Transport for London
London Underground

## Guidance Document

# G1323 Noise and Vibration Asset Design Guidance

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**MAYOR OF LONDON**

## Contents



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# 1 Purpose

1.1 The purpose of this Guidance is to define noise and vibration assessment methodologies and criteria that should be used in the design of new operational assets. LUL assets are often in close proximity to noise and vibration sensitive receptors, e.g. residential properties, offices, theatres etc. When noise and vibration is not controlled LUL receives complaints from these receptors which can be expensive to rectify once an asset is built and operational.

# 2 Scope

2.1.1 LU Category 1 Standards 1-050 “Civil Engineering – Common Requirements” and 1-154 Permanent Way System – Strategy and Interfaces, define the requirement for noise and vibration assessments to be carried out.

2.1.2 This Guidance applies to all new operational assets, assets undergoing major upgrade works, or assets being brought back into use after a period of five years or more.

2.1.3 The assessment methodologies and criteria described in this document are for residential dwellings. It is recognised that other noise sensitive receptors exist e.g. schools, offices, hospitals, hotels, theatres, churches etc. Assessment methods and criteria for these receptors should be determined on a project by project basis as applicable. It is likely that similar assessment methodologies would apply for these receptors but the criteria may differ (example criteria can be found in BS 8233:1999 Sound insulation and noise reduction for buildings – Code of practice).

2.1.3 Please note that the assessments and criteria provided in this guidance document are not extensive. Individual project stakeholders and local authorities may require further assessments and may apply different criteria.

# 3 Guidance

## 3.1 Design Options

3.1.1 At the design stage it is normal to consider more than one option. A qualitative high level assessment of the noise and vibration impacts should be carried out for each option; these should be considered for the construction and for the life of the scheme. The noise and vibration impacts of the options should be assessed against any other impacts and practical and economic considerations to ensure that the best scheme design is selected.

3.1.2 Important considerations at this stage could include (but not be limited to):

a) For railways - track type, route, rolling stock type, running speeds; and

b) For fixed installations – location (including outlet orientation if applicable) relative to sensitive receptors, operational times, the character of the noise.

3.1.3 An example of how the design of a railway route can affect noise is when the route includes tight curves. Tight curves can result in two unwanted noise generating phenomena: rail corrugation and wheel squeal. Rail corrugation can be removed by rail grinding but this is a costly exercise and nearby sensitive receivers may be disturbed by increasing noise levels in between periods of rail grinding as corrugation reappears. Wheel squeal is very difficult to predict and mitigation can be limited as it usually involves increasing rail lubrication which may conflict with safe braking requirements.

## 3.2 Fixed Installations Noise and Vibration

3.2.1 Fixed installations include:

a) Forced ventilation shafts located along tunnelled sections;

b) Draught relief shafts located along tunnelled sections;

c) Electrical trackside equipment located along the surface railway;

d) Power supply facilities e.g. transformers located along the surface railway, sub-stations;

e) Mechanical ventilation and air conditioning equipment associated with LU buildings including those located at depots, sidings, control rooms and stations;

f) Static sources of noise located at depots and sidings (for example train washes, wheel lathes, and stationary trains) but excluding noise from the train movements; and

g) Public address systems and audible warning systems at stations, depots and sidings.

**Noise**

3.2.2 Under the National Planning Policy Framework March 2012, new developments should look to conserve and enhance the natural environment. Noise assessments for the majority of fixed installations (excluding public address systems and audible warning systems) should therefore be based on the method described in BS4142:1997 which assesses the impact of fixed developments on the local noise environment.

3.2.3 The assessment method in BS4142:1997 requires the airborne noise arising from a fixed installation to be predicted (expressed in terms of the rating level) and subtracts it from the existing background noise (expressed in terms of the $L_{A90,T}$ noise level). The rating level takes account of tonal or impulsive characteristics of mechanical and electrical services plant.

3.2.3 The noise from the fixed installations in normal operation would not be considered to be significant if the difference between the predicted rating level (as determined for the worst affected residential dwelling) and the existing background noise level is not more than +5dB, assessed in accordance with BS 4142:1997. The assessment should be carried out for day and night time periods as described in BS 4142:1997 and as appropriate for the fixed installations. The criterion must be met for both periods.

3.2.4 The criterion should be applied to the combined noise of all new or upgraded fixed installations (except public address and audible warning systems) at a single development site.

3.2.5 In recognition that local authorities' preference is for the rating levels of fixed installations to be no greater than $L_{A90,T}$-10, the designers should use reasonable endeavours to meet this requirement where it is practical and feasible.

3.2.6 Assessment methods and criterion for public address and audible warning systems are contained in LUL standard 1-142 and LUL guidance G-148.

**Vibration**

3.2.7 It is possible for vibration generated by fixed assets to disturb sensitive receptors. A qualitative assessment should be carried out to determine whether there is a risk of vibration disturbance. If a risk is identified then expert advice should be sought.

Potential mitigation could include alternative components or the application of special measures for vibration isolation.

## 3.3 Surface Railway Noise and Vibration

**Noise**

3.3.1 Surface railway noise applies to moving trains. Stationary train noise whether at a station, siding etc is not considered in this section.

3.3.2 An assessment of eligibility for noise insulation under The Noise Insulation (Railways and Other Guided Transport Systems) Regulations (NIR) 1996 must be carried out. These Regulations set out a requirement to carry out or make a grant toward the provision of insulation works in eligible buildings, where noise levels from new surface railway, or additional tracks that will be located next to an existing surface railway, exceed certain thresholds and triggers set out in the Regulations. An assessment must be carried out for daytime (06:00-00:00, 18hours) and night-time (00:00-06:00, 6hours) periods.

3.3.3 The assessment methodology called for under the Regulations is the Calculation of Railway Noise (CRN) 1995. The method determines the railway noise at a residential dwelling (expressed in terms of $L_{Aeq,T}$) based on the speed of the rolling stock, the size and type of rolling stock, the number of train passes during any given period, the distance between the railway and the residential dwelling and the intervening ground (including barriers) between the railway and the residential dwelling.

3.3.4 An assessment of noise impact should also be carried out based on the CRN procedure where the noise level ($L_{Aeq,T}$) at a residential dwelling before and after the new railway is constructed is compared. A significant impact should be deemed to have occurred if a change of 5dB(A) or more is predicted.

3.3.5 The design of all new surface, or alteration of existing surface railway tracks should endeavour to achieve, in all reasonably foreseeable circumstances, predicted operational noise level increase less than 5dB$L_{Aeq,T}$ at the nearest residential dwelling for day and night periods. There will however be cases where noise will exceed this criterion even after consideration for all practical and feasible mitigation measures has been explored.

**Vibration**

3.3.6 The design of a new surface railway, or altered railway, should be carried out giving consideration to the guidance set out in BS6472-1:2008. The design should endeavour to achieve, in all reasonably foreseeable circumstances, predicted operational vibration, expressed as VDVs, at residential dwellings no greater than the levels given in Table 1 for the stated day and night periods. These levels are in the range for low probability of adverse comment. It is assumed that existing vibration levels are minimal. If existing vibration levels are high (i.e. above 0.1ms$^{-1.75}$) then the criteria would need to be revised.

**Table 1 – Design VDV levels for residential properties adjacent to new surface railways**

| In the Absence of Appreciable Existing Levels of Vibration | |
|---|---|
| VDV ms$^{-1.75}$ Daytime (07:00-23:00) | VDV ms$^{-1.75}$ Night-time (23:00-07:00) |
| 0.2 | 0.1 |

## 3.4 Groundborne Railway Noise and Vibration

**Noise**

3.4.1 There are no UK legislative standards or criteria that define when groundborne noise becomes significant. LUL has therefore drawn upon available experience in constructing new underground railways and complaints received from existing sub surface and underground railways.

3.4.2 The noise from sub surface and underground railways should not be considered to be significant if the groundborne noise as measured in a residential dwelling does not give rise to an average maximum noise level exceeding 40dB $L_{Amax,F}$ . This is based on an assessment of at least 10 trains for the line being assessed (Note: the two directions of a line would be assessed separately).

3.4.3 In recognition that the sensitivity of people to noise can vary significantly the designers should use reasonable endeavours to meet a more stringent requirement of 35dB $L_{Amax,F}$.

**Vibration**

3.4.5 The design of new sub surface and underground railways should be carried out giving consideration to the guidance set out in BS6472-1:2008. The design should endeavour to achieve, in all reasonably foreseeable circumstances, predicted operational vibration, expressed as VDVs, at residential dwellings no greater than the levels given in Table 2 for the stated day and night periods. These levels are in the range for low probability of adverse comment. It is assumed that existing vibration levels are minimal. If existing vibration levels are high (i.e. above 0.1$ms^{-1.75}$) then the criteria will need to be revised.

**Table 2 – Design VDV levels for residential properties adjacent to new underground railways**

| In the Absence of Appreciable Existing Levels of Vibration | |
|---|---|
| VDV $ms^{-1.75}$ Daytime (07:00-23:00) | VDV $ms^{-1.75}$ Night-time (23:00-07:00) |
| 0.2 | 0.1 |

## 3.5 Monitoring

3.5.1 The sensitive receptors should be identified before works commence. Noise and vibration levels should be monitored at sensitive receptors or equivalent locations, as agreed with the relevant local authority, before works commence and again after works have been completed and the asset is operating normally.

## 3.6 Construction Noise and Vibration

3.6.1 It is known that demolition and construction works can generate noise and vibration disturbance. Local authorities in England have powers under the Control of Pollution Act 1974 and the Environmental Act 1990 which they can employ to control unreasonable levels of noise and vibration. These powers can result in works being suspended or restricted at great cost to LUL. It is therefore considered necessary to assess the potential disturbance and demonstrate how appropriate controls would be implemented to minimise disturbance.

3.6.2 A noise and vibration assessment should be carried out for all projects in line with the framework provided in BS5228:2009 Code of practice for noise and vibration control on construction and open sites Part 1: Noise and Part 2: Vibration. This assessment should be carried out as early as possible to ensure that the design of the scheme will not lead to unnecessary disturbance from demolition and construction activities.

3.6.3 For large projects it may be necessary to develop a Code of Construction Practice. The CoCP should include provision for noise and vibration control and monitoring of all demolition and construction activities and should be agreed with the relevant local authority prior to the commencement of works. It should detail any noise insulation and temporary re-housing policies for the project as permitted by The Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996.

3.6.4 In most circumstances a section 61 application (for prior consent for work on construction sites) under the Control of Pollution Act 1974 should be prepared by the main contractor and agreed with the local authority before works commence. LUL form F-10565 Site Noise and Vibration Evaluation and Control Form can be used to determine whether a section 61 is required and LUL form F-10564 is a template for a section 61 consent. The section 61 is likely to include a programme of noise and vibration monitoring, if appropriate, details of the Best Practicable Means that will be employed and the procedure to notify sensitive receivers of the works.

# 4 Responsibilities

4.1.1 Noise and Vibration Engineers shall be responsible for ensuring that the guidance is technically correct, clearly stated and updated to align with the relevant national standards.

4.1.2 Project Engineers should be responsible for the adoption of the appropriate sections of this guidance into asset design, specification and installation.

# 5 Supporting information

## 5.1 Background

5.1.1 Major new works are authorised in a number of ways which can include an Order made under the Transport & Works Act 1992, a Parliamentary Bill or Planning Permission all of which involve a level of public consultation and agreements with local planning authorities. A common concern by the general public is operational noise and vibration. Historically this has been dealt with on a project by project basis. This guidance document has been produced to ensure a common approach across projects and can be used in public consultation.

## 5.2 Safety considerations

5.2.1 There are no safety implications of this guidance.

## 5.3 Environmental considerations

5.3.1 The guidance has been written in order to minimise environmental noise and vibration pollution from new LUL operational assets. It draws on environmental law, British Standards, the London Mayor's Transport Strategy, precedents set by recent projects and best practice.

## 5.4 Customer considerations

5.4.1 Operational noise and vibration often leads to complaints from local residents. If the guidance given in this document is followed for new assets then this should result in fewer complaints.

# 6 References

## 6.1 Documents

Document references in the text are made to the latest editions unless specific editions are cited. Where references are made to other corporate engineering

documents which are not yet published, existing documents shall be followed until new documents have been authorised for use

| | |
|---|---|
| **Note:** | References to particular EU Directives and Regulations, Acts of Parliament, Statutory Instruments or Common Law are made only if the subject demands them. Users of the engineering standards are bound by all relevant requirements of the law, regardless of whether or not there is any reference to them in the standards. |

**Statutory Documents**

| Document | Title |
|---|---|
| CRN | Calculation of Railway Noise 1995 |
| NIR | Noise Insulation (Railways and Other Guided Transport Systems) Regulations 1996 |
| EA | Environmental Act 1990 |
| CoPA | Control of Pollution Act 1974 |

**British Standards**

| Document | Title |
|---|---|
| BS 8233 | Sound insulation and noise reduction for buildings – Code of practice |
| BS 4142 | Method for Rating industrial noise affecting mixed residential and industrial areas |
| BS 6472 – 1 | Guide to evaluation of human exposure to vibration in buildings Part 1: Vibration sources other than blasting |
| BS 5228 – 1 | Code of practice for noise and vibration control on construction and open sites Part 1: Noise |
| BS 5228 – 2 | Code of practice for noise and vibration control on construction and open sites Part 2: Vibration |

**LUL Company Documents**

| Document | Title |
|---|---|
| G-148 | Public Address Systems – Noise Management |
| 1-142 | Operational Information Systems |
| F-10564 | Section 61 Consent Application Template Noise |
| F-10565 | Site Noise and Vibration Evaluation and Control Form |

**Other**

| Document | Title |
|---|---|
| PPG24 | Planning Policy Guidance 24: Planning and Noise |

## 6.2 Abbreviations

The following abbreviations are created:

a) within London Underground's Glossary of Terms (1-622) (a Category 1 Standard);
b) from published sources that are clearly identified.

| Abbreviation | Definition | Source |
|---|---|---|
| LUL | London Underground Limited | a |
| VDV | Vibration Dose Value | b Standard |
| CoCP | Code of Construction Practice | b |

## 6.3 Definitions

The following topic specific definitions are created:

a) within London Underground's Glossary of Terms (1-622) (a Category 1 Standard);
b) from published sources that are clearly identified.

| Term | Definition | Source |
|---|---|---|
| Airborne Noise | Sound that propagates from source to receiver through air | b Standard |
| Ground-borne Noise | Noise inside a building due to vibration generated from a vibration source (i.e. pass-by of a train) that is propagated through the ground and into the building structure before it is radiated as noise inside a room. | b Standard |
| dB (decibel) | The scale on which sound pressure level is expressed. It is defined as 20 times the logarithm of the ratio between the root-mean-square pressure of the sound field and a reference pressure (2x10-5Pa). | b Standard |
| A-weighting | A frequency dependent correction that is applied to a measured or calculated sound of moderate intensity to mimic the varying sensitivity of the human ear to sound for different frequencies | b Standard |
| $L_{Aeq,T}$ Equivalent continuous A-weighted sound pressure level | The value of the A-weighted sound pressure level of a continuous, steady sound that, within a specified time interval, T, has the same mean square sound pressure as a sound under consideration whose level varies with time. | b Standard |
| $L_{Ar,Tr}$ Rating noise level | The equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source during a specified time interval, plus any adjustment for the characteristic features of the specific noise source. | b Standard |
| $L_{A90,T}$ Background noise level | The A-weighted sound pressure level that is exceeded for 90% of a given time interval, T, measured using time weighting, F. | b Standard |
| $L_{Amax}$ Maximum noise level | The highest value of the A-weighted sound pressure level recorded over the period stated. The time constant of the measure may be Fast, Slow or Impulsive. | b Standard |
| Time weighting Fast, F | Integration time corresponding to a time constant 0.125s which is thought to best approximate the human hearing system. | b Standard |
| Time weighting Slow, S | Integration time corresponding to a time constant 1s | b Standard |
| VDV Vibration Dose Value | A measure of the cumulative vibration experienced over a specified period of time. It is given by the fourth root of the time integral of the fourth power of the acceleration after it has been frequency weighted.<br>It defines a relationship that yields a consistent assessment of continuous, intermittent, occasional and impulsive vibration that correlates well with subjective human response. | b Standard |

## 6.4 Person accountable for the maintenance of the document

| Job Title | Name | Date document authorised and approved for use |
|---|---|---|
| Technical Services Manager | Dave Brabham | 18/04/2012 |

## 6.5 Document history

| Issue no | Date | Changes | Author |
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| A1 | April 2012 | New guidance document produced as per DRACCT No. 01325 | Averil McMahon |