Cole Jarman

St. Giles Circus, London

Vibration Survey Report

Report 16/0210/R1

St. Giles Circus, London

Vibration Survey Report

Report 16/0210/R1

SRW Engineering Services

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London
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Attachments

16/0210/SP1 & SP2
Ground and first floor site plans showing vibration survey measurement positions

16/0210/SCH1
Frequency based plots of measured vibration levels at positions 1-6

Glossary of Acoustic Terms

1 Introduction

1.1 The site at St. Giles Circus is currently under redevelopment, the southern edge of the site is formed by existing buildings which front onto Denmark Street.

1.2 The existing buildings are to be retained as part of the scheme, although some will be modified to tie into the new structures being built to the immediate North.

1.3 Cole Jarman were requested by Skanska to undertaken some sample measurements within these existing buildings, in order to quantify existing levels of vibration in the floors of the buildings. The measurements were to be undertaken during the daytime when normal activities were underway in the area that might generate environmental vibration (road traffic, underground trains etc.), but also while construction activities were underway on the northern side of the site.

1.4 This report sets out the methodology and results of a vibration survey undertaken at the site, and compares the measured results to relevant guidance in BS6472-1:2008 and the superseded BS6472:1992.

2 Site Layout

2.1 The development site is large and is bounded to the south by Denmark Street and the existing buildings which front onto the northern side of this road.

2.2 The eastern site boundary is formed by the A40 St. Giles High Street and the western boundary by Charing Cross Road.

2.3 The northern side of the site is currently being redeveloped and is the subject of regular construction activity. To the north of the site as a whole lies the temporarily diverted northern section of Charing Cross Road, with the Centre Point building beyond.

2.4 Vibration measurements were undertaken in a sample of the existing buildings on Denmark Street, which are generally of traditional masonry construction with internal timber joist floors.

3 Vibration Standards

3.1 It is common to measure and evaluate the effects of vibration on humans in buildings using guidance in BS6472:2008-1 "Guide to evaluation of human exposure to vibration in buildings. Vibration sources other than blasting". The standard considers the human response to vibration in buildings, in the frequency range 0.5Hz to 80Hz.

3.2 BS6472 uses the concept of Vibration Dose Values (VDVs) to consider the likely impact of vibration upon people. The measured vibration levels are first weighted, using curves

described in BS6841:1987 to give an overall weighted acceleration level, before a calculation procedure is applied to derive the VDV based upon the duration and number of events.

3.3 Two different constant vibration sources with different frequency characteristics, but with the same overall weighted acceleration levels could be considered to be equally annoying or not, as the case may be. The VDV is derived by totalling the time exposure to the particular weighted acceleration levels over a particular period. The totalling procedure is however, heavily weighted towards the higher vibration levels rather than the time exposure, as a high level of vibration exposure for say 30 seconds, is more intrusive than a level half that for an exposure of 1 minute.

3.4 BS6472 gives the following guidance on VDVs affecting residential properties.

Table 1. Vibration dose value ranges which might result in various probabilities of adverse comment within residential buildings

Place	Low probability of adverse comment $ms^{-1.75}$ (1)	Adverse comment Possible $ms^{-1.75}$	Adverse comment Probable $ms^{-1.75}$ (2)
Residential buildings 16h day	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Residential buildings 8h night	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8
Office buildings 16h day	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2
Workshop buildings 16h day	0.4 to 1.6	1.6 to 3.2	3.2 to 6.4

(1) Below these ranges adverse comment is not expected
(2) Above these ranges adverse comment is very likely

3.5 The superseded version of BS6472[1] contained a set of reference curves against which measured vibration levels could be plotted. Although superseded, curve 1 of the standard gave an approximation of the threshold of perceptibility of vibration to humans.

3.6 While not an absolute gauge as to whether or not vibration in a building would be perceptible, the base curve can be used to help put the levels of vibration measured on the floor of a building in context.

[1] BS6472:1992 Guide to evaluation of human exposure to vibration in buildings (1 Hz to 80 Hz)

4 Vibration Survey

4.1 In order to quantify existing vibration levels in the retained buildings, an attended vibration survey was undertaken on site on 14th July 2016.

4.2 Measurements were made at a total of six locations as shown in the attached figures 16/0210/SP1 and SP2 and described below.

- P1: On the ground floor of 23 Denmark Street, (Wunjo Keys).
- P2: On the first floor of 23 Denmark Street, (Skanska Office).
- P3: On the ground floor of 19 Denmark Street.
- P4: On the first floor of 19 Denmark Street.
- P5: On the ground floor of 27 Denmark Street, (Hanks Acoustic Guitars).
- P6: On the first floor of 27 Denmark Street, (Hanks Acoustic Guitars).

4.3 Measurements were made using the equipment listed in table T1.

Item	Manufacturer	Type
Tough book PC running Samurai real time analyser software	*Panasonic*, and *Noise & Vibration Works*	Soundbook 4 channel interface + siNoise version 2.2.2
Accelerometer x3	*Dytran*	3191A1 (10V/G)

T1 Equipment used during noise and vibration measurements

4.4 The Dytran accelerometers were mounted in a mass block in the three orthogonal directions so as to determine the vibration levels in the vertical and two horizontal axes. The block was located on the floor at each measurement location and adjusted so as to sit level, in each case the horizontal axes were aligned so as to correspond with the alignment of the front/rear walls and the side walls to the adjacent property.

4.5 Measurements were made over continuous 1 minute periods for a total period of 30 minutes at each of the six measurement locations, this being considered representative to obtain typical vibration levels evident in the floor of each sample building. The measurements were made in terms of the RMS equivalent continuous (L_{eq}) vibration level over each 1 minute period.

4.6 Measurements were also made in terms of the Vibration Dose Value (VDV) over each 1 minute period to enable this to be considered.

5 Survey Results

Measured Vibration Spectra

5.1 The measured $^1/_3$ octave band L_{eq} vibration levels in each of the three measurement axes at each location are displayed in the attached schedule 16/0210/SCH1. The following points should be noted when consulting the graphs in the schedule:

- Channel 1 is the vertical measurement axis, channel 2 and channel 3 are the two horizontal axes of measurement.
- The horizontal axis (X-axis) on each graph shows the frequency of vibration in one third octave bands from 0.8Hz to 80Hz.
- The vertical axis shows the vibration levels plotted in terms of acceleration in m/s^2.
- Each line on the plot represents the L_{eq} level measured over an individual 60 second period, plotting all of the individual traces in this way allows a picture to be gained of the variability of vibration levels over the 30 minute measurement period.
- The relevant base curve from BS6472:1992 is also plotted for reference.

5.2 Vibration was noted to be subjectively low at measurement positions 1-5 and remained below the curve 1 values, only at position 6 did the levels exceed curve 1 during some of the 1 minute periods.

5.3 Although efforts were made to locate the measurements in parts of the building where people were not walking around, during most measurements there were some instances of people walking past the measurement location which generated some vibration due to footfall.

5.4 Location 6 was a busy music store premises and there were several instances of people walking around on the floor near to the measurement location and this is the reason for the higher levels recorded at this position.

Measured VDV levels

5.5 Vibration dose values have been reviewed to provide the equivalent vibration dose value (VDV) calculated in accordance with methodology in BS6472:2008-1, and then scaled up to equate to exposure of an occupant of the building to vibration over a 16 hour day. This has assumed that the vibration levels measured during the 30 minute daytime period at each location occur over each 30 minute period continuously throughout the entire 16 hour day.

5.6 This is a pessimistic assumption as in reality construction activity is limited to certain hours of the day and levels of road and underground train traffic will be lower during times of the late evening and early morning and night.

5.7 The calculated VDV values are summarised in table T2. It can be seen that the extrapolated 16 hour daytime levels at position 1-5 all correspond to a level at or below that where there would be expected to be a *"low probability of adverse comment"* in the context of a residential type environment.

5.8 At measurement position 6, horizontal levels are equivalent to those where *"adverse comment possible"* and in the vertical axis where *"adverse comment probable"* for a residential type environment, however these measurements were significantly affected by footfall on the floor of the building rather than any external environmental sources and this explains the disparity in the results at these locations compared to others in the survey.

5.9 The measured levels at position 6 in the context of an office building equate to *"low probability of adverse comment"* in the horizontal axes and *"adverse comment possible"* in the vertical axis.

Location/Measurement	**Vibration Dose Value $ms^{-1.75}$**		
	Channel 1 (vertical) VDV_b	**Channel 2 (horizontal) VDV_d**	**Channel 3 (horizontal) VDV_d**
Position 1 – Half hour measurement	0.04	0.01	0.06
Position 1 – Scaled up to 16h daytime	0.09	0.02	0.15
Position 2 – Half hour measurement	0.07	0.01	0.03
Position 2 – Scaled up to 16h daytime	0.16	0.02	0.06
Position 3 – Half hour measurement	0.01	0.003	0.08
Position 3 – Scaled up to 16h daytime	0.03	0.01	0.01
Position 4 – Half hour measurement	0.01	0.005	0.005
Position 4 – Scaled up to 16h daytime	0.03	0.01	0.01
Position 5 – Half hour measurement	0.005	0.001	0.05
Position 5 – Scaled up to 16h daytime	0.01	0.003	0.12
Position 6 – Half hour measurement	0.44	0.17	0.16
Position 6 – Scaled up to 16h daytime	1.04	0.41	0.39

T2 Measured and extrapolated Vibration Dose Values

6 Conclusions

6.1 A vibration survey has been undertaken in retained buildings forming part of the St. Giles Circus redevelopment scheme.

6.2 Vibration measurements have been made at 6 internal locations in these buildings, using a mixture of ground and first floor locations.

6.3 The results have been plotted against curve 1 of the superseded BS6472:1992 as an approximation of the threshold of perception. Levels were found to be generally below this curve except at one location where footfall from occupants of the building caused the curve to be exceeded.

6.4 Vibration Dose Values were also recorded and have been extrapolated to an equivalent 16 hour daytime level. The extrapolated VDV values all correspond to a level at or below that where there would be expected to be a *"low probability of adverse comment"* in the context of a residential building, except at one location where due to footfalls of occupants on the floor concerned, levels equated to *"adverse comment possible"* or *"adverse comment probable"*.

6.5 At the location affected by footfall vibration, in the context of an office building, measured VDV values equate to *"low probability of adverse comment"* in the horizontal axes and *"adverse comment possible"* in the vertical axis.

6.6 The survey indicates generally low levels of vibration and the effects of footfall at the one affected location should be considered when comparing and evaluating the results.

End of Section

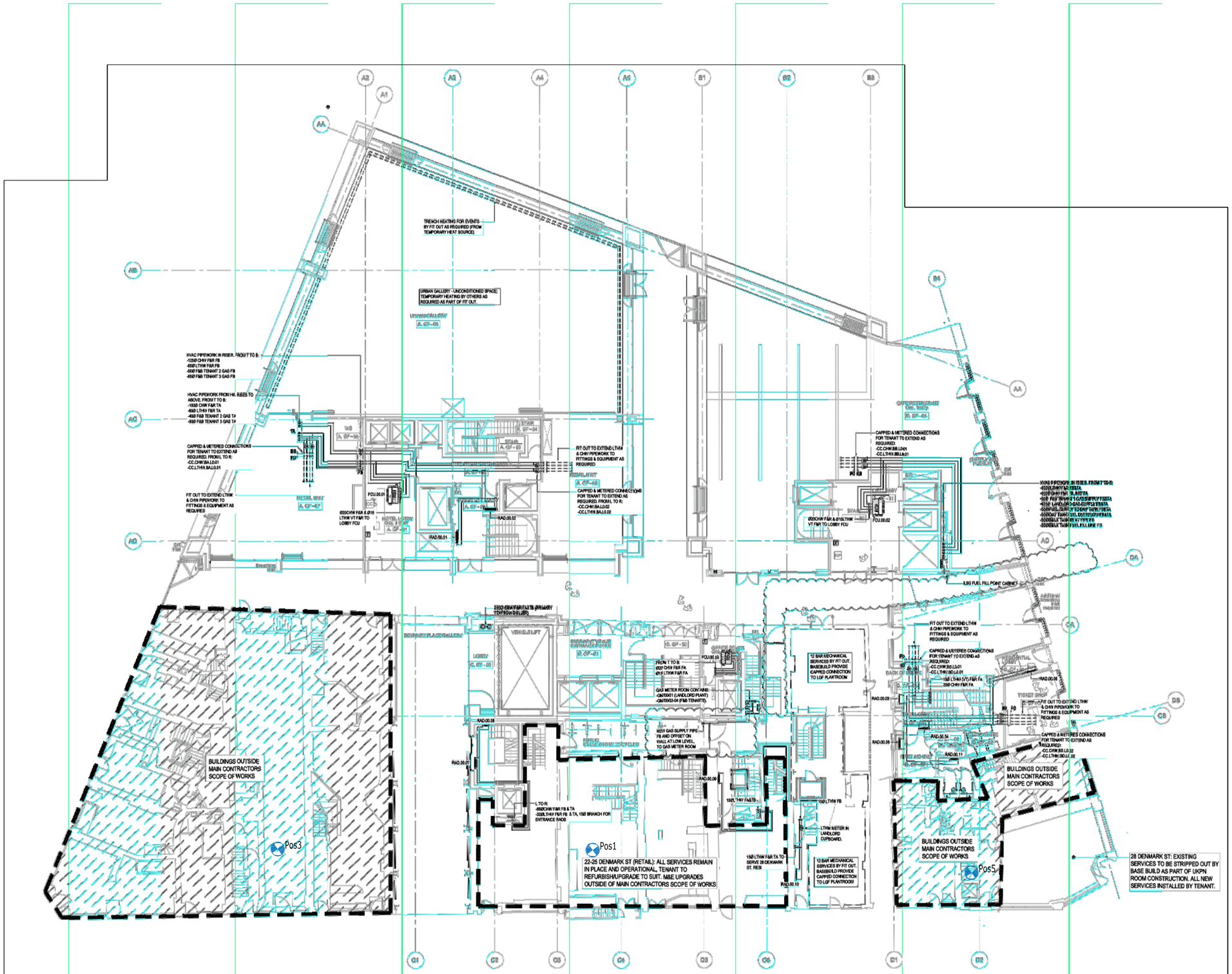

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Figure 16/0210/SP1

Title:

Site Plan Showing Vibration Measurement locations. Ground Floor.

Measurement Position

North

Project:

St. Giles Circus, Plant Noise Review

Date:

July 2016

Revision:

-

Scale:

Not to scale

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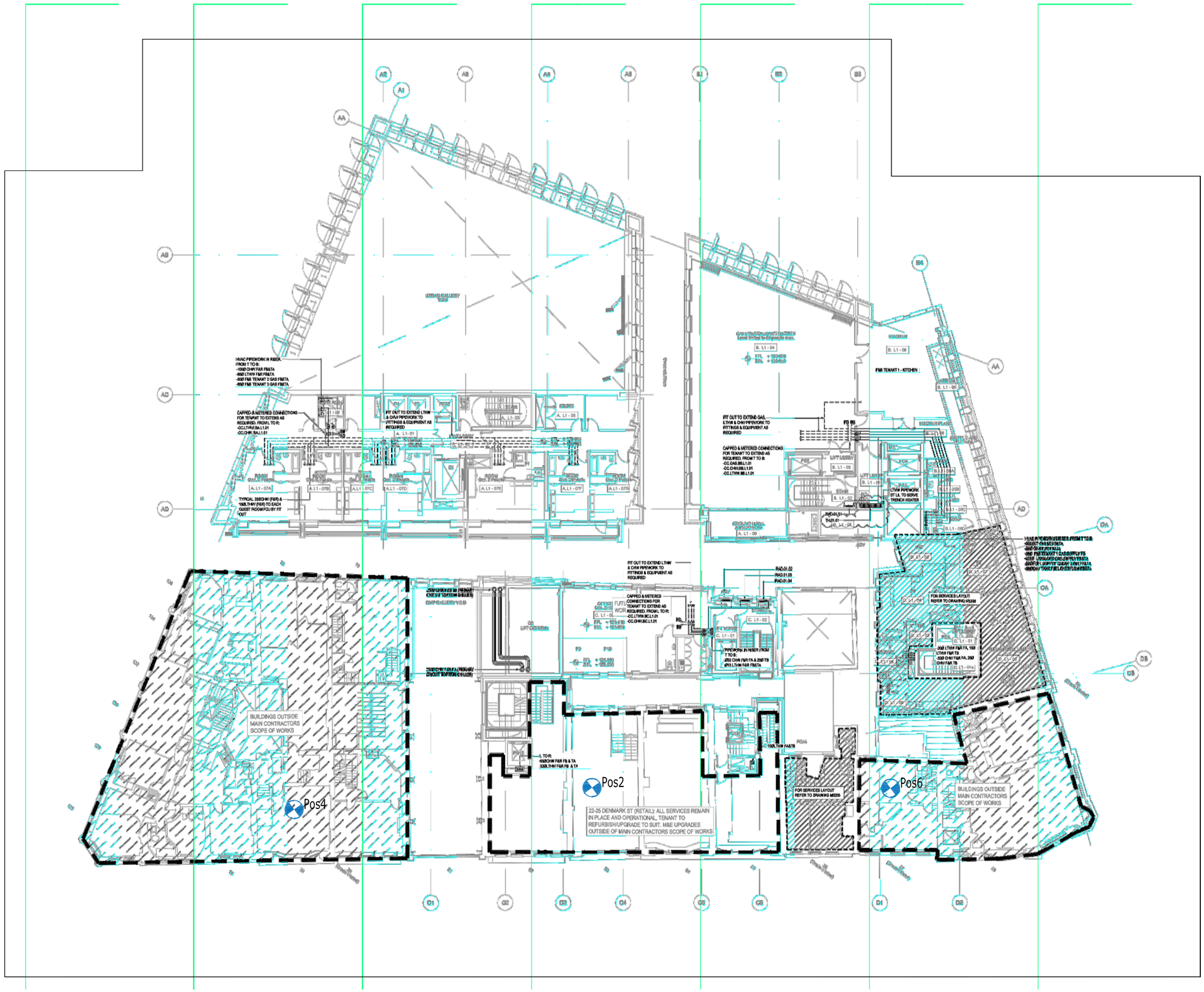

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Figure 16/0210/SP2

Title:

Site Plan Showing Vibration Measurement Positions. First Floor.

Project:

St. Giles Circus, Plant Noise Review

Date: July 2016

Revision: -

Scale: Not to scale

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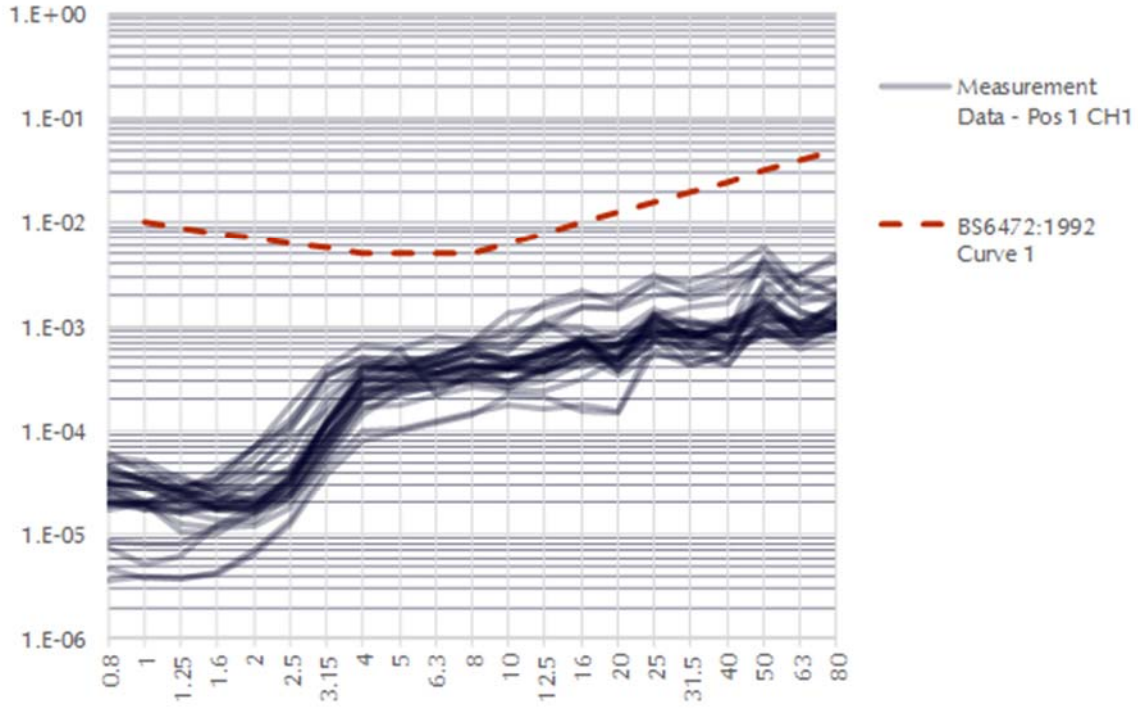
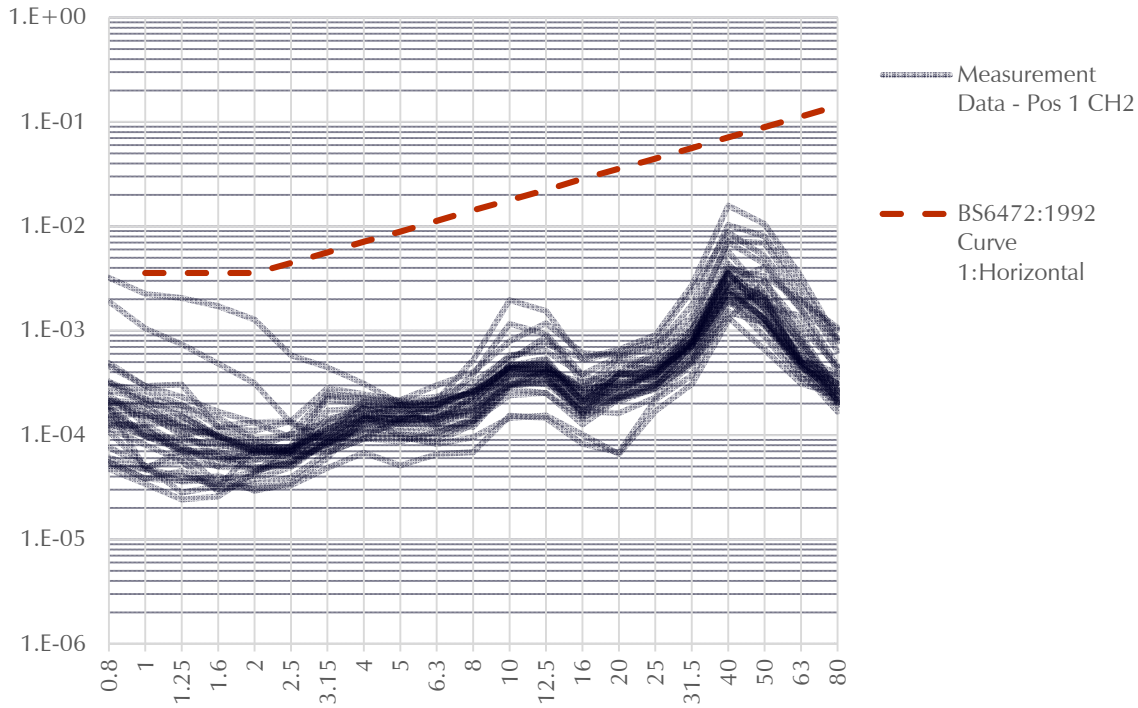
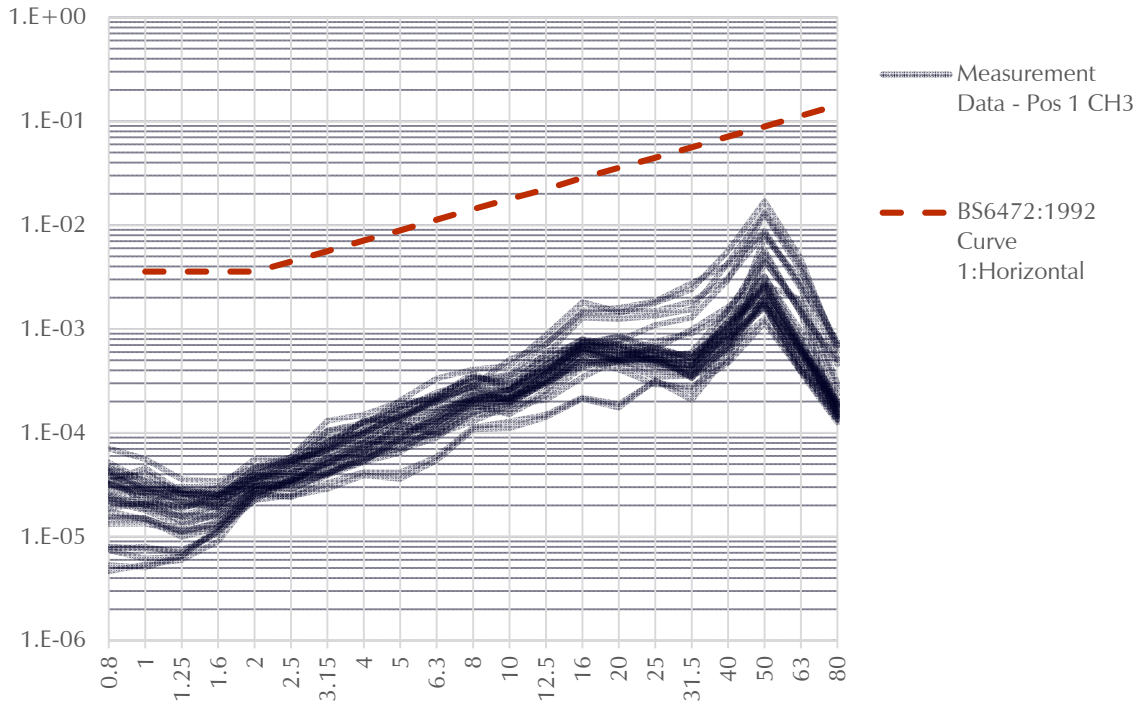
Vibration Survey Results – Position 1



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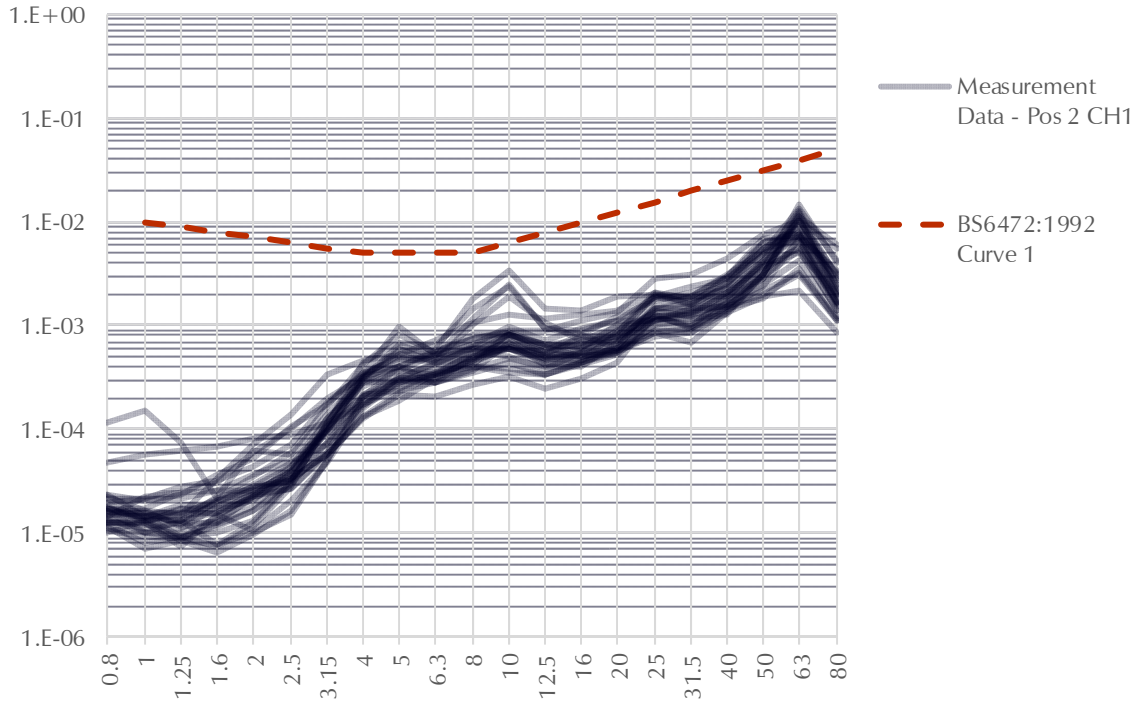
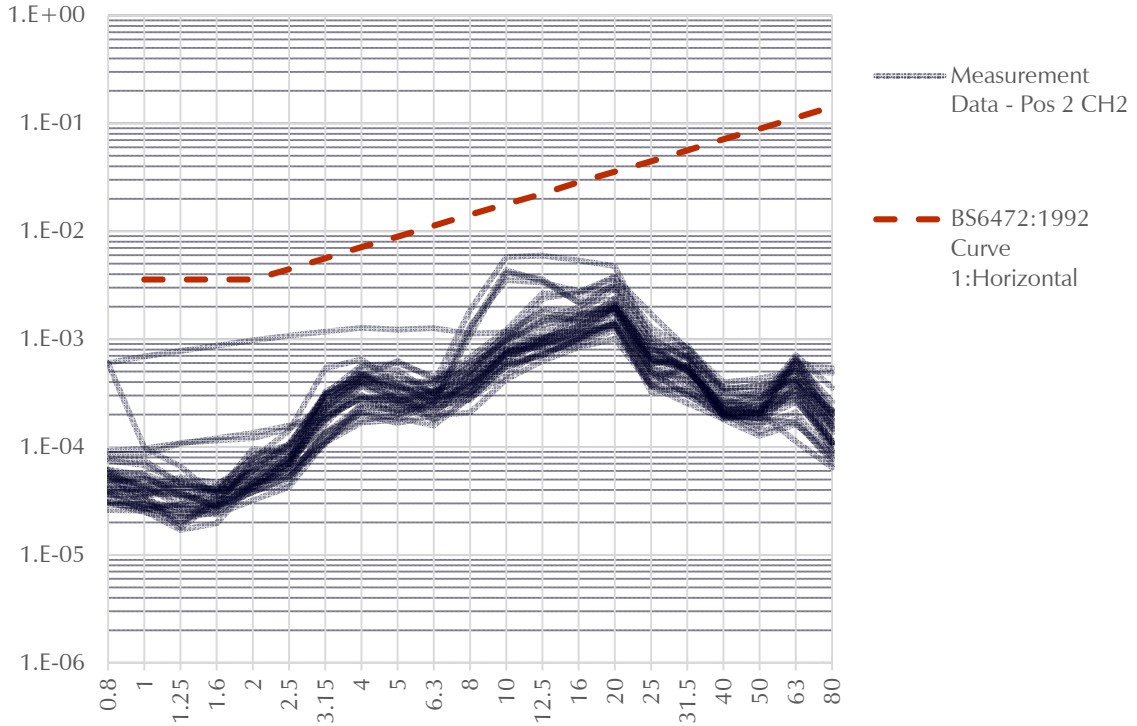
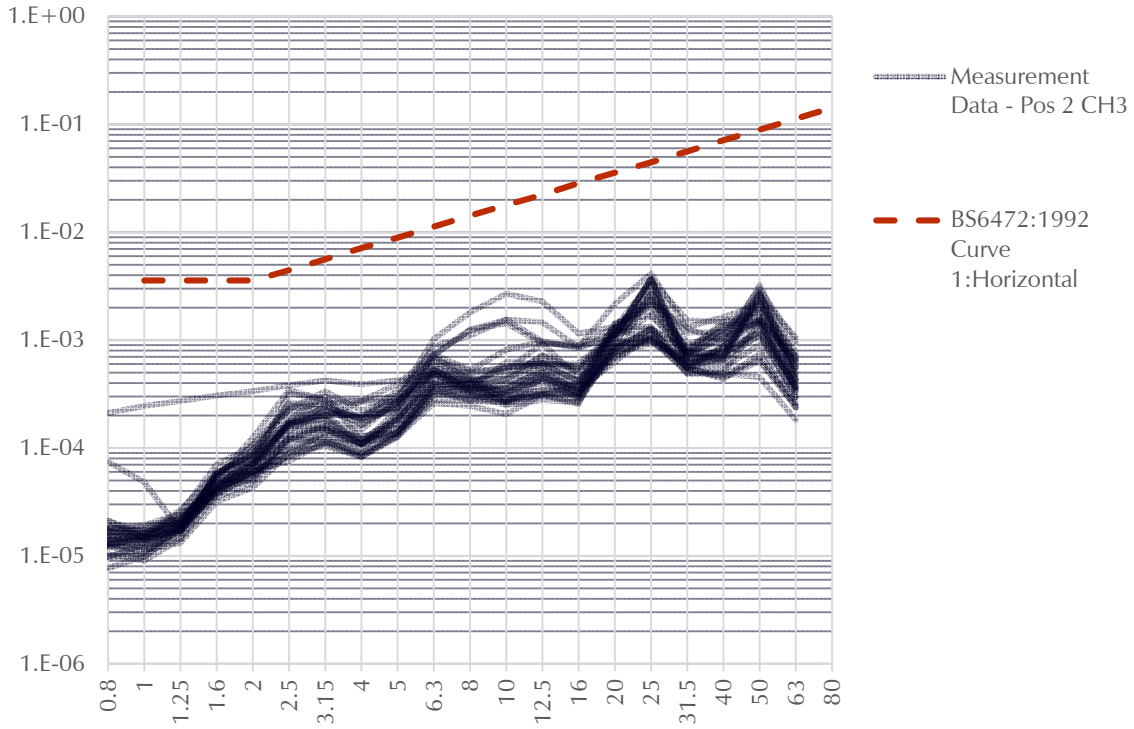
Measurement Data - Pos 1 CH3
BS6472:1992 Curve 1:Horizontal

Vibration Survey Results – Position 2



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Measurement Data - Pos 2 CH3
BS6472:1992 Curve 1:Horizontal

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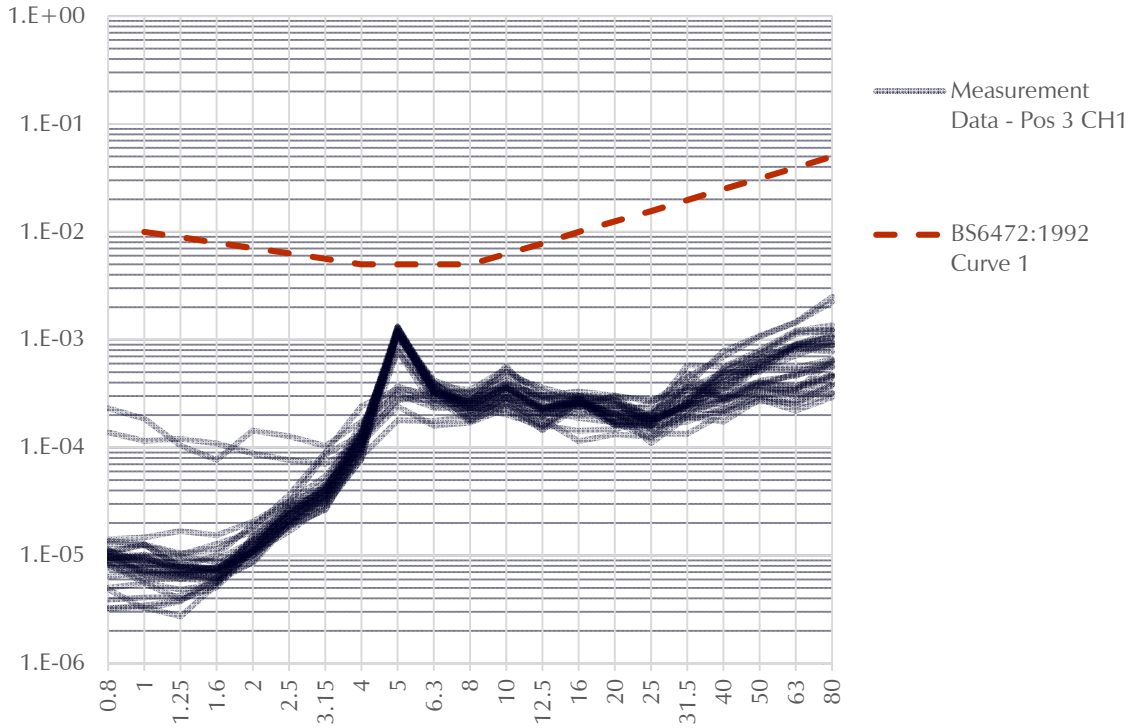

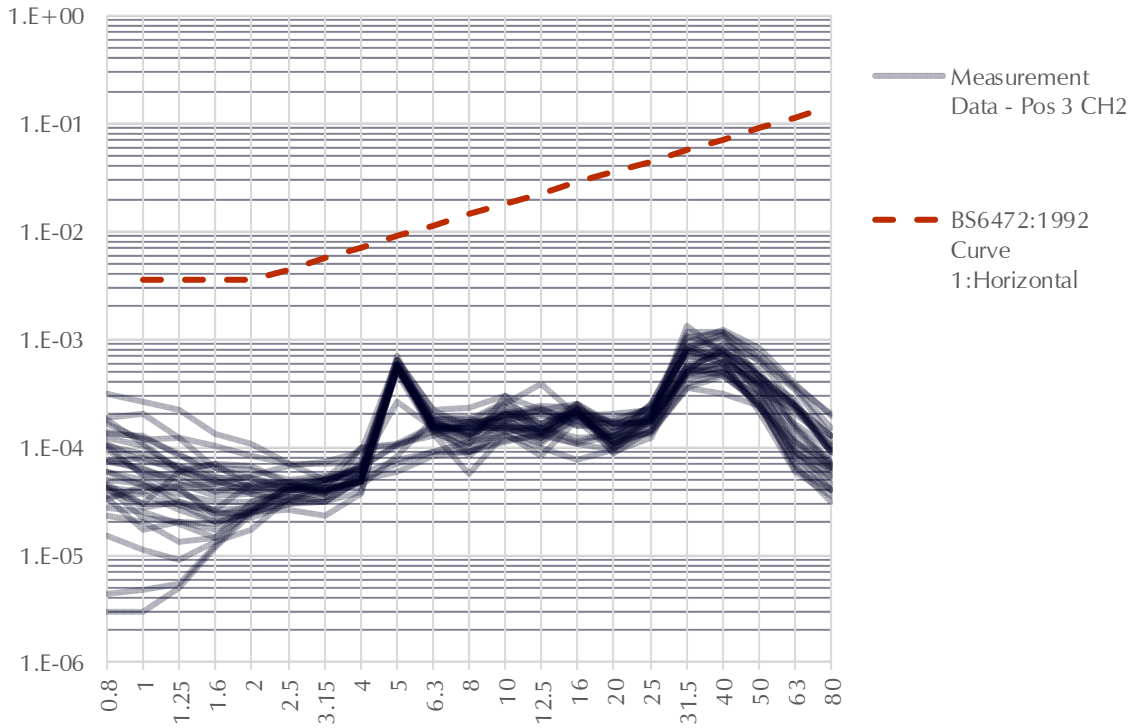

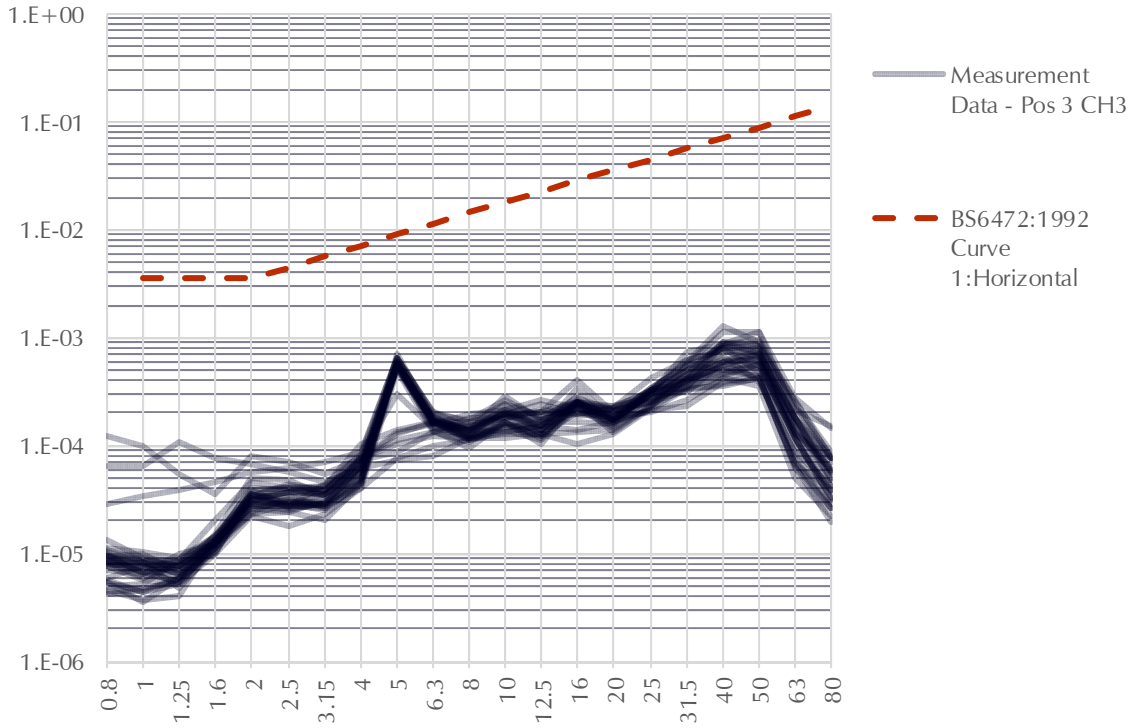
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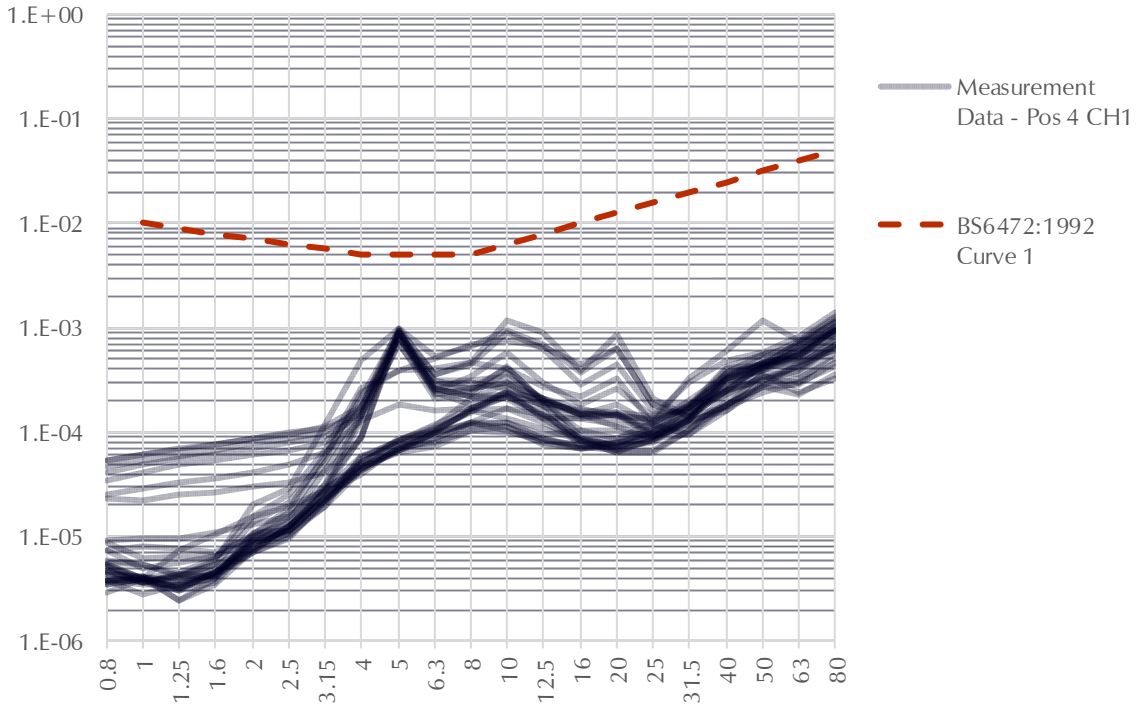
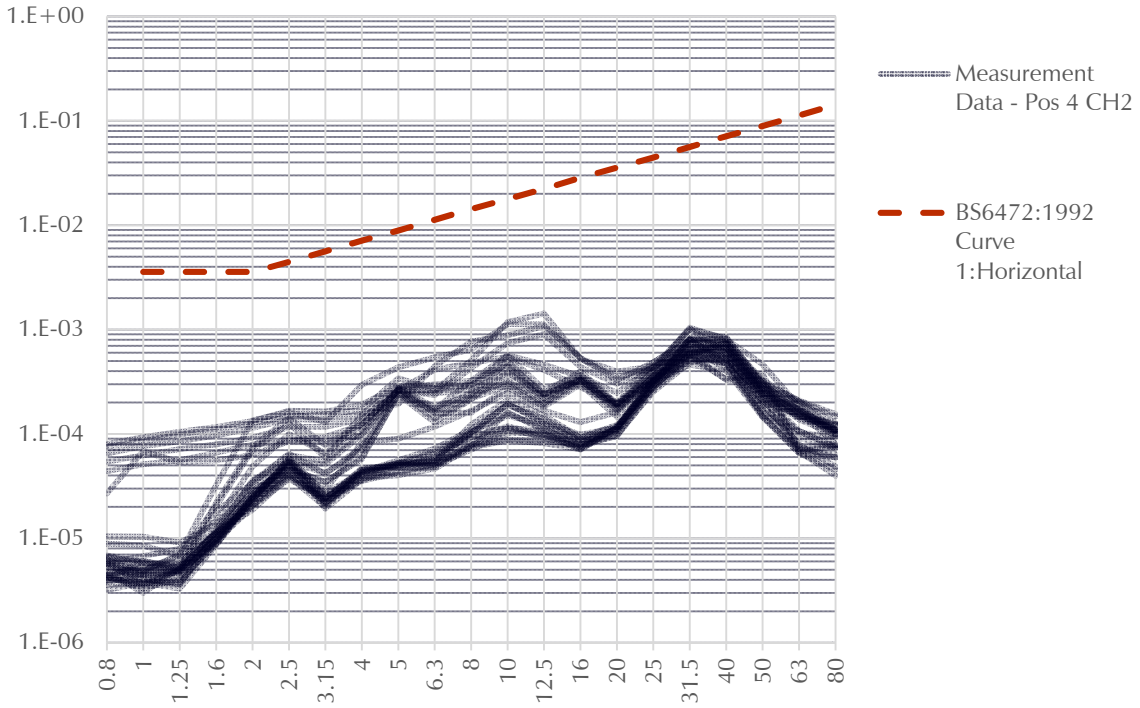
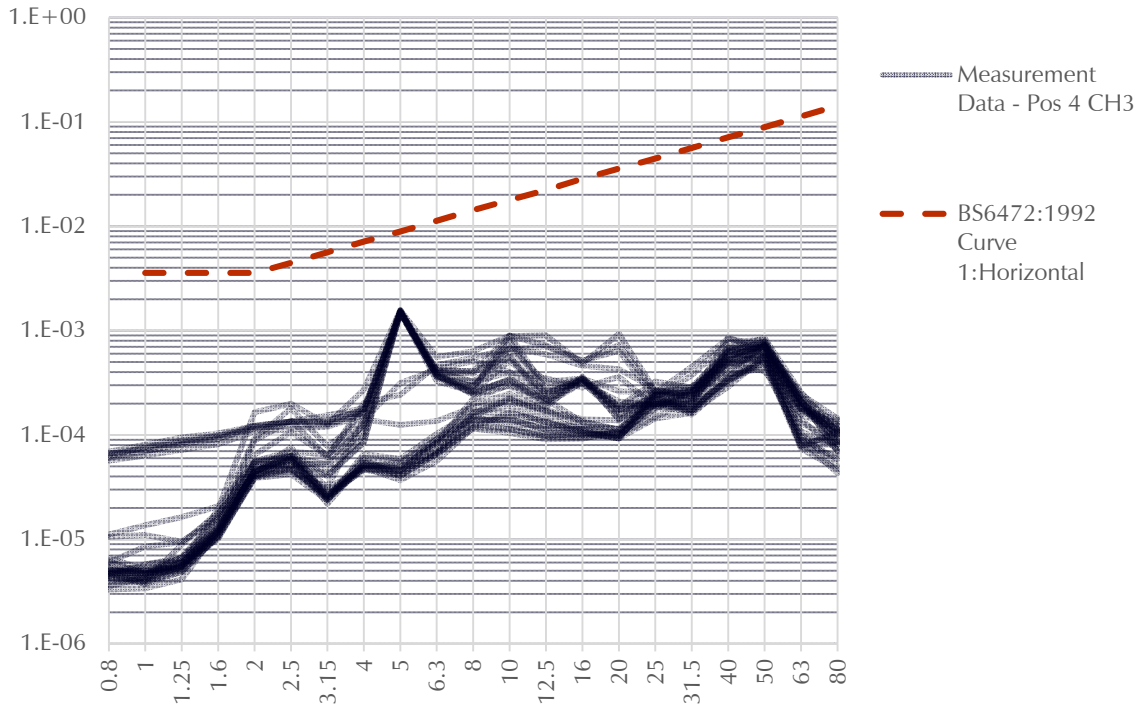
Measurement Data - Pos 3 CH3
BS6472:1992 Curve 1:Horizontal

Vibration Survey Results – Position 4



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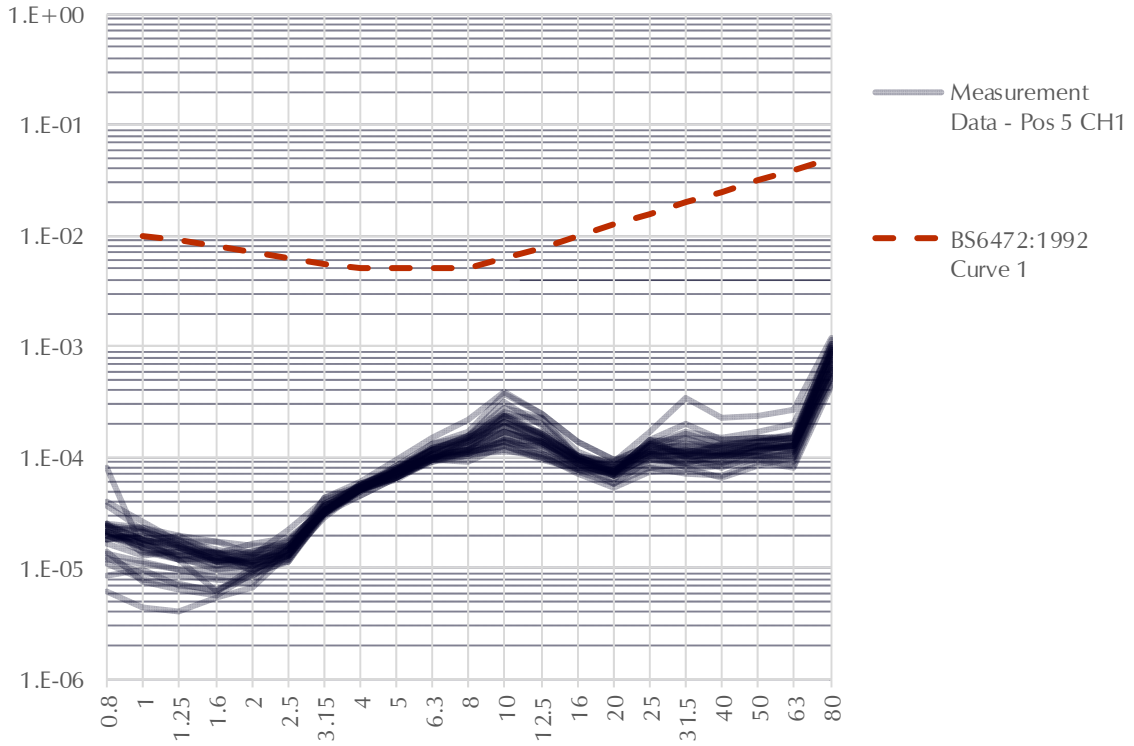
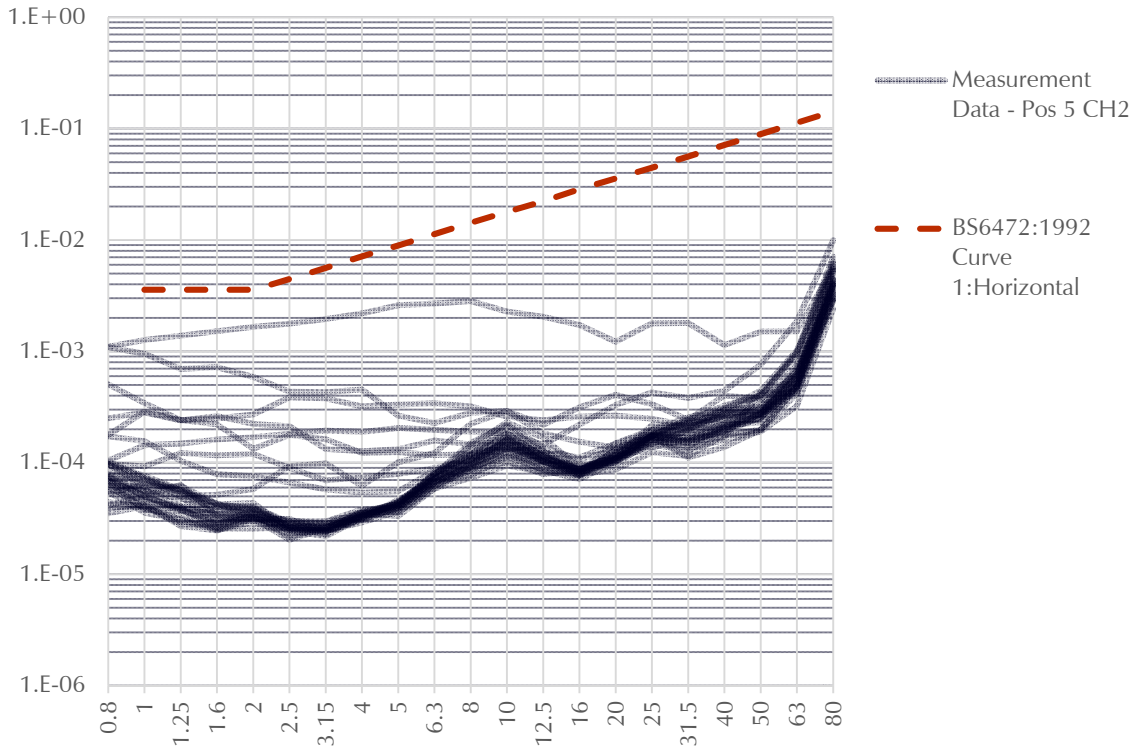
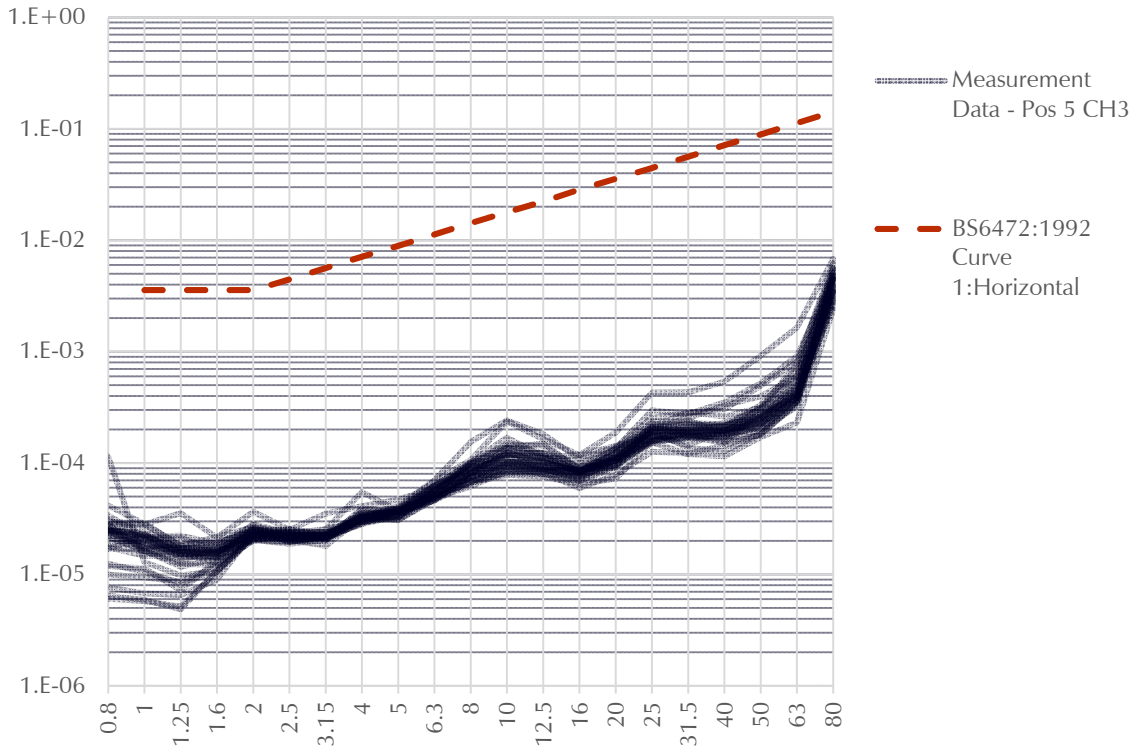
Measurement Data - Pos 4 CH3
BS6472:1992 Curve 1:Horizontal

Vibration Survey Results – Position 5



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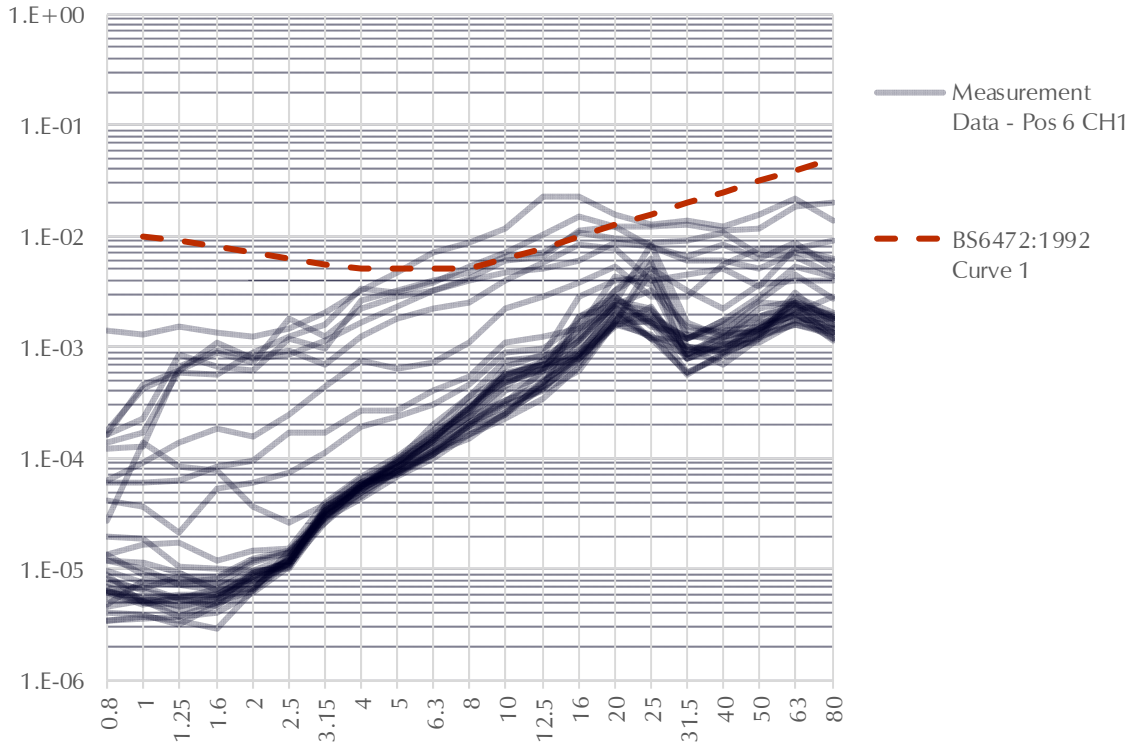
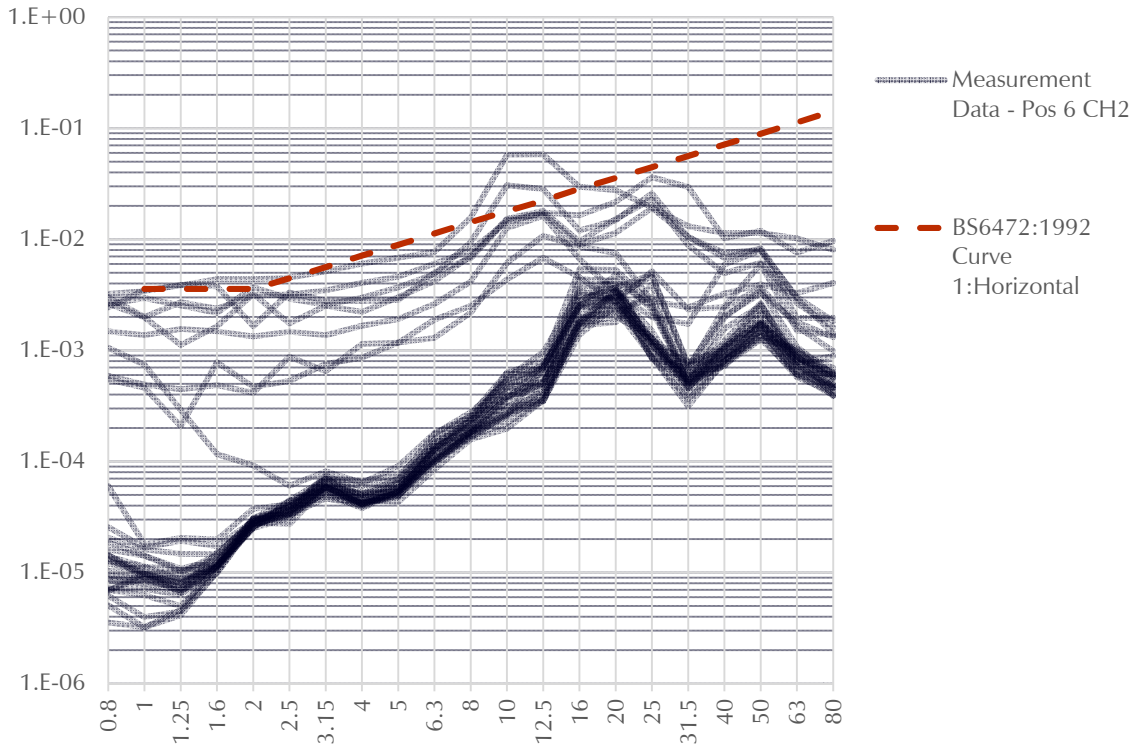
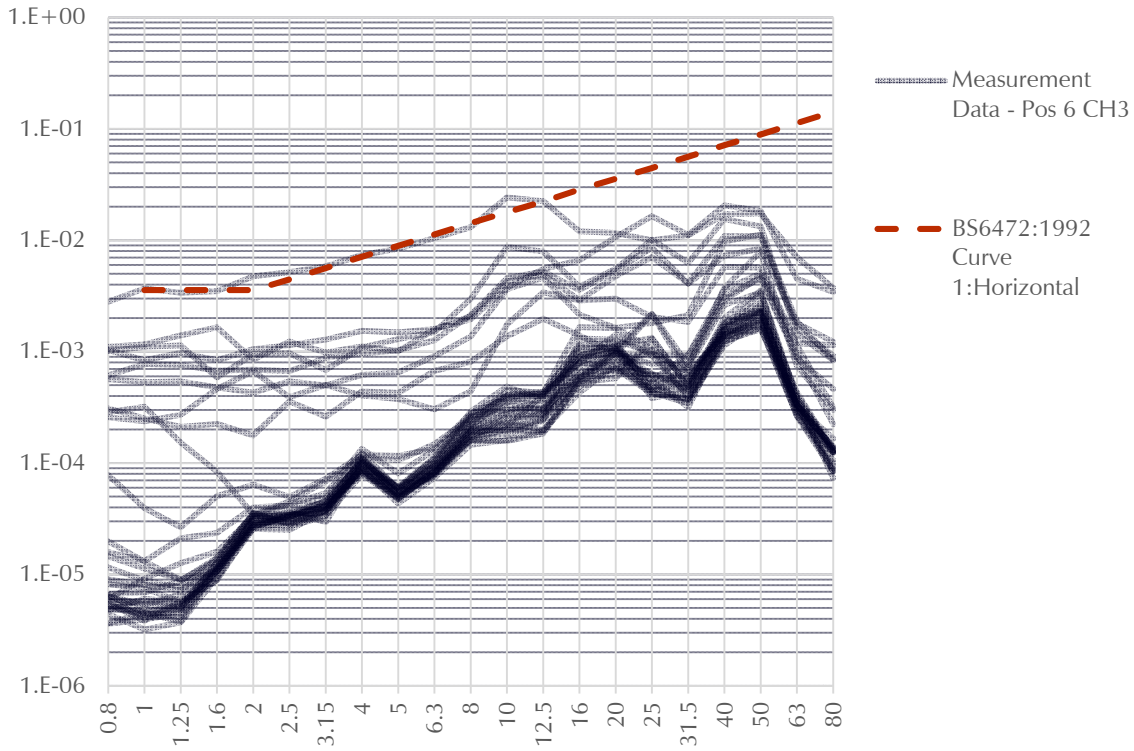
BS6472:1992 Curve 1:Horizontal

Vibration Survey Results – Position 6



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Measurement Data - Pos 6 CH3
BS6472:1992 Curve 1:Horizontal

Glossary of Acoustic Terms

L_{Aeq}:

The notional steady sound level (in dB) which over a stated period of time, would have the same A-weighted acoustic energy as the A-weighted fluctuating noise measurement over that period. Values are sometimes written using the alternative expression dB(A) L_{eq}.

L_{Amax}:

The maximum A-weighted sound pressure level recorded over the period stated. L_{Amax} is sometimes used in assessing environmental noise when occasional loud noises occur, which may have little effect on the L_{Aeq} noise level. Unless described otherwise, L_{Amax} is measured using the "fast" sound level meter response.

L_{A10} & L_{A90}:

If non-steady noise is to be described, it is necessary to know both its level and degree of fluctuation. The L_{An} indices are used for this purpose. The term refers to the A-weighted level (in dB) exceeded for n% of the time specified. L_{A10} is the level exceeded for 10% of the time and as such gives an indication of the upper limit of fluctuating noise. Similarly L_{A90} gives an indication of the lower levels of fluctuating noise. It is often used to define the background noise.

L_{A10} is commonly used to describe traffic noise. Values of dB L_{An} are sometimes written using the alternative expression dB(A) L_{n}.

L_{AX}, L_{AE} or SEL

The single event noise exposure level which, when maintained for 1 second, contains the same quantity of sound energy as the actual time varying level of one noise event. L_{AX} values for contributing noise sources can be considered as individual building blocks in the construction of a calculated value of L_{Aeq} for the total noise. The L_{AX} term can sometimes be referred to as Exposure Level (L_{AE}) or Single Event Level (SEL).

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