noise Policy Statement for England (NPSE) apply to the design, construction and operation of the Proposed Scheme.

<p style="text-align: center;">Noise Policy Aims</p> <p>Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:</p> <ul style="list-style-type: none">• 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 improvement of health and quality of life.
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2. Government's guiding principles of sustainable development include: ensuring a strong, healthy and just society; using sound science responsibly; living within environmental limits; achieving a sustainable economy; and promoting good governance.
3. There is a need to integrate consideration of the economic and social benefit of the activity or policy under examination with proper consideration of the adverse environmental effects, including the impact of noise on health and quality of life. This should avoid noise being treated in isolation in any particular situation.
4. The first two aims of the NPSE follow established concepts from toxicology that are applied to noise impacts, for example, by the World Health Organisation. They are:
 - NOEL – No Observed Effect Level - the level below which no effect can be detected. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise; and
 - LOAEL – Lowest Observed Adverse Effect Level - the level above which adverse effects on health and quality of life can be detected.

⁴ Note: all sound levels reported in this Appendix are outdoor free-field levels unless otherwise stated

5. The NPSE extends these to the concept of a significant observed adverse effect level.
 - SOAEL – Significant Observed Adverse Effect Level - The level above which significant adverse effects on health and quality of life occur.
6. The NPSE notes "It is not possible to have a single objective noise-based measure that defines SOAEL that is applicable to all sources of noise in all situations. Consequently, the SOAEL is likely to be different for different noise sources, for different receptors and at different times".

Planning Practice Guidance - Noise (2014)

7. 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.
8. As exposure increases above the LOAEL, the noise begins to have an adverse effect and consideration needs to be given to mitigating and minimising those effects, taking account of the economic and social benefits being derived from the activity causing the noise. As the noise exposure increases, it will then at some point cross the SOAEL boundary.
9. 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."
10. 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."

HS2 Environmental Policy (2019)

11. The HS2 environmental policy⁵ sets out HS2 Ltd's commitment to be an exemplar project. It further states that we will seek to minimise the impact of HS2

⁵ <https://www.gov.uk/government/publications/hs2-environmental-policy>

construction and operation on people and the environment including effects from air pollution, flooding and noise & vibration.

LOAELs for ground-borne noise and vibration

12. An indoor sound level of 35 dB L_{pASMax} , in any habitable room, is considered the LOAEL for ground-borne noise.
13. A low level of annoyance would be expected at ground-borne noise levels at or below 35 dB L_{pASMax} .
14. Vibration (indoors, near the centre of any dwelling room on the ground floor) of 0.2 VDV m/s^{1.75} daytime (0700-2300) and/or 0.1 VDV m/s^{1.75} night time (2300 – 0700) are considered the LOAELs for ground-borne vibration.
15. At these values, the relevant British Standard on human exposure to vibration in buildings suggest a low probability of adverse comment.

SOAELs for ground-borne noise and vibration

16. An indoor sound level of 45 dB L_{pASMax} , in any habitable room, is considered the SOAEL for ground-borne noise.
17. A significant number of people would be expected to be seriously annoyed at or above ground-borne noise levels of 45 dB L_{pASMax} .
18. Vibration (indoors, near the centre of any dwelling room on the ground floor) of 0.8 VDV m/s^{1.75} daytime (0700-2300) and/or 0.4 VDV m/s^{1.75} night time (2300 – 0700) are considered the SOAELs for ground-borne vibration.
19. At these levels, relevant British Standard on human exposure to vibration in buildings suggest that adverse comment is probable.

Appendix B

Ground-borne noise and vibration impact and effect levels from the operational railway

Table 1 - Ground-borne noise and vibration effect levels for permanent residential buildings

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	$VDV_{day}[m/s^{1.75}]$	0.2
		$VDV_{night}[m/s^{1.75}]$	0.1
	Significant Observed Adverse Effect Level	$VDV_{day}[m/s^{1.75}]$	0.8
		$VDV_{night}[m/s^{1.75}]$	0.4

Table 2 - Ground-borne noise impact levels for non-residential buildings

Examples	L_{pASMax} [dB]
Large auditoria; and concert halls	25
Sound recording & broadcast studios; theatres, and small auditoria	30
Places of meeting for religious worship; courts; cinemas; lecture theatres; museums; and small auditoria or halls	35
Offices; schools; colleges, hospitals; hotels; and libraries	40

Table 3 - Ground-borne vibration impact levels for non-residential buildings

Examples	$VDV_{day}[m/s^{1.75}]$	$VDV_{night}[m/s^{1.75}]$
Hotels; hospital wards; and education dormitories	0.2	0.1
Offices; Schools; and Places of Worship	0.4	n/a
Workshops	0.8	n/a
Vibration sensitive research and manufacturing (e.g. computer chip manufacture); hospitals with vibration sensitive equipment / operations; universities with vibration sensitive research equipment / operations	Risk assessment will be undertaken based on the information currently available for the relevant equipment / process, or where information provided by the building owner or equipment manufacturer.	

Appendix C

Glossary

Decibel (dB) - Between the quietest audible sound and the loudest tolerable sound there is a ten 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. Audible sound covers a range of approximately 0-140 dB.

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)'.

L_{pASMax} - the maximum A-weighted sound pressure level attained during a given time interval, T (30 seconds, 5 minutes etc) measured using a noise meter's slow (S) time weighting setting. It is used internationally in the measurement and assessment of ground-borne noise from railways.

Permanent railway – the railway infrastructure used to carry operational train services.

Temporary railway - railway laid inside a tunnel to transport material, personnel and equipment to and from the tunnel boring machine (TBM) during the tunnel's construction.

Vibration Dose Value (VDV) - measure used to estimate the probability of adverse comment which might be expected from human beings experiencing vibration in buildings.

