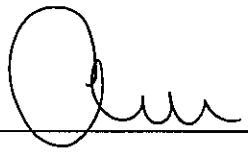
MTR Corporation Limited

Kwun Tong Line Extension (KTE)

Ground-borne Noise Review Report (Phase 1 and Phase 2)

Verified by: 

Position: Independent Environmental Checker

Date: 5 Nov 2014

MTR Corporation Limited

Kwun Tong Line Extension (KTE)

Ground-borne Noise Review Report (Phase 1 and Phase 2)

Certified by: _____

Position: Environmental Team Leader

Date: - 5 NOV 2014

MTR Corporation Limited

Ground-borne Noise Review Report for KTE

October 2014

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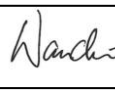
Ground-borne Noise Review Report for KTE

October 2014

Reference 0132172

For and on behalf of
ERM-Hong Kong, Limited

Approved by: Frank Wan

Signed: 

Position: Partner

Date: 13 October 2014

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LIST OF ANNEXES

1 INTRODUCTION

1.1 BACKGROUND

The Kwun Tong Line Extension (KTE) is a ~2.6km extension of the existing MTR Kwun Tong Line service from the Yau Ma Tei Station (YMT) to a new terminus station at Whampoa via the Ho Man Tin Station (HOM).

The Environmental Impact Assessment (EIA) Report of the KTE was approved on 19 August 2010, Register No.: AEIAR-154/2010 (the approved KTE EIA Report). According to Condition 4.2 of the Environmental Permit (EP-399/2010/B), the Permit Holder is responsible for carrying out the review of the proposed mitigation measure for operation groundborne noise (GBN) (including the verification of the Line Source Response (LSR) and ground vibration condition) assumed in the approved EIA Report. A Review Report shall be submitted to justify the adequacy of the operation GBN mitigation measures proposed in the approved KTE EIA Report.

ERM-Hong Kong, Limited (ERM) is commissioned by MTR Corporation Limited (MTRCL) as the Environmental Term Consultant. ERM is supported by Wilson Acoustics Limited (WAL) who acts as the GBN specialist.

1.2 PURPOSE OF THIS REPORT

According to the submitted KTE Ground-Borne Noise Review Plan, measurements are proposed to be conducted at NSR12 (Methodist Primary School at 10-12 Wylie Road), NSR14 (Shun Man House, Oi Man Estate) and NSR26 (Wing Fu Building, Whampoa Estate) to verify the ground conditions. The review of GBN impact was separated into two phases. Phase 1 covers the section from DN CH10+400 to CH9+200, NSR 1 to NSR12 sit along this section. Phase 2 covers the section from DN CH9+200 to CH7+891, NSR 13 to NSR 62 sit along this section.

The Review Report of Phase 1 was submitted in March 2014, GBN of NSR12 was reviewed in the report.

This *GBN Review Report* incorporate the measurement results and updated GBN assessment of Phase 1 and Phase 2. It is used to justify the adequacy of the updated mitigation measures for operation GBN along the KTE alignment.

2 ALIGNMENT DRAWING AND GEOLOGICAL PROFILE

The GBN assessment is based on the alignment drawing and geological profile updated on 03 January 2012, and received from MTRC on 16 May 2013, as shown in *Figure 2.1* to *Figure 2.3*, respectively.

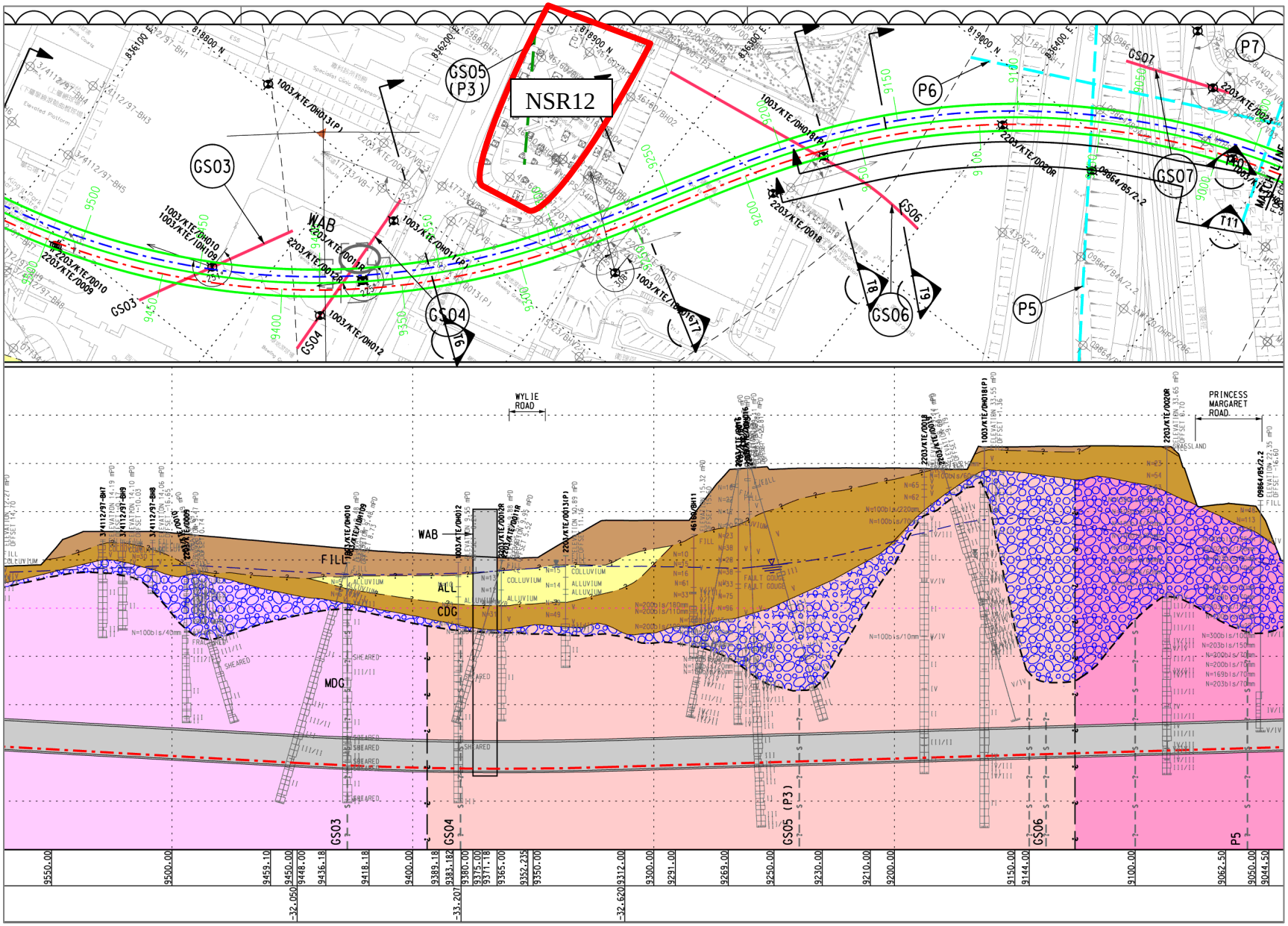

Figure 2.1

Alignment and Geology Profile of NSR12, Methodist Primary School at 10-12 Wylie Road

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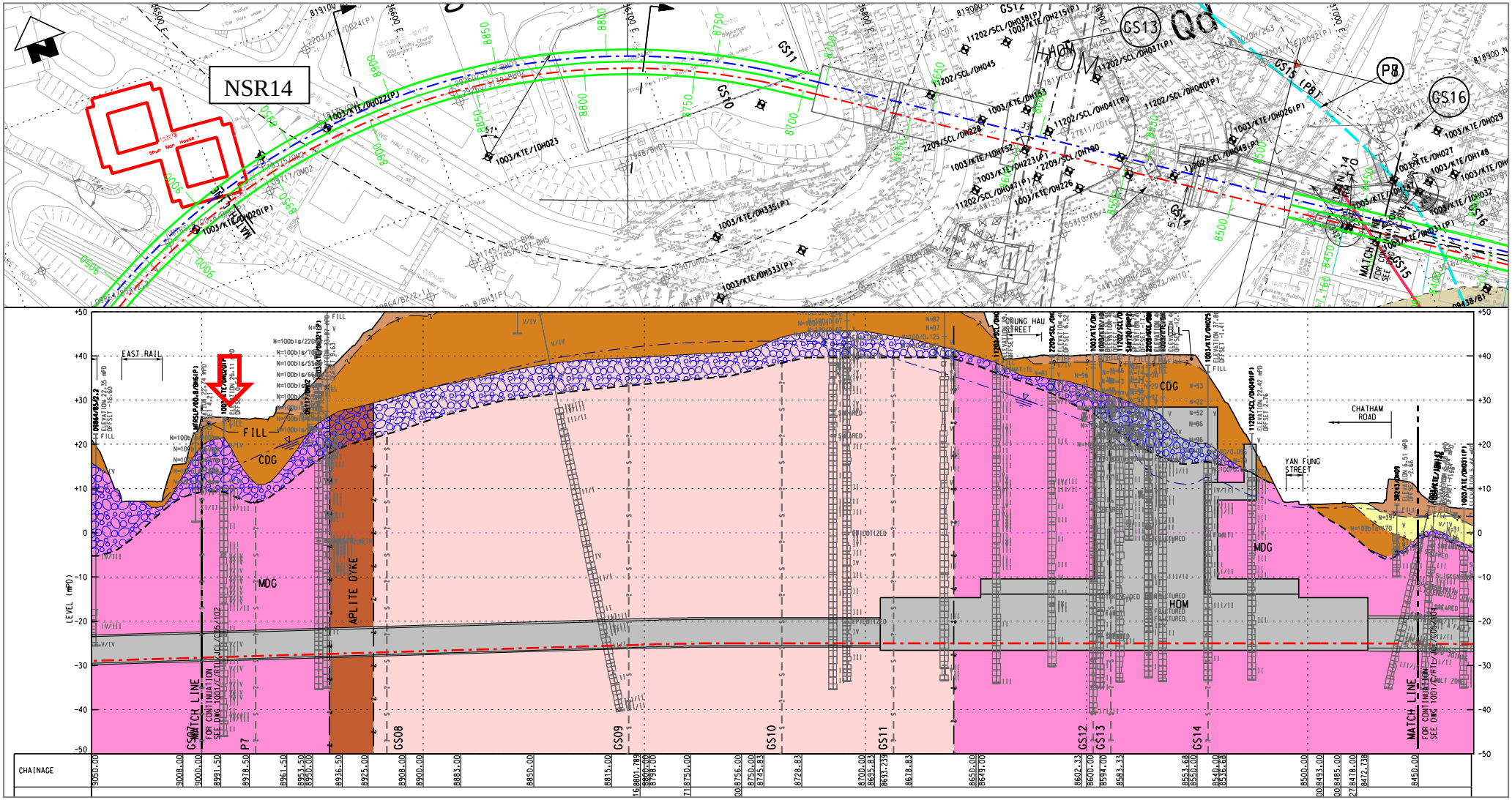

Figure 2.2

Alignment and Geology Profile of NSR14, Shun Man House, Oi Man Estate

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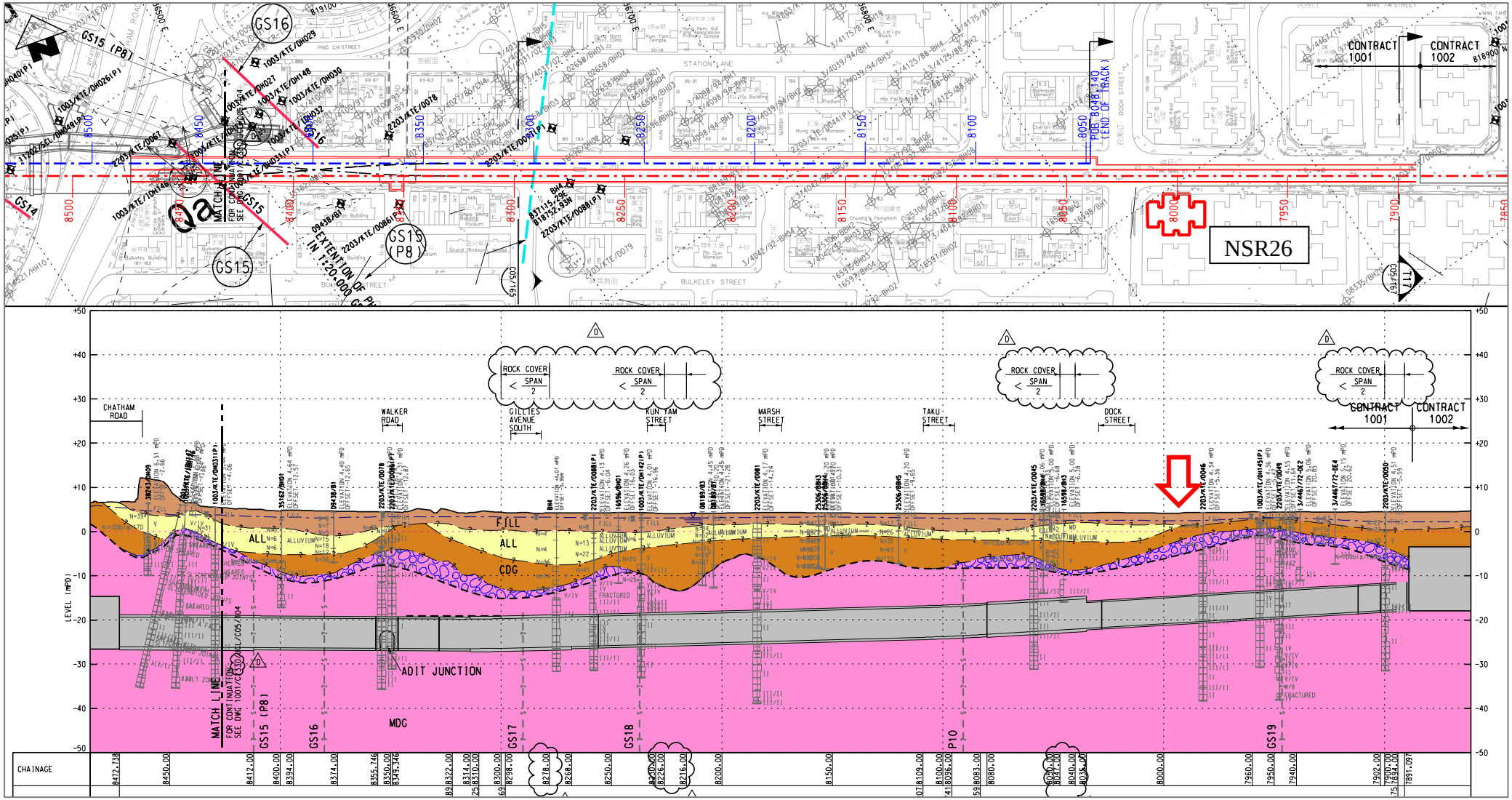

Figure 2.3

Alignment and Geology Profile of NSR26, Wing Fu Building, Whampoa Estate

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3 TRAIN INDUCED GROUNDBORNE NOISE ASSESSMENT METHODOLOGY

According to the approved KTE EIA Report, the methodology for the vibration and groundborne railway noise assessment is in accordance with the procedures outlined in *The Transit Noise and Vibration Impact Assessment* published by US Department of Transportation Federal Transit Administration (FTA Manual) for detailed vibration analysis.

The GBN level at the identified NSRs was calculated as follows:

$$L = FDL + TIL + TOC + TCF + LSR + BCF + BVR + CTN + SAF$$

where:

L = GBN level, in dB re 20μPa

FDL = Force density level, in dB re $1N/m^{0.5}$

TIL = trackform attenuation or insertion loss, relative level

TOC = turnout and crossover factor

TCF = vibration coupling between the tunnel and the ground for soil based tunnels, relative level

LSR = line source transfer mobility, in dB re $(nm/s)/(N/m^{0.5})$

BCF = adjustment to account for building coupling loss, in dB

BVR = building vibration amplification within the structure, in dB

CTN = conversion from vibration to noise within the building, in dB

SAF = 10dB safety factor to account for wheel/rail condition and uncertainties in ground conditions, in dB

This *Review Report* updates the LSRs used in GBN assessment for the three NSRs.

4 MEASUREMENT AND ANALYSIS PROCEDURES

4.1 PSR MEASUREMENT AND ANALYSIS PROCEDURE FOR NSR12 AND NSR14

Vibration measurements were conducted during drill rig excavation at West Island Line (WIL), NSR12 and NSR14 of Kwun Tong Line Extension (KTE) on 9 May 2013, 15 March 2013 and 16 April 2014, respectively. The vibration measurement results are used to estimate the point source response at NSR12 and NSR14 of KTE. The principle employed in the estimation is described below. More details of measurement and analysis procedures can be referenced to the GBN Review Plan.

The vibration level (Vibr) arising from drill rig excavation is given by logarithmic addition of drill rig excitation force (FDL) and vibration transfer mobility of the ground, which is the Point Source Responce (PSR).

$$\mathbf{Vibr}_{WIL} = \mathbf{FDL}_{WIL} + \mathbf{PSR}_{WIL}$$
$$\mathbf{Vibr}_{KTE} = \mathbf{FDL}_{KTE} + \mathbf{PSR}_{KTE}$$

The drill rigs used for the construction of WIL and KTE are identical, i.e. Atlas Boomer 352 (specification of the drill rig has been provided in *Annex B*). It can be deduced that $\mathbf{FDL}_{WIL}$ and $\mathbf{FDL}_{KTE}$ are the same. Therefore the difference in PSR at the two locations is directly given by the difference in vibration level.

$$\Delta\mathbf{PSR} = \mathbf{Vibr}_{WIL} - \mathbf{Vibr}_{KTE}$$

The PSR at WIL site ($\mathbf{PSR}_{WIL}$) has been determined by borehole impact test at WIL D028 (impact depth 44.3m) during EIA stage of WIL. Therefore PSR at NSR12 and NSR14 of KTE site ($\mathbf{PSR}_{KTE}$) can be estimated based on the measured drill rig vibration level, respectively.

After estimating the PSR, the Line Source Response (LSR) is calculated from numerical integration of the PSR at each impact point along the alignment according to the equation below:

$$LSR(s,d,f) = 10\log\left[\int_{-l/2}^{l/2} 10^{PSR\left(\sqrt{s^2+d^2+y^2},f\right)/10}\,dy\right]$$

where
s = perpendicular setback
l = train length
d= tunnel depth
f= frequency

The deployments of accelerometers at WIL, NSR12 and NSR14 KTE are shown in *Figure 4.1* to *Figure 4.3* respectively. Photos showing the locations of vibration sensors deployed at WIL, NSR12 and NSR14 of KTE are provided in *Figures 4.4* to *Figures 4.6* respectively.

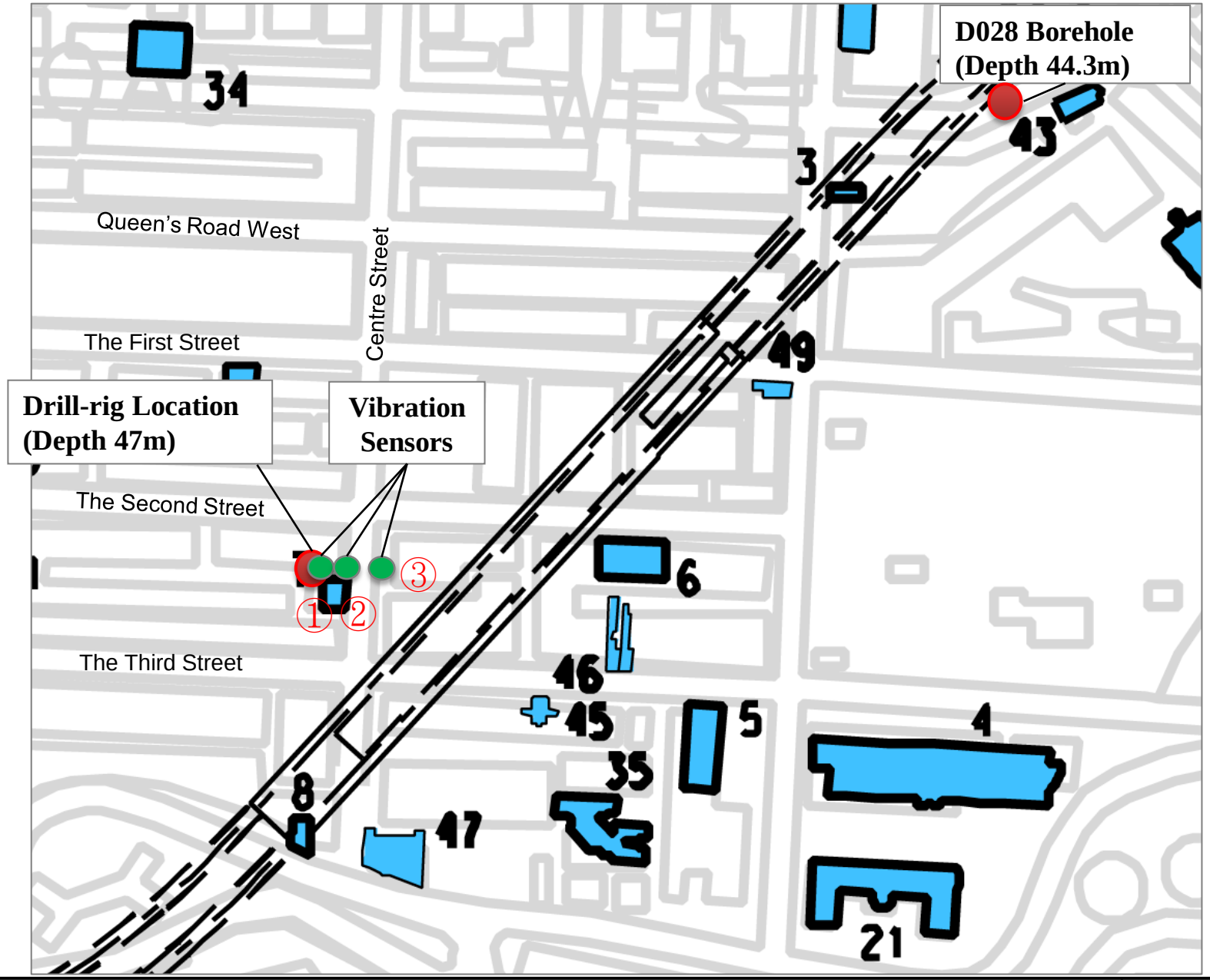

Figure 4.1

WIL D028 Borehole, Drill-rig and Measurement Locations

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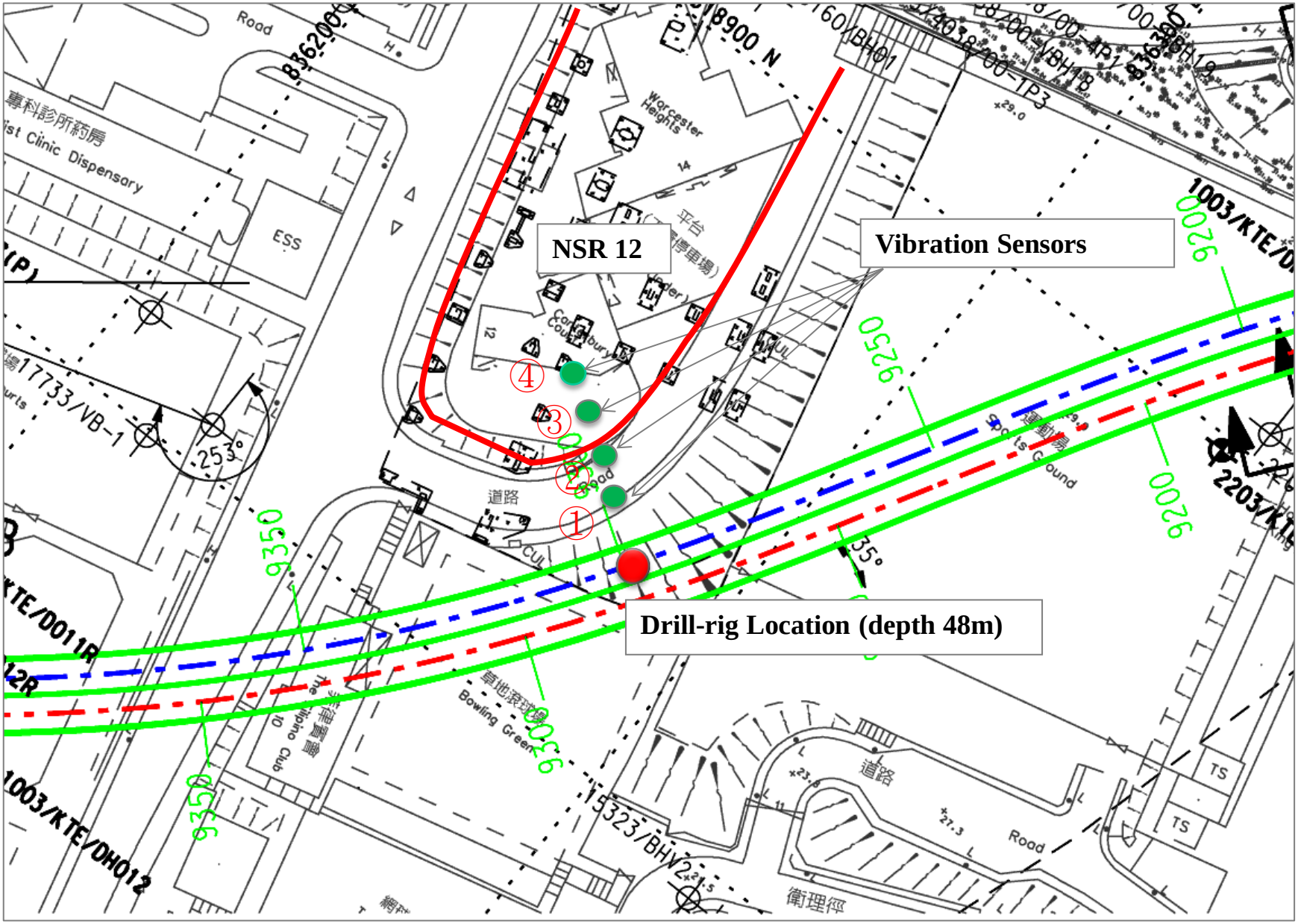

Figure 4.2

KTE NSR12 Drill-rig Location and Measurement Locations

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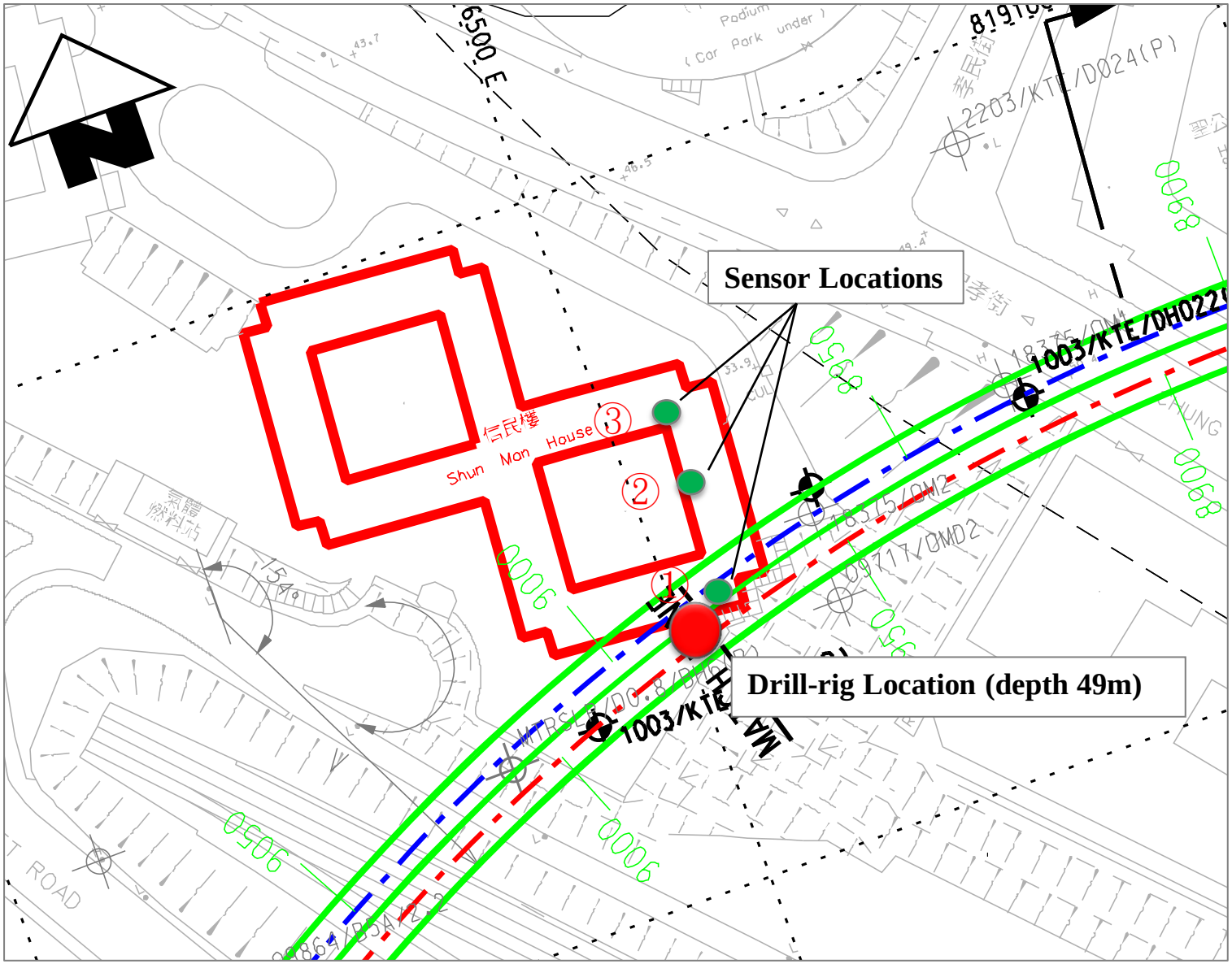

Figure 4.3

KTE NSR14, Drill-rig and Measurement Locations

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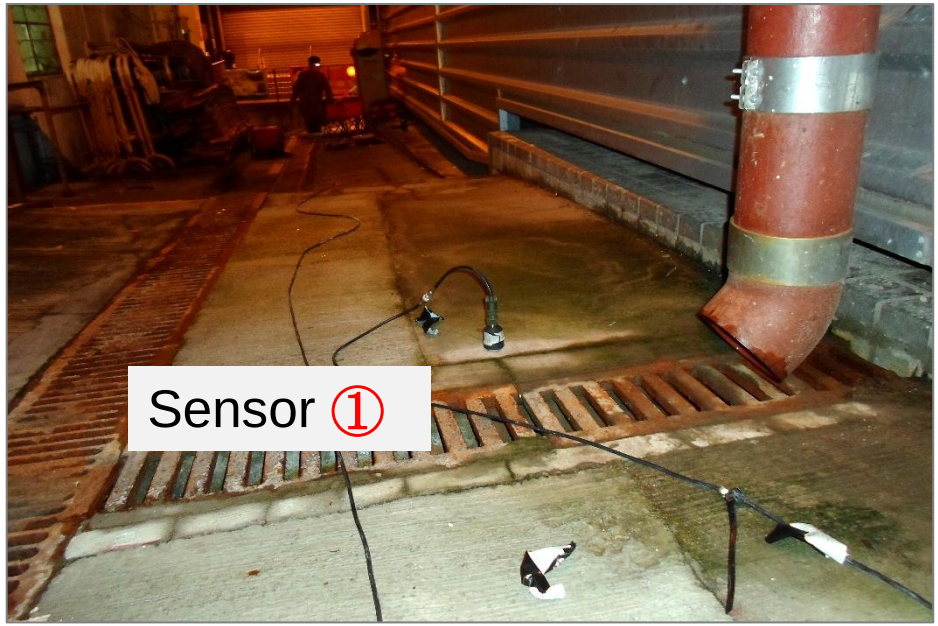

Figure 4.4

WIL Sensor Deployment Photos

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Sensor ①

Sensor ②

Sensor ③

Sensor ④

Figure 4.5

KTE NSR12 Sensor Deployment Photos

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Sensor ①

Sensor ②

Sensor ③

Figure 4.6

KTE NSR14 Sensor Deployment Photos

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4.2 PSR MEASUREMENT AND ANALYSIS PROCEDURE FOR NSR26

Following the Review Plan, hammer impact tests was conducted at eight points inside the tunnel next to NSR26 of KTE on 28 Aug 2014. The results are used to determine the LSR at NSR26 of KTE.

One pneumatic impact hammer was employed in the hammer impact test. A force transducer was located at the base of the hammer to measure the force applied to the tunnel invert. Accelerometers were placed at 3 setbacks on the ground level to pick up the vibration signals simultaneously.

The PSR is calculated from dividing the vibration signal by the force signal at each individual 1/3 octave band. The LSR is calculated from numerical integration of the PSR at each impact point along the alignment according to the equation below:

$$LSR(s,d,f) = 10\log\left[\int_{-l/2}^{l/2} 10^{PSR\left(\sqrt{s^2+d^2+y^2},f\right)/10} dy\right]$$

where
s = perpendicular setback
l = train length
d= tunnel depth

By invoking the assumption that the ground is transversely isotropic along the alignment over the length of the train, LSR can be determined from a single hammer impact point. In this verification test, hammer impact test was conducted at 8 points along the alignment inside the tunnel, so as to take into account possible geological variations along the alignment.

The 8 hammer impact points cover 70 m in length along the alignment, which is the closest section to NSR26. Accelerometers were deployed at 3 locations on pavements and the staircase of NSR26. To enhance the measurement accuracy at frequencies below 160Hz, an additional Endevco Model 86 accelerometer was deployed at NSR26 staircase.

Hammer impact points and sensor deployment locations are shown in *Figure 4.7*. Photos showing the hammer impact test at 8 selected points are provided in *Figures 4.8* and *4.9*. Photos showing the locations of vibration sensors at NSR26 are provided in *Figures 4.10* and *4.11*.

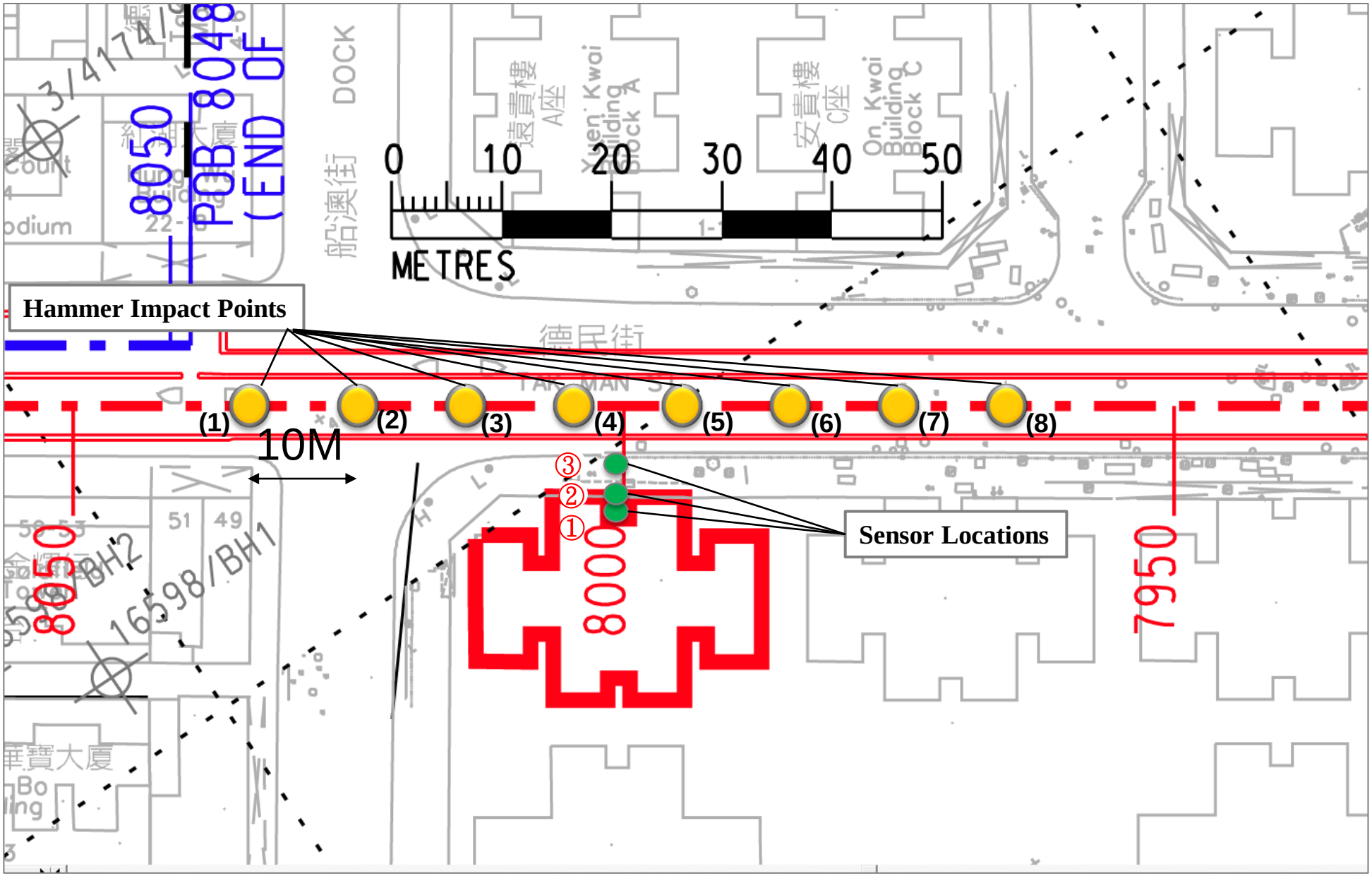

Figure 4.7

KTE NSR26 Hammer Impact and Sensor Deployment Locations

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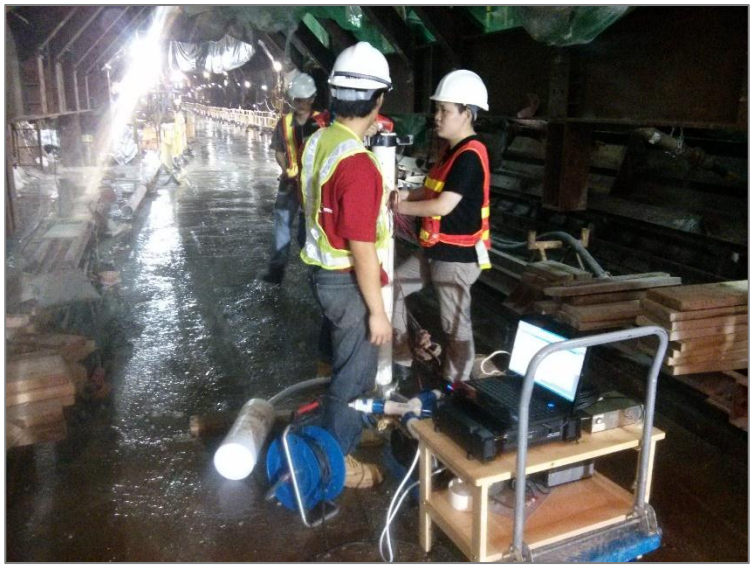
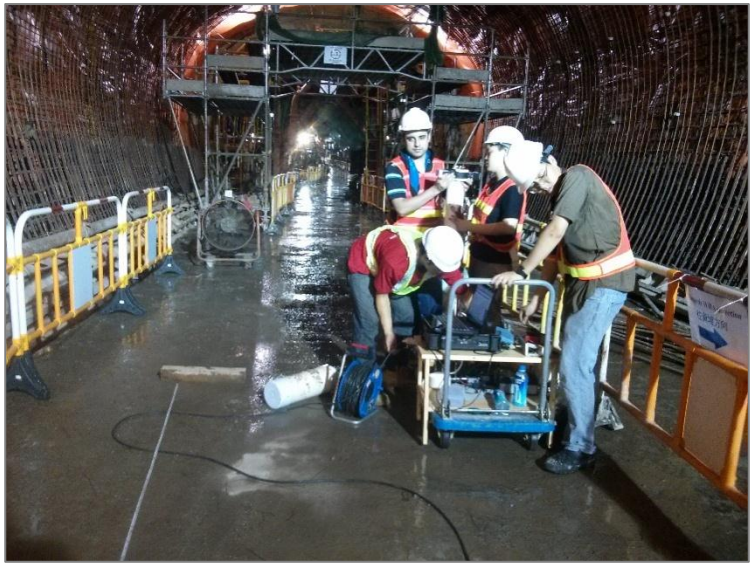
Hammer Impact Point 1



Hammer Impact Point 2

Hammer Impact Point 3



Hammer Impact Point 4

Figure 4.8

KTE NSR26 Hammer Impact Test Photos, Point 1 to 4

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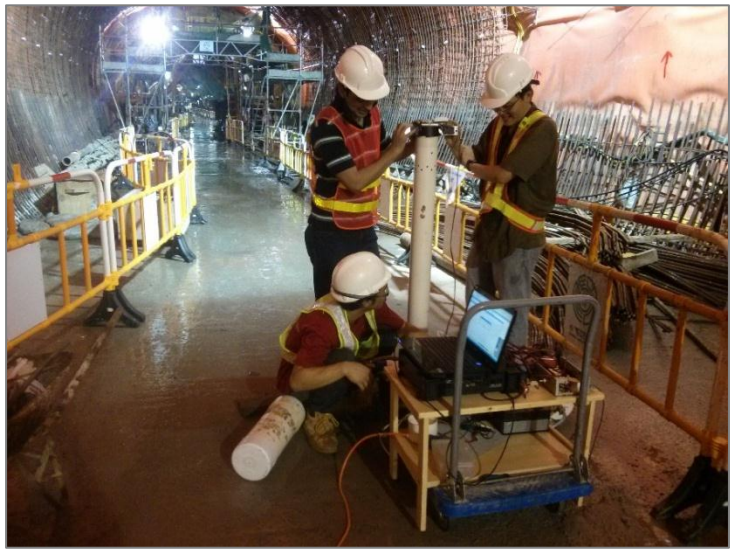
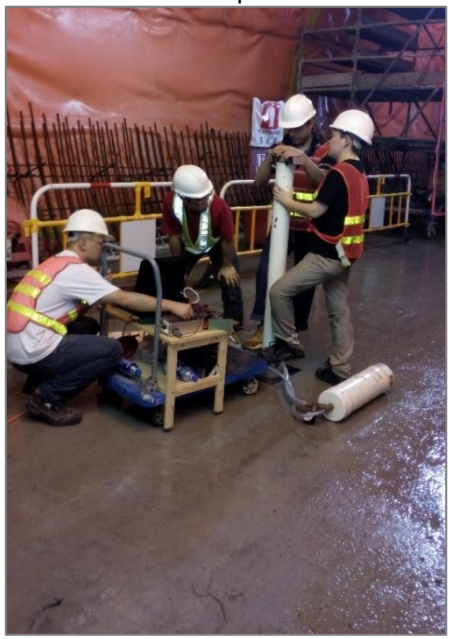
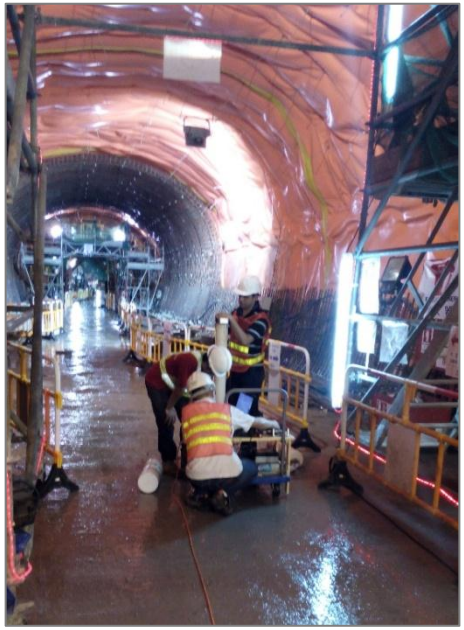


Hammer Impact Point 5

Hammer Impact Point 6



Hammer Impact Point 7



Hammer Impact Point 8

Figure 4.9

KTE NSR26 Hammer Impact Test Photos, Point 5 to 8

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Figure 4.10

KTE NSR26 Sensor Deployment Photos, Overview

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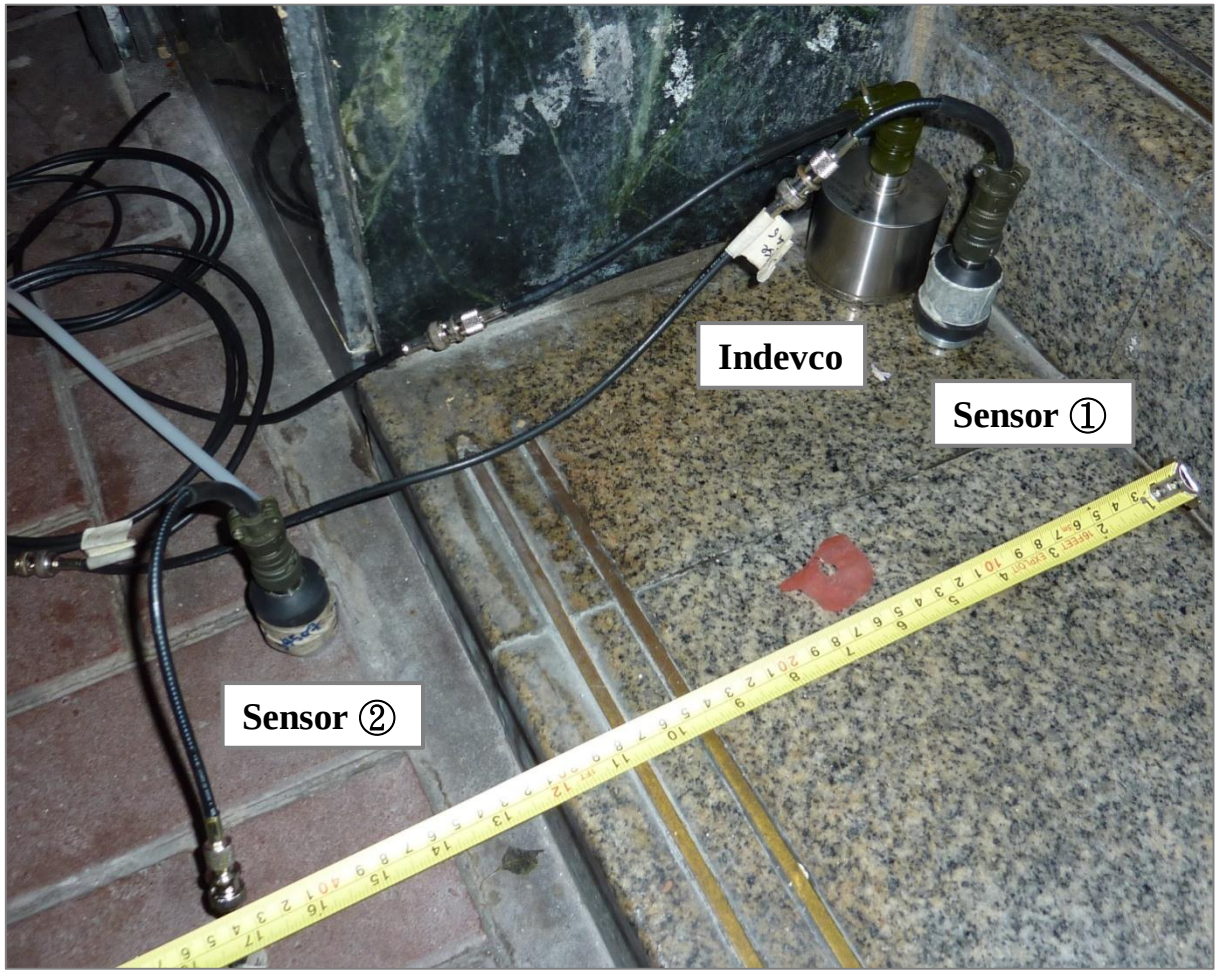
Sensor ③



Sensor ①, ② and Indevco

Figure 4.11

KTE NSR26 Sensor Deployment Photos, Close-up Shot

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5 MEASUREMENT RESULTS

5.1 NSR12 MEASUREMENT RESULT

For NSR12, the measured vibration level at various slant distances at WIL and KTE sites are compared and shown in *Figure 5.1*, *5.3* and *5.5*, while the estimated PSR for the corresponding slant distances are shown in *Figure 5.2*, *5.4* and *5.6*.

The updated LSRs for downtrack and uptrack are shown in *Figure 5.7* and *5.8* respectively, in comparison with the LSRs adopted in EIA.

5.2 NSR14 MEASUREMENT RESULT

For NSR14, the measured vibration level at various slant distances at WIL and KTE sites are compared and shown in *Figure 5.9*, *5.11* and *5.13*, while the estimated PSR for the corresponding slant distances are shown in *Figure 5.10*, *5.12* and *5.14*.

The updated LSRs for downtrack and uptrack are shown in *Figure 5.15* and *5.16* respectively, in comparison with the LSRs adopted in EIA. The sensors were deployed on the building foundation, which indicates that BCF and BVR-Amplification have been included in the updated LSRs. For direct comparison, the updated LSRs are compared with LSRs adopted in EIA, which include the BCF and BVR-Amplification.

5.3 NSR26 MEASUREMENT RESULT

For NSR26, the 3 PSR datasets measured from 3 locations at KTE sites are shown in *Figures 5.17* to *5.19,* respectively. Wherein, the PSR dataset from the sensor deployed at staircase of the building is selected to calculate the LSR for GBN prediction. The reason is that the said PSR was measured on the building foundation, which provides more accurate result in GBN prediction.

The updated LSR for downtrack are shown in *Figure 5.20*, in comparison with the LSR adopted in EIA. The BCF and BVR-Amplification have been included in the updated LSR, for direct comparison, the LSR of EIA is provided with these two factors included.

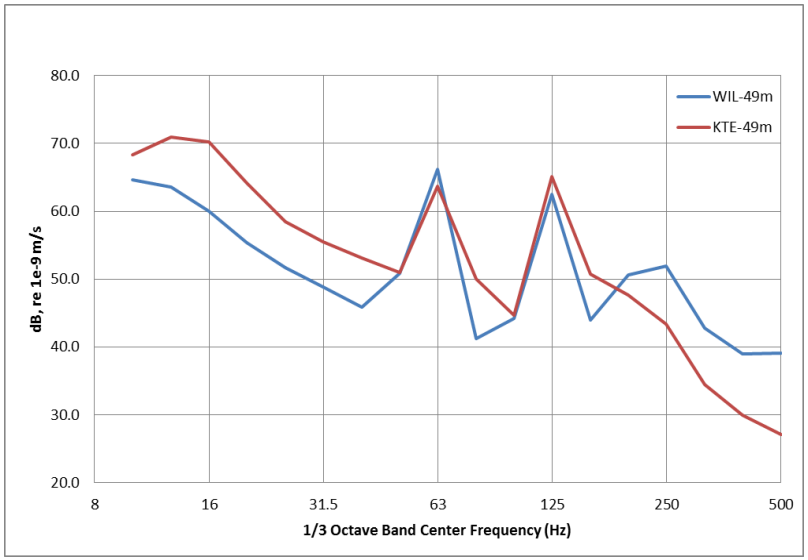

Figure 5.1 Vibration Level of WIL and KTE NSR12 at 49m

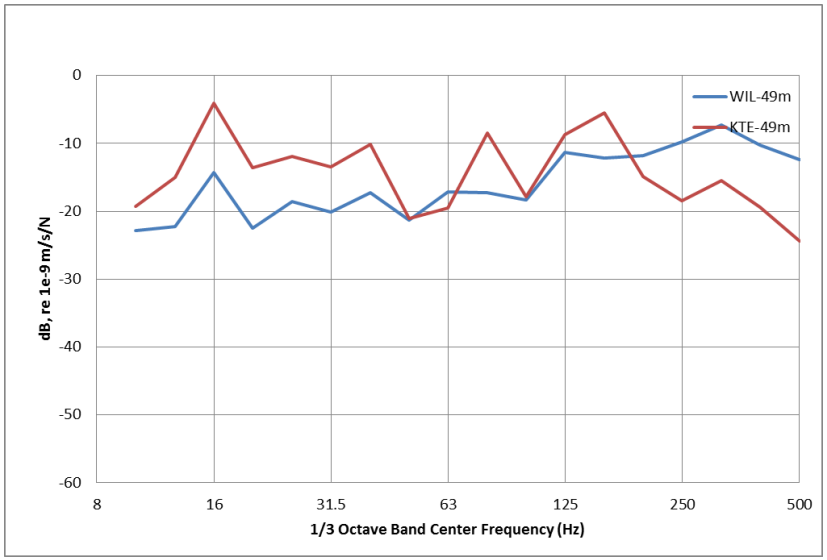

Figure 5.2 PSR Result of WIL and KTE NSR12 at 49m

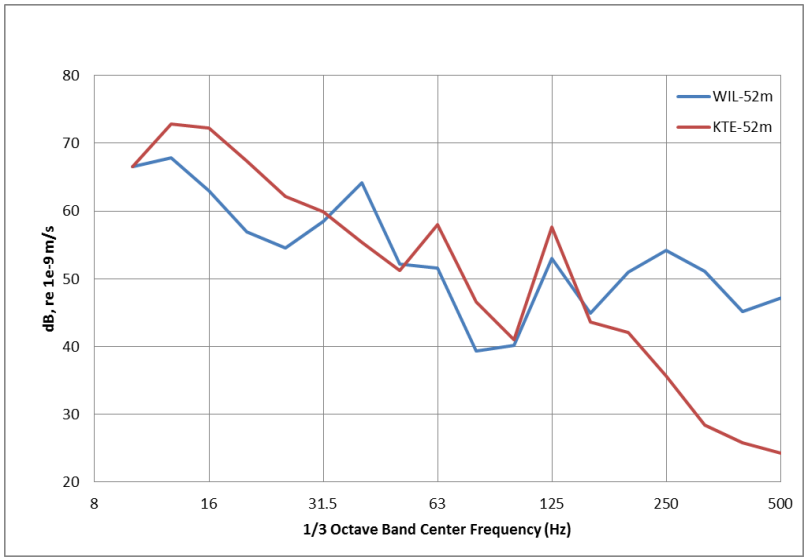

Figure 5.3 Vibration Level of WIL and KTE NSR12 at 52m

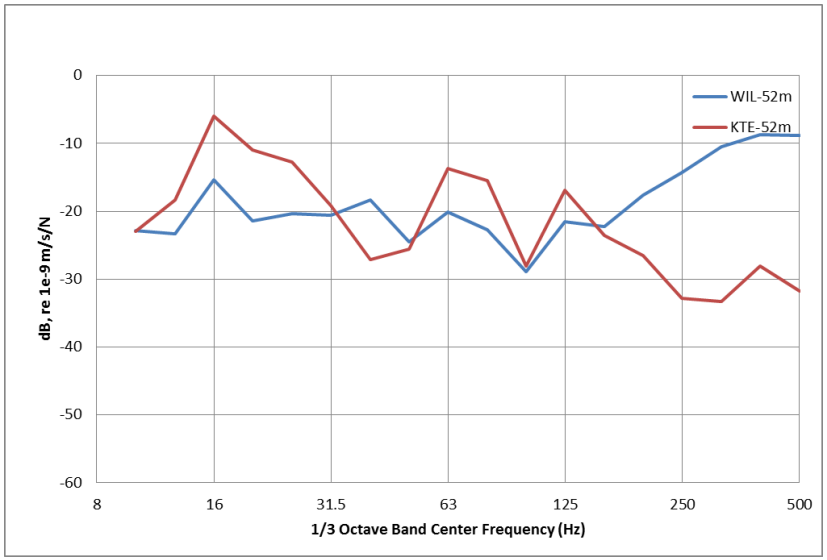

Figure 5.4 PSR Result of WIL and KTE NSR12 at 52m

Figures 5.1 to 5.4

WIL and KTE NSR12 - Vibration Measurement Results and PSR Results at 49m and 52m

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Figure 5.5 Vibration Level of WIL and KTE NSR12 at 55m

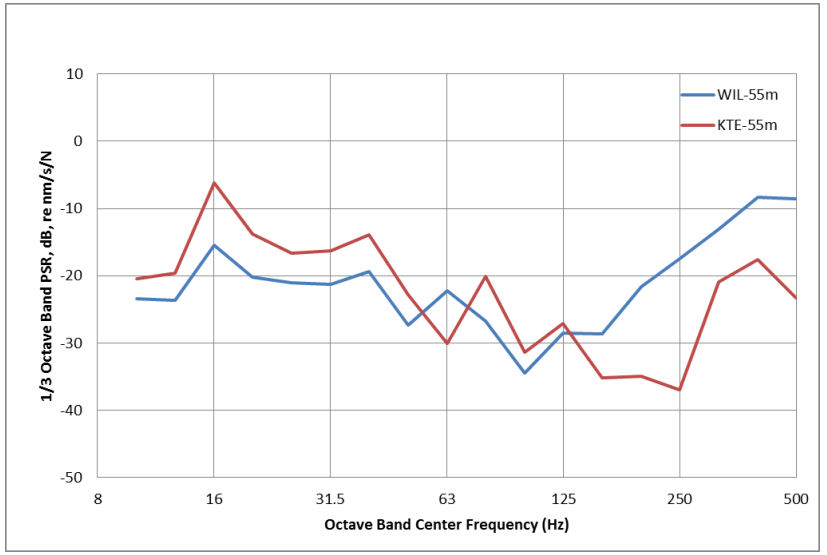

Figure 5.6 PSR Result of WIL and KTE NSR12 at 55m

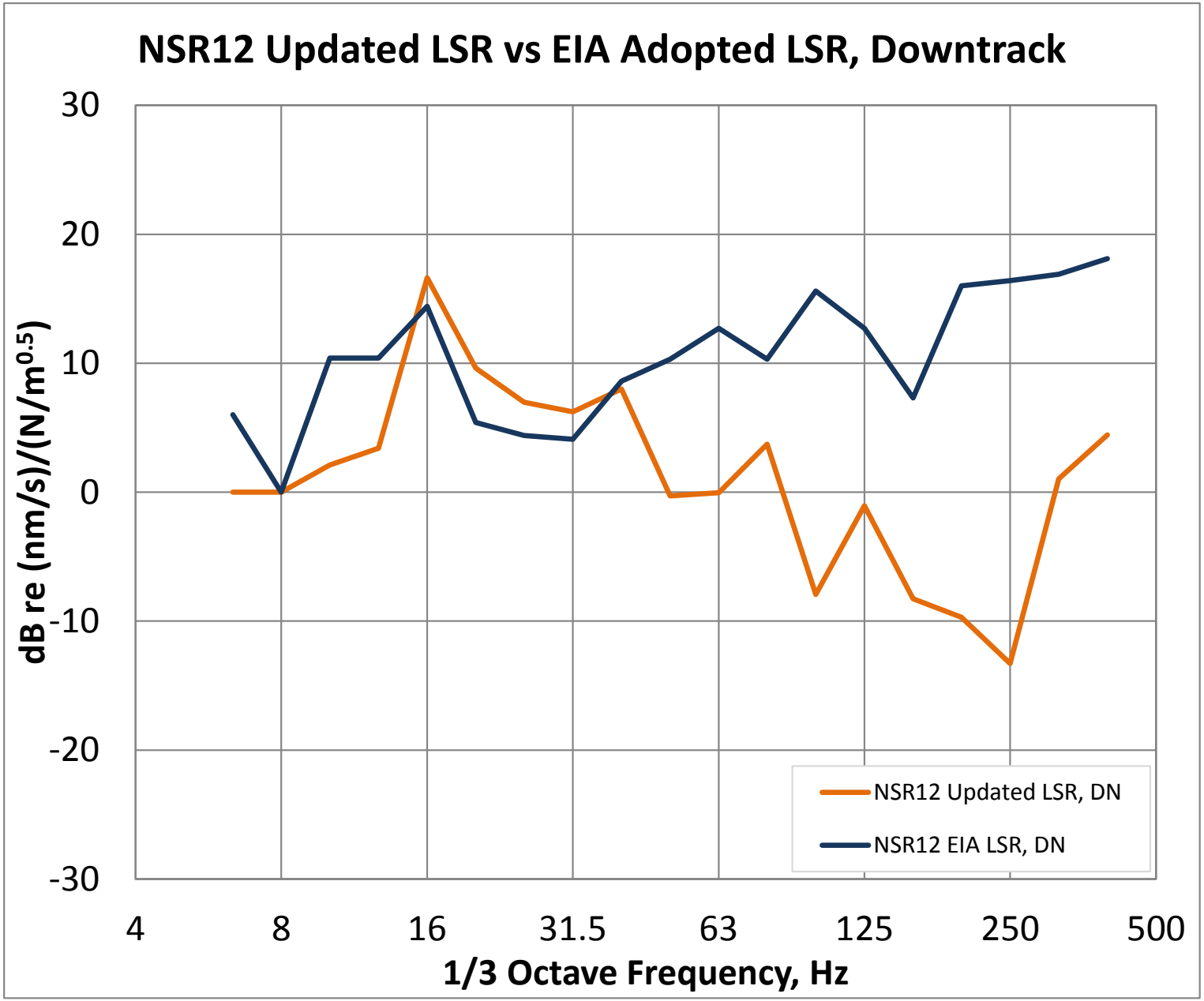

Figure 5.7

NSR12 Updated LSR vs. EIA Adopted LSR, Downtrack

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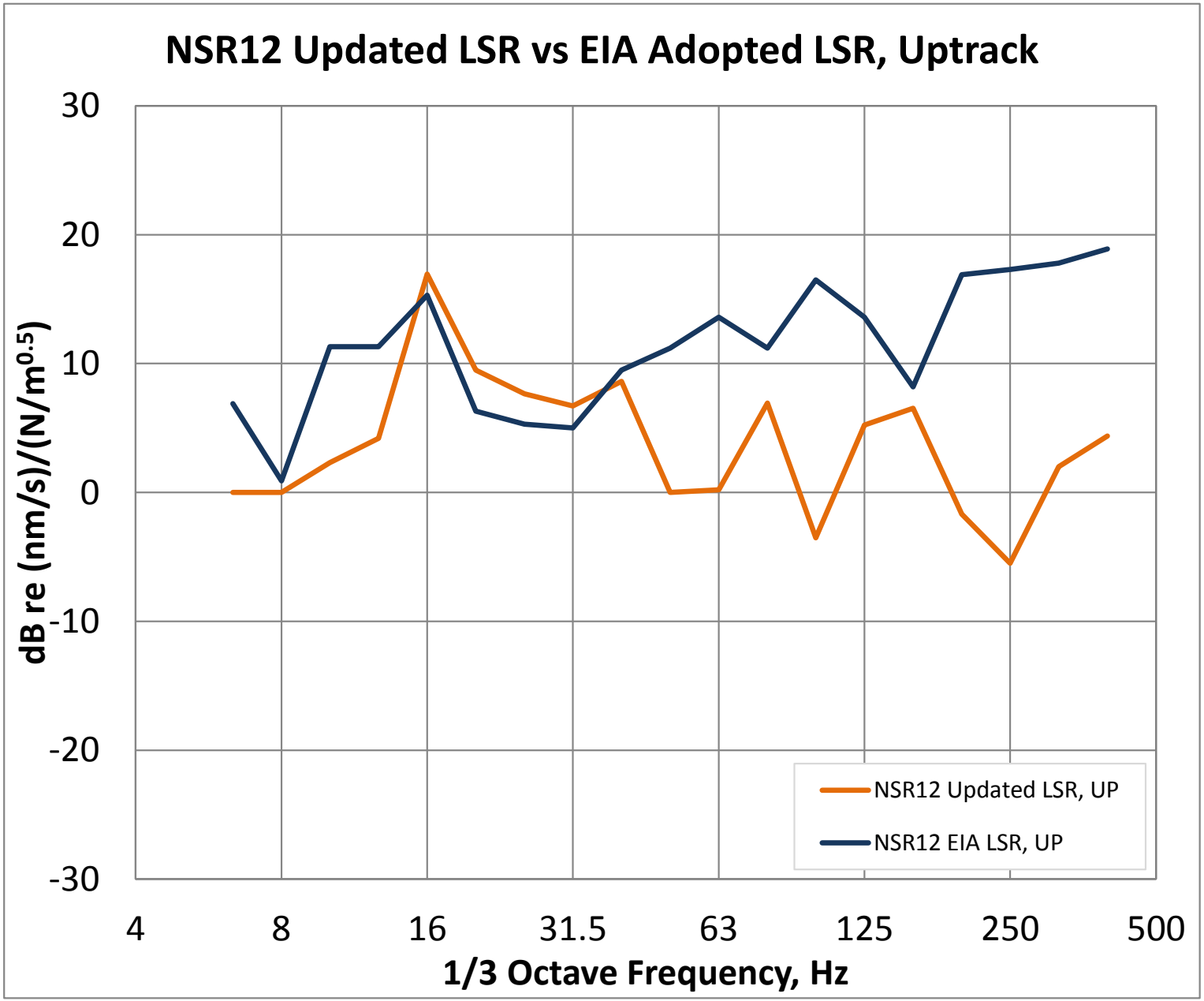

Figure 5.8

NSR12 Updated LSR vs. EIA Adopted LSR, Uptrack

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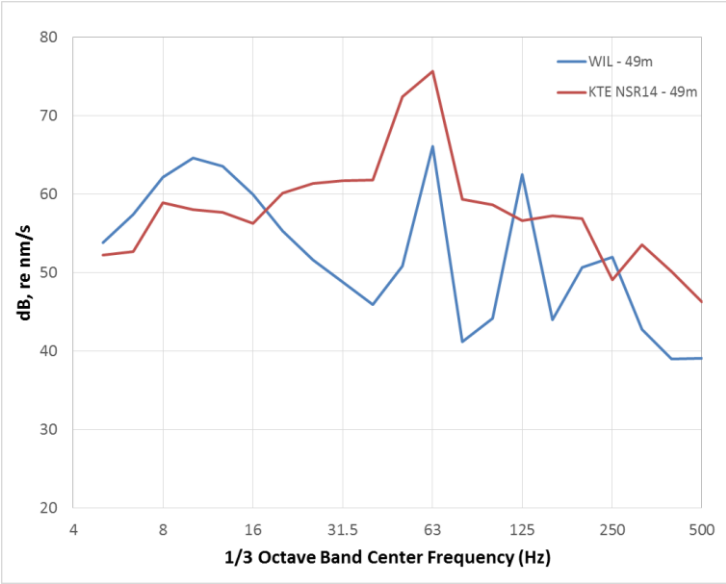

Figure 5.9 Vibration Level of WIL and KTE NSR14 at 49m

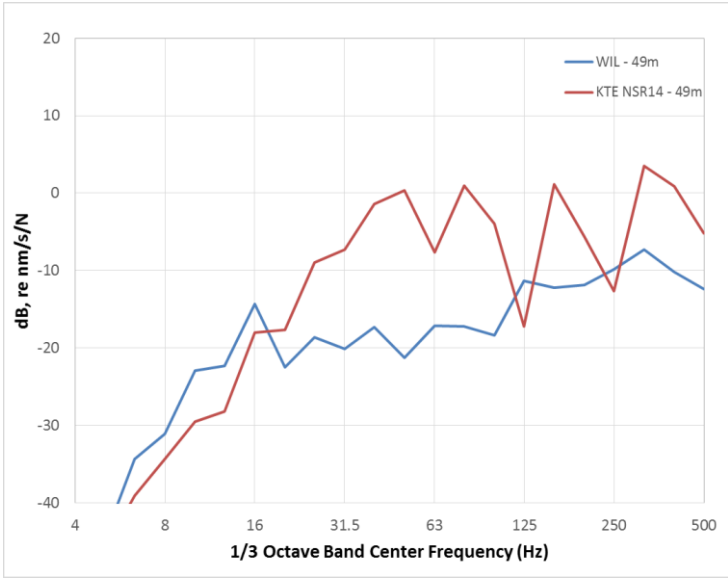

Figure 5.10 PSR Result of WIL and KTE NSR14 at 49m

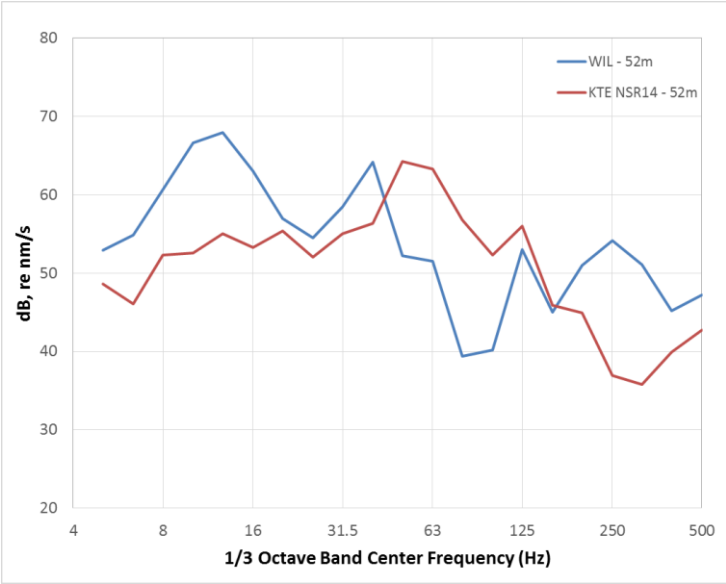

Figure 5.11 Vibration Level of WIL and KTE NSR14 at 52m

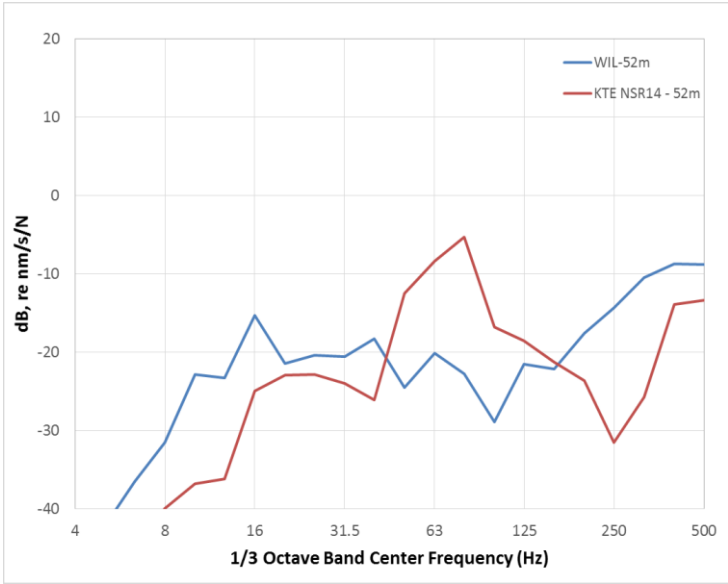

Figure 5.12 PSR Result of WIL and KTE NSR14 at 52m

Figure 5.9 to 5.12

WIL and KTE NSR14 - Vibration Measurement Results and PSR Results at 49m and 52m

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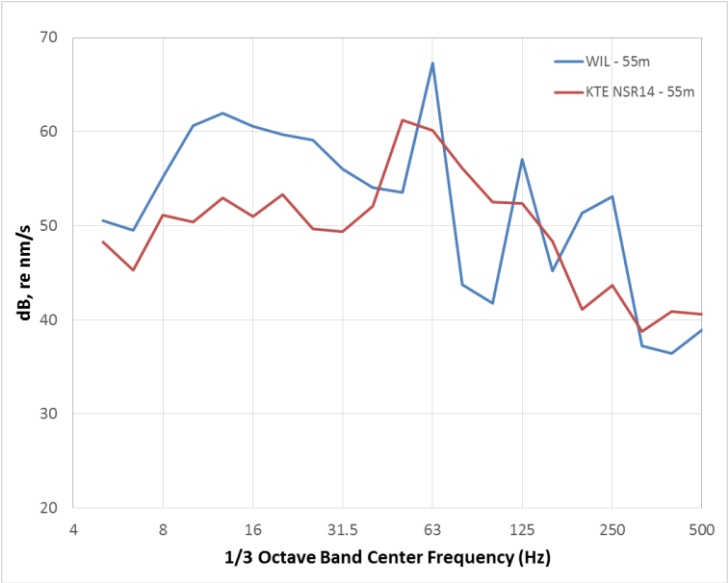

Figure 5.13 Vibration Level of WIL and KTE NSR14 at 55m

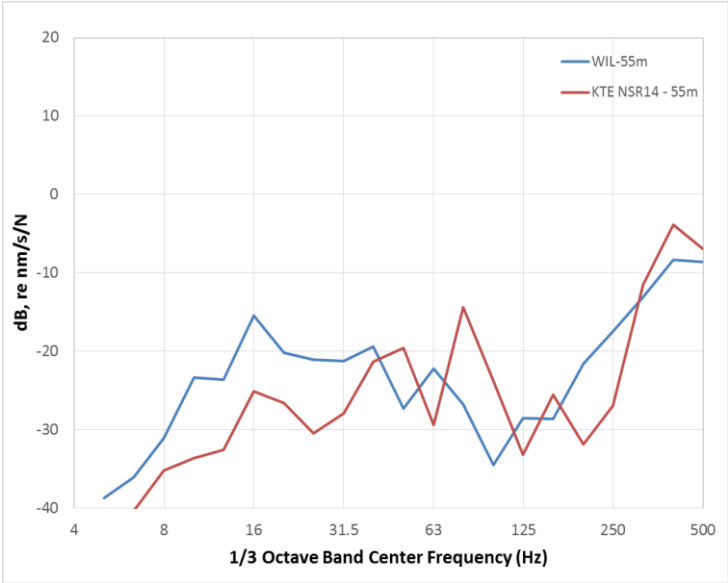

Figure 5.14 PSR Result of WIL and KTE NSR14 at 55m

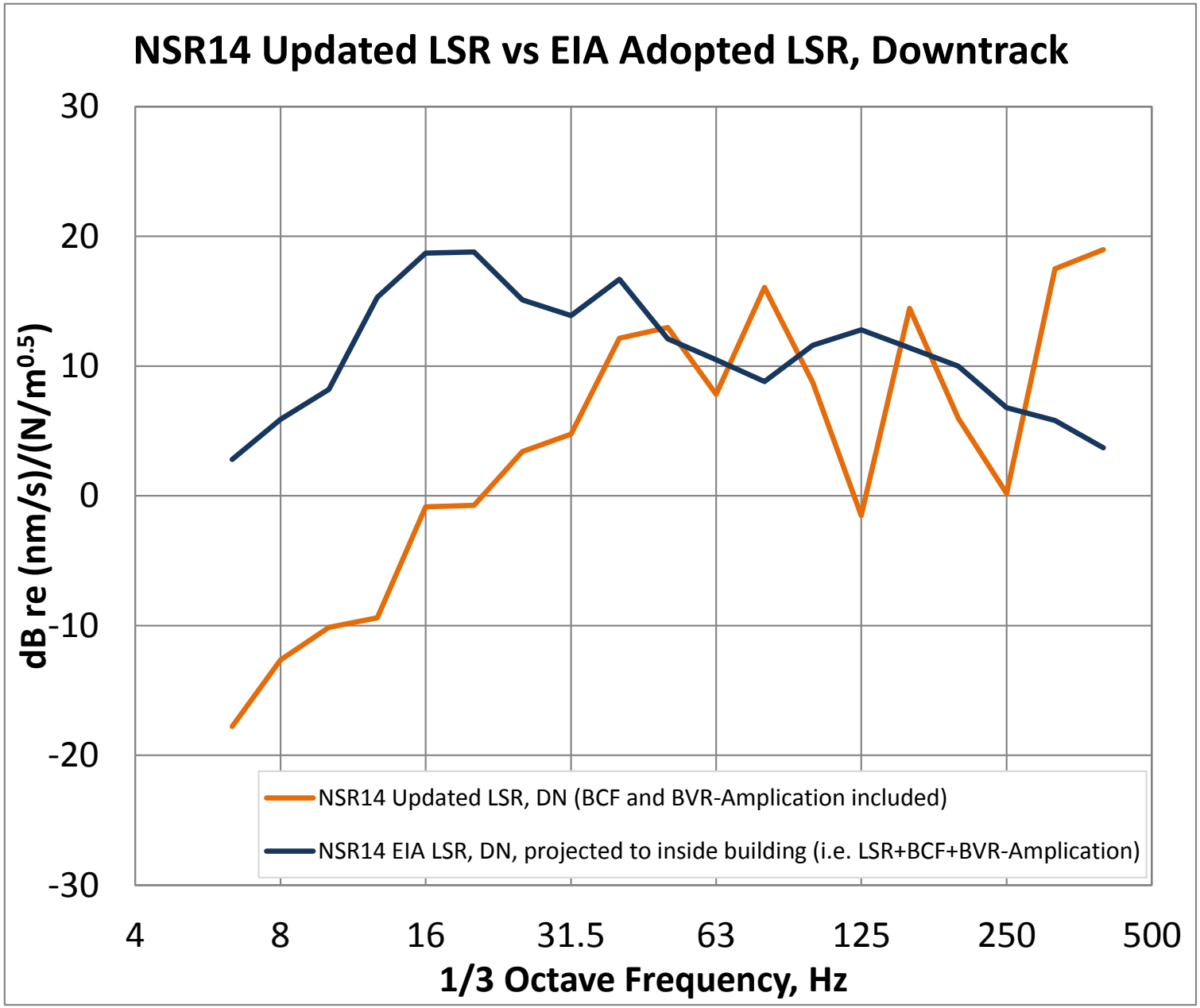

Figure 5.15

NSR14 Updated LSR vs. EIA Adopted LSR, Downtrack

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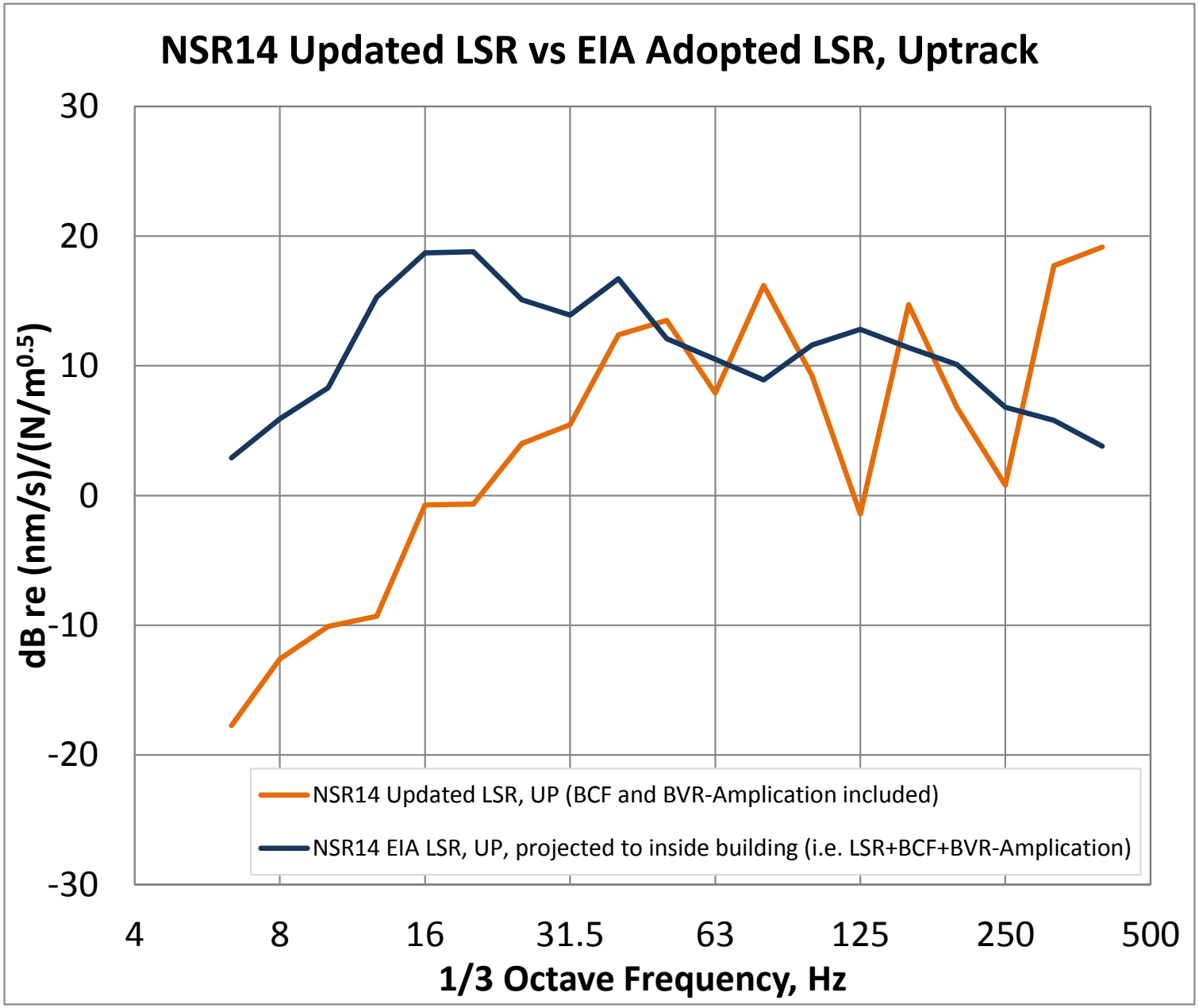

Figure 5.16

NSR14 Updated LSR vs. EIA Adopted LSR, Uptrack

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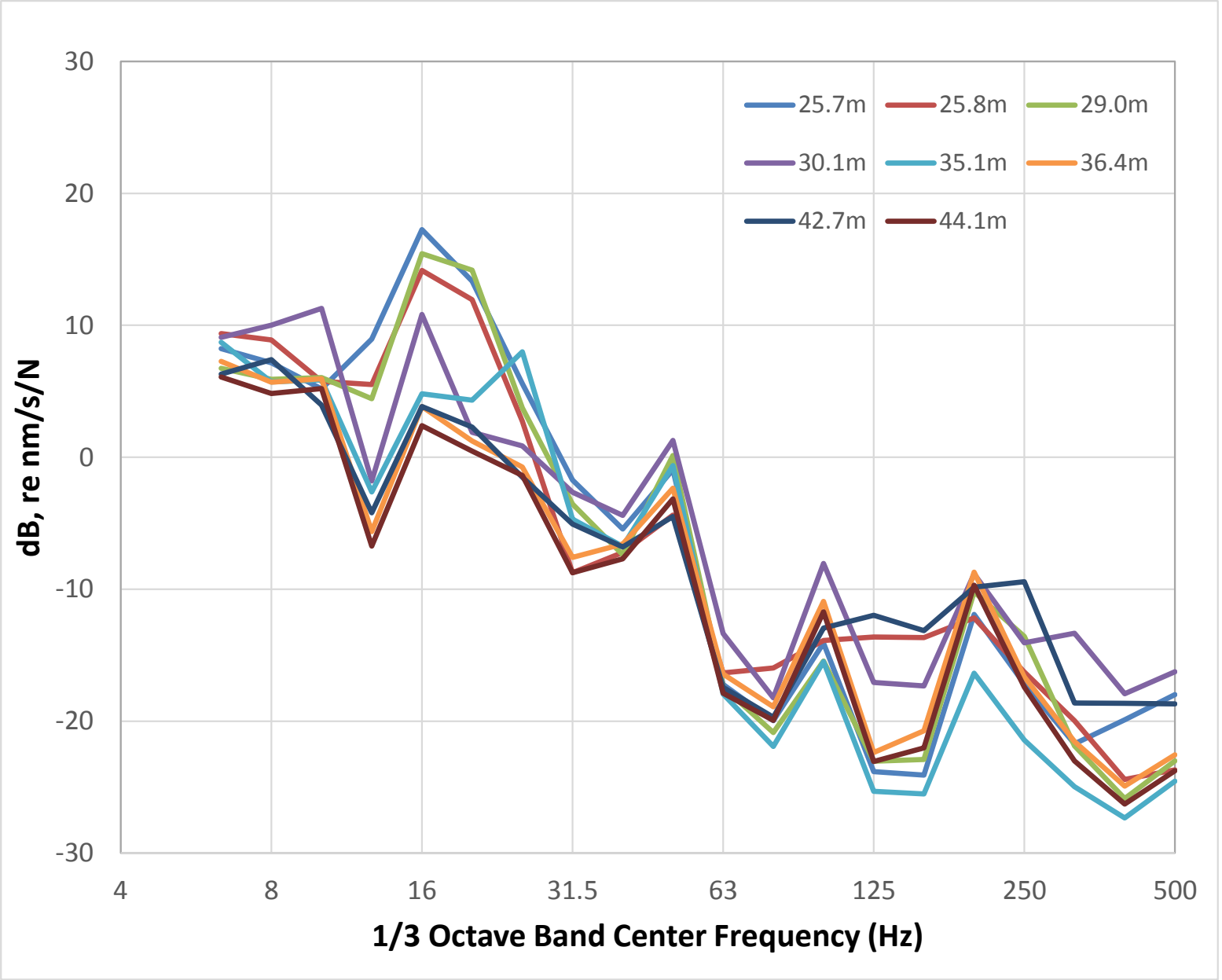

Figure 5.17

PSR Result at NSR26, Sensor ①, Building Stair Case

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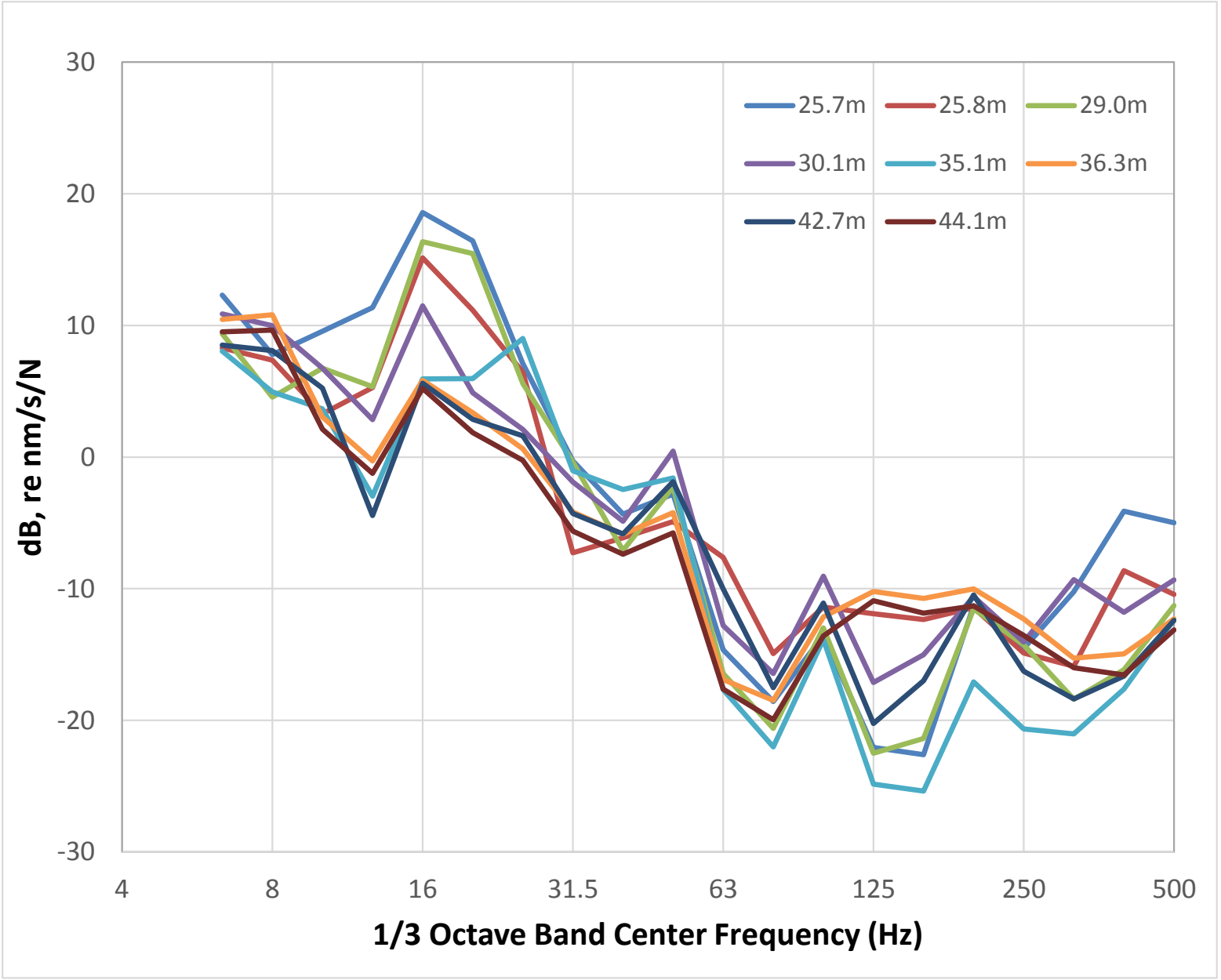

Figure 5.18

PSR Result at NSR26, Sensor ②, Corner Outside Building

Date 13 Oct 2014

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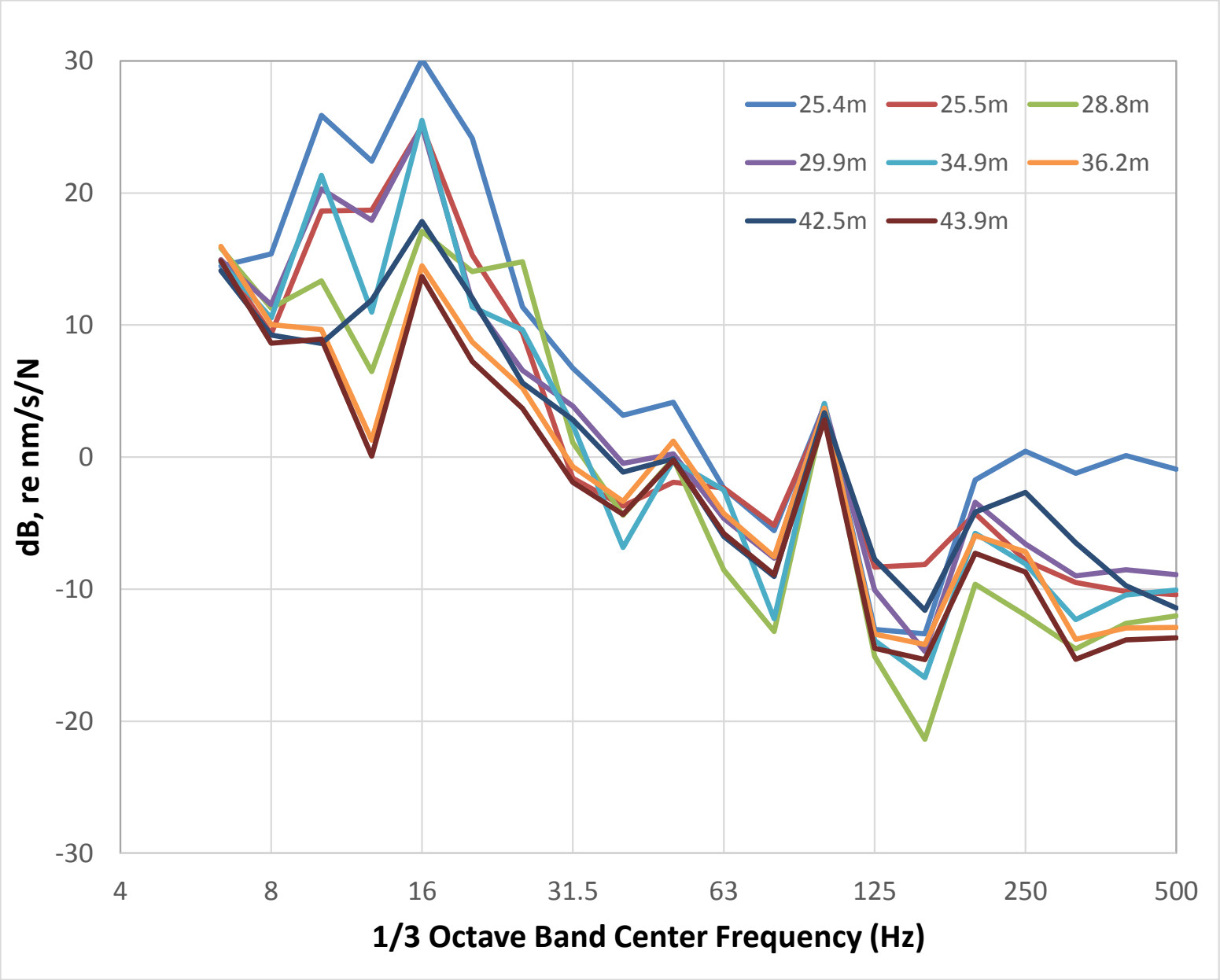

Figure 5.19

PSR Measured at NSR26, Sensor ③, Pavement

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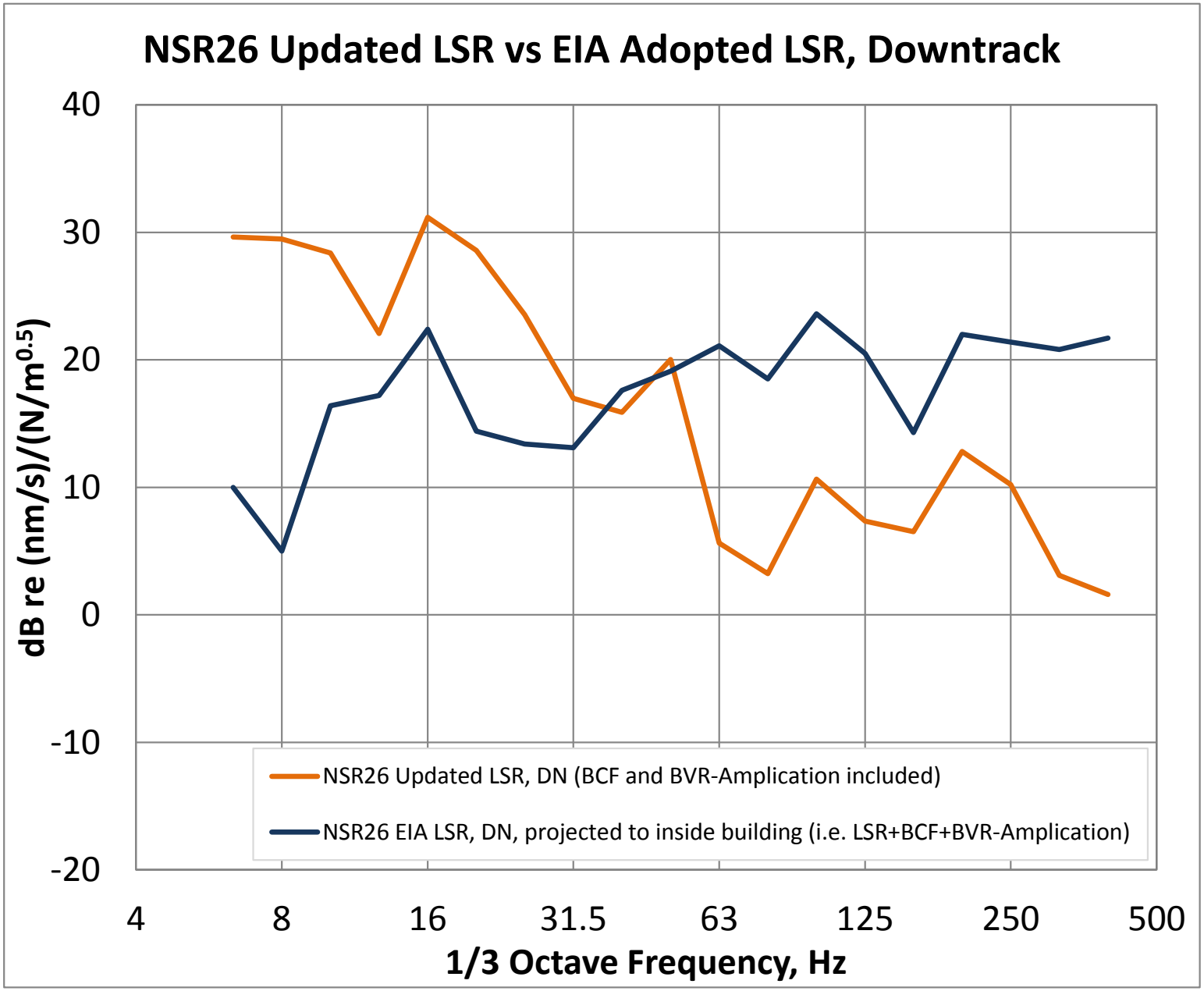

Figure 5.20

NSR26 Updated LSR vs EIA Adopted LSR, Downtrack

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The GBN prediction has been updated following EIA's methodology. The results are summarized in *Table 6.1*. Detailed calculations of NSR12, NSR14 and NSR26 GBN predictions are shown in *Annex A*. The assumptions and calculations follow the approved KTE EIA Report.

Table 6.1 Groundborne Noise Prediction Result of NSR12, NSR14 and NSR26, Including 10dB Safety Factor

		EIA's Prediction	Updated Prediction	Noise Criteria
NSR12	Lmax, dBA	50	39	85
	Leq, 30min (day and evening), dBA	43	30	55
	Leq, 30min (night), dBA	40	27	N/A[(a)]
	Leq, 24hr, dBA	42	29	N/A
NSR14	Lmax, dBA	38	47	85
	Leq, 30min (day and evening), dBA	31	40	55
	Leq, 30min (night), dBA	28	37	45
	Leq, 24hr, dBA	30	39	N/A
NSR26	Lmax, dBA	52	39	85
	Leq, 30min (day and evening), dBA	42	31	55
	Leq, 30min (night), dBA	42	28	45
	Leq, 24hr, dBA	41	29	N/A

Note:
(a) Methodist School has no sensitive use at nigh-time period.

The updated GBN level at NSR12 is lower than that predicted in the approved EIA report. As shown in *Figures 5.2*, *5.4* and *5.6*, the vibration level at WIL is significantly higher at the high frequency range above 160Hz, which implies the WIL site has more effective vibration transmission at high frequencies. This results in a lower PSR for NSR12 above 160Hz and thus a lower predicted groundborne noise level.

The updated GBN level at NSR14 is higher than that predicted in the approved EIA report, which implies the actual ground condition is found to be favourable for vibration transmission than that assumed in the approved KTE EIA Report. As shown in *Figures 5.15* and *5.16*, the updated LSR levels at 315Hz (12dB higher) and 400Hz (15 dB higher) are significantly higher, which leads to the higher prediction at GBN level. Nevertheless, the updated GBN is still within the statutory requirements.

The updated prediction of operational GBN levels of NSR26 are lower than that predicted in the approved KTE EIA Report. This is because the actual ground condition is found to be less favourable for vibration transmission than that assumed in the approved KTE EIA Report.

7 *CONCLUSIONS*

Vibration measurements were conducted during drill rig excavation at West Island Line (WIL) and Kwun Tong Line Extension (KTE). The measurement results were used to estimate the point source response at NSR12 and NSR14 of KTE, and update operational GBN noise prediction result.

Hammer impact test was conducted inside the tunnel near NSR26 of KTE, which identified as one of the most critical NSR with respect to operational ground-borne noise impact identified in the approved KTR EIA Report. The LSR are determined and the operational GBN prediction for NSR26 had been updated using the determined LSR.

The updated groundborne noise level at NSR12 and NSR26 are lower than that predicted in the EIA. The updated groundborne noise levels at NSR14 is higher than EIA prediction. Nevertheless, including 10dB safety factor, they are still within the statutory requirements.

In summary, the GBN mitigation measures proposed in the approved KTE EIA Report are considered to be adequate.

Annex A

Detailed GBN Calculation Results

NSR No.	12				Down Track Chainage		9+280	Vertical Distance (m)		48	Horizontal Setback (m)		18	Speed (km/h)			68		
Location	Methodist Primary School, 10-12 Wylie Road				Up Track Chainage		9+320	Vertical Distance (m)		48	Horizontal Setback (m)		10	Speed (km/h)			69		
		1/3 Octave Band Center Frequency																	
		6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400
YMT-Turnback Calculation																				
FDL	dB re $N/m^{1/2}$	62.1	62.9	63.4	64.2	57.4	58.4	64.1	61.2	64.2	59.3	57.2	61.3	64.3	65.1	64.6	60.7	62.9	58.7	55.6
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	0.0	0.0	2.1	3.4	16.6	9.6	7.0	6.2	8.0	-0.3	0.0	3.7	-7.9	-1.0	-8.3	-9.7	-13.3	1.0	4.4
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	1.0	2.0	3.0	3.8	5.0	6.0	6.0	6.0	6.0	5.8	5.4	5.2	5.0	4.8	4.0	3.0	2.0	1.0	0.7
BVR-Floor Attenuation	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	48.6	49.4	51.5	54.5	61.1	53.0	55.1	53.5	58.2	47.8	36.6	40.2	34.4	39.9	31.4	24.5	22.6	33.8	38.8
Lmax	dBA	**35.8**																		
YMT - WHA Calculation																				
FDL	dB re $N/m^{1/2}$	62.1	62.9	63.4	64.2	57.4	58.4	64.1	61.2	64.2	59.3	57.2	61.3	64.3	65.1	64.6	60.7	62.9	58.7	55.6
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	0.0	0.0	2.1	3.4	16.6	9.6	7.0	6.2	8.0	-0.3	0.0	3.7	-7.9	-1.0	-8.3	-9.7	-13.3	1.0	4.4
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	1.0	2.0	3.0	3.8	5.0	6.0	6.0	6.0	6.0	5.8	5.4	5.2	5.0	4.8	4.0	3.0	2.0	1.0	0.7
BVR-Floor Attenuation	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	48.6	49.4	51.5	54.5	61.1	53.0	55.1	53.5	58.2	47.8	36.6	40.2	34.4	39.9	31.4	24.5	22.6	33.8	38.8
Lmax	dBA	**35.8**																		
Turnback-YMT Calculation																				
FDL	dB re $N/m^{1/2}$	62.3	63.1	63.6	64.4	57.6	58.6	64.3	61.4	64.4	59.5	57.4	61.5	64.5	65.3	64.8	60.9	63.1	58.9	55.8
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	0.0	0.0	2.3	4.2	16.9	9.5	7.7	6.7	8.6	0.0	0.2	6.9	-3.5	5.2	6.5	-1.7	-5.5	2.0	4.4
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	1.0	2.0	3.0	3.8	5.0	6.0	6.0	6.0	6.0	5.8	5.4	5.2	5.0	4.8	4.0	3.0	2.0	1.0	0.7
BVR-Floor Attenuation	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	48.8	49.6	51.9	55.4	61.5	53.1	55.9	54.1	59.0	48.3	37.0	43.6	38.9	46.3	46.3	32.7	30.6	34.9	38.8
Lmax	dBA	**38.5**																		
WHA - YMT Calculation																				
FDL	dB re $N/m^{1/2}$	62.3	63.1	63.6	64.4	57.6	58.6	64.3	61.4	64.4	59.5	57.4	61.5	64.5	65.3	64.8	60.9	63.1	58.9	55.8
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	0.0	0.0	2.3	4.2	16.9	9.5	7.7	6.7	8.6	0.0	0.2	6.9	-3.5	5.2	6.5	-1.7	-5.5	2.0	4.4
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	1.0	2.0	3.0	3.8	5.0	6.0	6.0	6.0	6.0	5.8	5.4	5.2	5.0	4.8	4.0	3.0	2.0	1.0	0.7
BVR-Floor Attenuation	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	48.8	49.6	51.9	55.4	61.5	53.1	55.9	54.1	59.0	48.3	37.0	43.6	38.9	46.3	46.3	32.7	30.6	34.9	38.8
Lmax	dBA	**38.5**																		
Total Prediction Noise level																				
Lmax	dBA	**39**																		
Leq,30min (day)	dBA	**30**																		
Leq,30min (night)	dBA	**27**																		
Leq,24hr	dBA	**29**																		

Detailed GBN Calculation of NSR12, Methodist Primary School at 10-12 Wylie Road

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NSR No.	14				Down Track Chainage			8+970	Vertical Distance (m)			49	Horizontal Setback (m)			3	Speed (km/h)			66
Location	Shun Man House, Oi Man Estata				Up Track Chainage			9+000	Vertical Distance (m)			49	Horizontal Setback (m)			0	Speed (km/h)			61
		1/3 Octave Band Center Frequency																		
		6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400
YMT-Turnback Calculation																				
FDL	dB re $N/m^{1/2}$	61.9	62.7	63.2	64.0	57.2	58.2	63.9	61.0	64.0	59.1	57.0	61.1	64.1	64.9	64.4	60.5	62.7	58.5	55.4
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	-17.8	-12.6	-10.1	-9.4	-0.9	-0.7	3.4	4.7	12.1	13.0	7.8	16.1	8.7	-1.5	14.5	6.0	0.2	17.5	19.0
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	27.6	32.5	34.0	35.6	36.3	34.4	43.3	43.7	54.1	53.1	36.8	45.2	43.8	32.4	47.8	35.0	31.9	47.0	50.4
Lmax	dBA	**47.1**																		
YMT - WHA Calculation																				
FDL	dB re $N/m^{1/2}$	61.9	62.7	63.2	64.0	57.2	58.2	63.9	61.0	64.0	59.1	57.0	61.1	64.1	64.9	64.4	60.5	62.7	58.5	55.4
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	-17.8	-12.6	-10.1	-9.4	-0.9	-0.7	3.4	4.7	12.1	13.0	7.8	16.1	8.7	-1.5	14.5	6.0	0.2	17.5	19.0
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	27.6	32.5	34.0	35.6	36.3	34.4	43.3	43.7	54.1	53.1	36.8	45.2	43.8	32.4	47.8	35.0	31.9	47.0	50.4
Lmax	dBA	**47.1**																		

Turnback-YMT Calculation																				
FDL	dB re $N/m^{1/2}$	61.2	62.0	62.5	63.3	56.5	57.5	63.2	60.3	63.3	58.4	56.3	60.4	63.4	64.2	63.7	59.8	62.0	57.8	54.7
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	-17.7	-12.6	-10.1	-9.3	-0.7	-0.7	4.0	5.4	12.4	13.5	7.9	16.2	9.2	-1.4	14.7	6.8	0.8	17.7	19.1
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	26.9	31.9	33.4	35.0	35.8	33.8	43.2	43.7	53.7	52.9	36.2	44.6	43.6	31.8	47.4	35.1	31.8	46.5	49.8
Lmax	dBA	**46.6**																		
WHA - YMT Calculation																				
FDL	dB re $N/m^{1/2}$	61.3	62.0	62.5	63.3	56.5	57.5	63.2	60.3	63.3	58.4	56.3	60.4	63.4	64.2	63.7	59.8	62.0	57.8	54.7
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	-17.7	-12.6	-10.1	-9.3	-0.7	-0.7	4.0	5.4	12.4	13.5	7.9	16.2	9.2	-1.4	14.7	6.8	0.8	17.7	19.1
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	27.1	31.9	33.4	35.0	35.8	33.8	43.2	43.7	53.7	52.9	36.2	44.6	43.6	31.8	47.4	35.1	31.8	46.5	49.8
Lmax	dBA	**46.8**																		
Total Prediction Noise level																				
Lmax	dBA	**47**																		
Leq,30min (day)	dBA	**40**																		
Leq,30min (night)	dBA	**37**																		
Leq,24hr	dBA	**39**																		

NSR No.	26				Down Track Chainage			7+900	Vertical Distance (m)			24.9	Horizontal Setback (m)			5	Speed (km/h)			69
Location	Block R, Wing Fu Building, Whampoa Estate				Up Track Chainage			-	Vertical Distance (m)			-	Horizontal Setback (m)			-	Speed (km/h)			53
		1/3 Octave Band Center Frequency																		
		6.3	8	10	12.5	16	20	25	31.5	40	50	63	80	100	125	160	200	250	315	400
YMT-Turnback Calculation																				
FDL	dB re $N/m^{1/2}$	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	4.6	-1.7	9.0	9.0	13.0	3.5	-0.5	-1.1	-2.3	-0.1	-3.0	0.9	-9.7	-9.6	-9.2	-6.8	-3.8	-0.7	0.0
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	1.0	2.0	3.0	3.8	5.0	6.0	6.0	6.0	6.0	5.8	5.4	5.2	5.0	4.8	4.0	3.0	2.0	1.0	0.7
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	33.5	28.3	38.7	40.3	37.7	27.7	30.9	29.7	36.4	36.0	26.8	24.4	35.1	30.8	24.3	27.4	29.6	26.8	29.6
Lmax	dBA	**28.2**																		
YMT - WHA Calculation																				
FDL	dB re $N/m^{1/2}$	62.3	63.1	63.6	64.4	57.6	58.6	64.3	61.4	64.4	59.5	57.4	61.5	64.5	65.3	64.8	60.9	63.1	58.9	55.8
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	29.6	29.5	28.4	22.1	31.2	28.6	23.5	17.0	15.9	20.0	5.6	3.2	10.6	7.3	6.5	12.8	10.2	3.1	1.6
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	75.4	75.0	72.9	67.4	68.7	64.1	63.8	56.4	58.2	60.5	35.0	32.7	46.1	41.6	40.3	42.2	42.3	32.9	33.4
Lmax	dBA	**38.8**																		

Turnback-YMT Calculation																				
FDL	dB re $N/m^{1/2}$	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0	-999.0
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	4.6	-1.7	9.0	9.0	13.0	3.5	-0.5	-1.1	-2.3	-0.1	-3.0	0.9	-9.7	-9.6	-9.2	-6.8	-3.8	-0.7	0.0
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	1.0	2.0	3.0	3.8	5.0	6.0	6.0	6.0	6.0	5.8	5.4	5.2	5.0	4.8	4.0	3.0	2.0	1.0	0.7
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	32.9	28.6	38.1	39.9	37.2	28.0	32.3	31.3	37.8	37.1	28.8	25.6	36.1	32.1	25.7	28.5	30.7	27.9	30.7
Lmax	dBA	**29.4**																		
WHA - YMT Calculation																				
FDL	dB re $N/m^{1/2}$	60.0	60.8	61.3	62.1	55.3	56.3	62.0	59.1	62.1	57.2	55.1	59.2	62.2	63.0	62.5	58.6	60.8	56.6	53.5
TIL (25kN/mm Baseplate)	dB	2.5	1.5	0.0	0.0	-1.0	-4.0	-5.0	-3.0	-3.0	0.0	-9.0	-13.0	-10.0	-12.0	-12.0	-12.5	-12.0	-10.0	-5.0
TOC	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LSR	dB re $(nm/s)/(N/m^{1/2})$	29.6	29.5	28.4	22.1	31.2	28.6	23.5	17.0	15.9	20.0	5.6	3.2	10.6	7.3	6.5	12.8	10.2	3.1	1.6
BCF	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Amplification	dB	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
BVR-Floor Attenuation	dB	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0	-2.0
CTN	dB	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0	-27.0
SAF	dB	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Lmax	dB	73.1	72.7	70.7	65.1	66.5	61.8	61.5	54.1	55.9	58.2	32.7	30.4	43.8	39.3	38.0	39.9	40.0	30.7	31.1
Lmax	dBA	**36.6**																		
Total Prediction Noise level																				
Lmax	dBA	**39**																		
Leq,30min (day)	dBA	**31**																		
Leq,30min (night)	dBA	**28**																		
Leq,24hr	dBA	**29**																		

Note: -999 for FDL means the level is negligible

Annex B

Specification of Drill-rig Employed in WIL and KTE

Table B. Specification of Drill-rig Employed in WIL and KTE

Item	Specification
Carrier Model	BOOMER 352
Hydraulic Drill Model	COP1238ME
Energy per blow	300J
Blow Frequency	40 - 60Hz
Drill Weight	151kg
Impact Power	15kW
Rotation Torque	500Nm
Rotation Speed	0-300rpm (0-5Hz)
Rotation Power	2.50kW

Annex C

Calibration Certificates

Table C. Equipments Employed in Vibration Measurements and Hammer Impact Test

Item	Model	Qty.
Vibration Analyzer	SVAN 958	1
Accelerometer	PCB 393A03	4
Handheld Vibration Calibrator	IMI 699A02	1
Force Transducer (Load Cell)	Futek LCM550	1

Calibration Certificates for the Measurements at NSR12

SVANTEK

ISO9001 certified

FACTORY CALIBRATION DATA OF THE SVAN 958 *No. 28422*

SOUND LEVEL METER

1. CALIBRATION (electrical)

LEVEL METER; Filter: LIN; Input signal =114.0dB, f_{sin}=1kHz

	Range 105dB		Range 130dB	
	Indication [dB]	Error [dB]	Indication [dB]	Error [dB]
Channel 1	114.04	0.04	114.05	0.05
Channel 2	114.03	0.03	114.03	0.03
Channel 3	114.02	0.02	114.03	0.03
Channel 4	114.03	0.03	114.08	0.08

2. CALIBRATION* (acoustical)

LEVEL METER; Range: 130 dB; Reference frequency: 1000Hz;

Filter	LIN		A		C	
	Indication [dB]	Error [dB]	Indication [dB]	Error [dB]	Indication [dB]	Error [dB]
Channel 1	113.7	-0.1	113.7	-0.1	113.7	-0.1
Channel 2	113.7	-0.1	113.7	-0.1	113.7	-0.1
Channel 3	113.7	-0.1	113.7	-0.1	113.7	-0.1
Channel 4	113.7	-0.1	113.7	-0.1	113.7	-0.1

Calibration measured with the microphone SVANTEK type SV22 No. 4010479. Calibration factor: -0.4dB

3. LINEARITY TEST* (electrical)

LEVEL METER; Range: 105 dB; Filter: A; f_{sin}= 1000 Hz

	Input [dB]	24.0	30.0	40.0	60.0	80.0	100.0	114.0
Channel 1	Error [dB]	0.24	0.12	0.00	-0.01	0.00	0.01	0.01
Channel 2	Error [dB]	0.29	0.15	0.02	0.00	0.01	0.01	0.02
Channel 3	Error [dB]	0.16	0.03	-0.01	-0.01	0.00	0.01	0.02
Channel 4	Error [dB]	0.20	0.04	-0.01	-0.00	0.01	0.01	0.02

LEVEL METER; Range: 130 dB; Filter: A; f_{sin}= 1000 Hz

	Input [dB]	45.0	50.0	60.0	80.0	100.0	120.0	135.0
Channel 1	Error [dB]	0.18	0.15	0.05	0.00	0.00	0.00	0.01
Channel 2	Error [dB]	0.21	0.15	0.06	0.01	0.01	0.01	0.01
Channel 3	Error [dB]	-0.02	0.02	0.01	0.01	0.01	0.01	0.01
Channel 4	Error [dB]	0.02	0.03	0.01	0.01	0.01	0.00	0.01

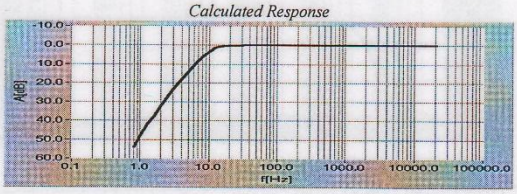
1/3 OCTAVE (1kHz); Range: 130 dB; Filter: A; f_{sin}= 1000 Hz

	Input [dB]	35.0	40.0	60.0	80.0	100.0	120.0	135.0
Channel 1	Error [dB]	0.52	0.11	0.03	0.00	0.01	0.00	0.01
Channel 2	Error [dB]	0.52	0.13	0.04	0.00	0.01	0.00	0.01
Channel 3	Error [dB]	0.48	0.08	0.02	0.00	0.01	0.00	0.01
Channel 4	Error [dB]	0.40	0.07	0.02	0.00	0.01	0.00	0.01

6. FREQUENCY RESPONSE (electrical)

LEVEL METER; Filter: Z; Range: 130 dB; Input signal =135 dB;

Calculated Response



Measured Response with Preamplifier SV12 (f-frequency, An-attenuation in channel n)

f [Hz]	A1 [dB]	A2 [dB]	A3 [dB]	A4 [dB]	f [Hz]	A1 [dB]	A2 [dB]	A3 [dB]	A4 [dB]
10	3.2	3.2	3.2	3.2	250	0.0	0.0	0.0	0.0
12.5	1.4	1.4	1.4	1.4	500	0.0	0.0	0.0	0.0
16	0.5	0.5	0.5	0.5	1000	0.0	0.0	0.0	0.0
20	0.2	0.1	0.1	0.1	2000	0.0	0.0	0.0	0.0
25	0.0	0.0	0.0	0.0	4000	0.1	0.0	0.0	0.0
31.5	0.0	-0.1	-0.1	0.0	8000	0.1	0.0	0.0	0.0
63	0.0	-0.1	0.0	0.0	16000	0.1	0.0	0.0	0.0
125	0.0	0.0	0.0	0.0	20000	0.1	0.0	0.0	0.0

All frequencies are nominal center values for the 1/3 octave bands

7. INTERNAL NOISE LEVEL* (electrical)

LEVEL METER; Range: 105 dB; Back-light – off; Calibration factor: 0dB

	Filter	**Z**	**A**	**C**
Channel 1	**Level [dB]**	14.8	11.7	11.3
Channel 2	**Level [dB]**	15.8	12.0	11.9
Channel 3	**Level [dB]**	16.5	11.8	11.6
Channel 4	**Level [dB]**	15.3	11.9	11.8

* measured with preamplifier SVANTEK type SV12 No. 1991.

VIBRATION LEVEL METER

1. CALIBRATION (electrical)

LEVEL METER; Filter: HP10; Input signal =140.0dB (10.0 m/s^2), f_{sin}=79,6Hz

	Range 145dB		**Range 170dB**	
	Indication [dB]	**Error [dB]**	**Indication [dB]**	**Error [dB]**
Channel 1	140.04	0.04	140.05	0.05
Channel 2	140.03	0.03	140.03	0.03
Channel 3	140.02	0.02	140.03	0.03
Channel 4	140.03	0.03	140.08	0.08

2. CALIBRATION (vibrational)

LEVEL METER; Range: 145dB; Input signal: 120dB;

Filter	HP1		HP10		Wd		Wm		Wh	
	Indication [dB]	**Error [dB]**	**Indication [dB]**	**Error [dB]**	**Indication [dB]**	**Error [dB]**	**Indication [dB]**	**Error [dB]**	**Indication [dB]**	**Error [dB]**
Channel 1	120.1	0.1	120.1	0.1	106.2	0.1	102.2	0.2	110.7	0.1
Channel 2	120.1	0.1	120.0	0.0	106.2	0.1	102.2	0.2	110.7	0.1
Channel 3	120.1	0.1	120.1	0.1	106.2	0.1	102.2	0.2	110.7	0.1
Channel 4	120.1	0.1	120.1	0.1	106.2	0.1	102.2	0.2	110.7	0.1

Calibration measured with the accelerometer DYTRAN type 3185D No. 2327. Calibration factor: -0.2dB

Range: **130dB**; Equivalent input steady level = 74dB

Result	Detector	Ch.	Duration [ms]	1000	500	200	100	50	20	10	5
MAX	Fast	1	Indication [dB]	74.0	73.9	73.0	71.4	69.2	65.7	62.8	59.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0
		2	Indication [dB]	74.0	73.9	73.0	71.4	69.1	65.7	62.8	59.9
			Error [dB]	0.0	0.0	73.0	0.0	-0.0	-0.0	-0.1	0.0
		3	Indication [dB]	74.0	73.9	73.0	71.4	69.1	65.7	62.8	59.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	0.0	-0.1	0.0
		4	Indication [dB]	74.0	74.0	73.0	71.5	69.2	65.7	62.9	60.0
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0
	Slow	1	Indication [dB]	72.0	69.9	66.6	63.8	60.9	57.0	54.0	51.0
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
		2	Indication [dB]	72.0	69.9	66.5	63.8	60.9	56.9	54.0	51.0
			Error [dB]	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	0.1
		3	Indication [dB]	72.0	69.9	66.5	63.7	60.8	56.9	53.9	51.0
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
		4	Indication [dB]	72.0	70.0	66.6	63.8	60.9	57.0	54.0	51.0
			Error [dB]	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
SEL	-	1	Indication [dB]	74.0	71.0	67.0	64.0	61.0	57.0	54.0	51.1
			Error [dB]	0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.1
		2	Indication [dB]	74.0	71.0	67.0	64.0	61.0	57.0	54.0	51.1
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	0.1	0.1
		3	Indication [dB]	74.0	70.9	67.0	64.0	61.0	57.0	54.0	51.1
			Error [dB]	0.0	-0.0	0.0	0.0	0.0	0.0	0.0	0.1
		4	Indication [dB]	74.0	71.0	67.0	64.0	61.0	57.1	54.1	51.1
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	0.1

Range: **130dB**; Equivalent input steady level = 54dB

Result	Detector	Ch.	Duration [ms]	1000	500
MAX	Fast	1	Indication [dB]	54.0	53.9
			Error [dB]	0.0	-0.0
		2	Indication [dB]	54.0	53.9
			Error [dB]	0.1	0.1
		3	Indication [dB]	53.9	53.9
			Error [dB]	0.0	0.0
		4	Indication [dB]	54.1	54.0
			Error [dB]	-0.0	-0.0
	Slow	1	Indication [dB]	52.0	50.0
			Error [dB]	0.0	0.1
		2	Indication [dB]	52.0	49.9
			Error [dB]	0.1	0.1
		3	Indication [dB]	52.0	49.9
			Error [dB]	0.0	0.1
		4	Indication [dB]	52.1	50.1
			Error [dB]	-0.0	0.1
SEL	-	1	Indication [dB]	54.0	51.1
			Error [dB]	0.0	0.1
		2	Indication [dB]	54.1	51.1
			Error [dB]	0.1	0.1
		3	Indication [dB]	54.0	51.0
			Error [dB]	0.0	0.1
		4	Indication [dB]	54.1	51.2
			Error [dB]	-0.0	0.1

Range: **105dB**; Equivalent input steady level = 34dB

Result	Detector	Ch.	Duration [ms]	1000	500
MAX	Fast	1	Indication [dB]	34.0	34.0
			Error [dB]	-0.0	0.0
		2	Indication [dB]	34.0	34.0
			Error [dB]	0.0	0.1
		3	Indication [dB]	34.0	33.9
			Error [dB]	-0.0	-0.0
		4	Indication [dB]	34.0	33.9
			Error [dB]	0.0	-0.0
	Slow	1	Indication [dB]	32.0	30.1
			Error [dB]	0.0	0.1
		2	Indication [dB]	32.0	30.0
			Error [dB]	0.0	0.1
		3	Indication [dB]	31.9	30.0
			Error [dB]	-0.0	0.1
		4	Indication [dB]	32.0	30.0
			Error [dB]	-0.0	0.1
SEL	-	1	Indication [dB]	34.1	31.2
			Error [dB]	0.0	0.1
		2	Indication [dB]	34.1	31.2
			Error [dB]	0.1	0.2
		3	Indication [dB]	34.0	31.1
			Error [dB]	-0.0	0.1
		4	Indication [dB]	34.1	31.1
			Error [dB]	0.0	0.1

Range: **130dB**; Equivalent input steady level = 134dB

Result	Detector	Ch.	Duration [ms]	1000	500	200	100	50	20	10	5	2	1	0.5	0.25
MAX	Fast	1	Indication [dB]	134.0	133.9	133.0	131.4	129.2	125.7	122.8	119.9	116.0	112.9	109.9	106.9
			Error [dB]	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.1	-0.1	-0.1
		2	Indication [dB]	134.0	133.9	133.0	131.4	129.1	125.7	122.8	119.9	115.9	112.9	109.9	106.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.1	-0.1
		3	Indication [dB]	134.0	133.9	133.0	131.4	129.1	125.7	122.8	119.9	115.9	112.9	109.9	106.8
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.1	-0.1	-0.1
		4	Indication [dB]	134.1	134.0	133.1	131.4	129.2	125.7	122.9	120.0	116.0	113.0	110.0	106.9
			Error [dB]	0.0	0.0	0.0	-0.0	129.2	-0.0	-0.1	0.0	-0.0	-0.1	-0.1	-0.1
	Slow	1	Indication [dB]	132.0	129.9	126.6	123.8	120.9	117.0	114.0	111.0	107.0	-	-	-
			Error [dB]	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
		2	Indication [dB]	132.0	129.9	126.6	123.8	120.9	116.9	114.0	110.9	107.0	-	-	-
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
		3	Indication [dB]	132.0	129.9	126.5	123.8	120.9	116.9	113.9	110.9	107.0	-	-	-
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
		4	Indication [dB]	132.1	130.0	126.6	123.8	120.9	117.0	114.0	111.0	107.0	-	-	-
			Error [dB]	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
SEL	-	1	Indication [dB]	134.0	131.0	127.0	124.0	121.0	117.0	114.0	111.0	107.0	103.9	100.9	97.9
			Error [dB]	-0.0	-0.0	0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1
		2	Indication [dB]	134.0	131.0	127.0	124.0	121.0	117.0	114.0	111.0	107.0	103.9	100.9	97.8
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.1	-0.1
		3	Indication [dB]	134.0	131.0	127.0	124.0	121.0	117.0	114.0	111.0	107.0	103.9	100.9	97.8
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1
		4	Indication [dB]	134.1	131.0	127.1	124.0	121.0	117.1	114.0	111.0	107.0	104.0	101.0	97.9
			Error [dB]	0.0	-0.0	0.0	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1

4. TONEBURST RESPONSE* (electrical)

LEVEL METER; Characteristic: A; f_{sin}= 4000 Hz; Burst duration: 2s;

Range: **105dB**; Equivalent input steady level = 112dB

Result	Detector	Ch.	Duration [ms]	1000	500	200	100	50	20	10	5	2	1	0.5	0.25
MAX	Fast	1	Indication [dB]	112.0	111.9	111.0	109.4	107.2	103.7	100.8	97.9	94.0	91.0	87.9	84.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.0	-0.1	-0.1
		2	Indication [dB]	112.0	111.9	111.0	109.4	107.2	103.7	100.8	97.9	94.0	90.9	87.9	84.9
			Error [dB]	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.1	-0.1	-0.1
		3	Indication [dB]	112.0	111.9	111.0	109.4	107.1	103.7	100.8	97.9	93.9	90.9	87.9	84.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.0	-0.1	-0.1
		4	Indication [dB]	112.0	111.9	111.0	109.4	107.2	103.7	100.9	97.9	94.0	91.0	87.9	84.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0	-0.0	-0.0	-0.1	-0.1
	Slow	1	Indication [dB]	110.0	108.0	104.6	101.8	98.9	95.0	92.0	89.0	85.0	-	-	-
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
		2	Indication [dB]	110.0	107.9	104.6	101.8	98.9	95.0	92.0	89.0	85.0	-	-	-
			Error [dB]	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
		3	Indication [dB]	110.0	107.9	104.5	101.8	98.9	94.9	91.9	88.9	85.0	-	-	-
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
		4	Indication [dB]	110.0	108.0	104.6	101.8	98.9	95.0	92.0	89.0	85.0	-	-	-
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-	-	-
SEL	-	1	Indication [dB]	112.0	109.0	105.0	102.0	99.0	95.0	92.0	89.0	85.0	82.0	78.9	75.9
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1
		2	Indication [dB]	112.0	109.0	105.0	102.0	99.0	95.0	92.0	89.0	85.0	81.9	78.9	75.9
			Error [dB]	-0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1	-0.1
		3	Indication [dB]	112.0	109.0	105.0	102.0	99.0	95.0	92.0	89.0	85.0	81.9	78.9	75.8
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.1	-0.1
		4	Indication [dB]	112.0	109.0	105.0	102.0	99.0	95.0	92.0	89.0	85.0	82.0	78.9	75.9
			Error [dB]	0.0	-0.0	0.0	0.0	-0.0	0.0	0.0	-0.0	-0.0	-0.0	-0.1	-0.1

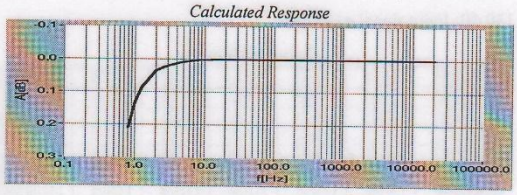
Range: **105dB**; Equivalent input steady level = 52dB

Result	Detector	Ch.	Duration [ms]	1000	500	200	100	50	20	10	5
MAX	Fast	1	Indication [dB]	52.0	51.9	51.0	49.4	47.1	43.7	40.8	37.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	0.0	-0.0	0.0
		2	Indication [dB]	52.0	51.9	51.0	49.4	47.1	43.7	40.8	37.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	0.0	-0.1	0.0
		3	Indication [dB]	51.9	51.9	51.0	49.3	47.1	43.6	40.8	37.8
			Error [dB]	-0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	0.0
		4	Indication [dB]	52.0	51.9	51.0	49.4	47.1	43.6	40.8	37.9
			Error [dB]	0.0	0.0	0.0	0.0	-0.0	-0.0	-0.1	-0.0
	Slow	1	Indication [dB]	50.0	47.9	44.6	41.8	38.9	35.0	32.0	29.0
			Error [dB]	0.0	0.1	0.0	-0.0	-0.0	0.0	0.0	0.0
		2	Indication [dB]	50.0	47.9	44.5	41.7	38.8	35.0	31.9	29.1
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	0.0	-0.0	0.1
		3	Indication [dB]	49.9	47.9	44.5	41.7	38.8	34.9	31.9	29.0
			Error [dB]	0.0	0.1	-0.0	-0.0	-0.0	-0.0	-0.0	0.0
		4	Indication [dB]	50.0	47.9	44.6	41.8	38.9	35.0	32.0	29.0
			Error [dB]	0.0	0.0	-0.0	-0.0	-0.0	-0.0	-0.0	-0.0
SEL	-	1	Indication [dB]	52.0	49.0	45.0	42.0	39.0	35.1	32.1	29.2
			Error [dB]	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.2
		2	Indication [dB]	52.0	49.0	45.0	42.0	39.0	35.0	32.1	29.2
			Error [dB]	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.3
		3	Indication [dB]	51.9	48.9	45.0	41.9	39.0	35.0	32.0	29.1
			Error [dB]	0.0	-0.0	0.0	0.0	0.0	0.1	0.1	0.2
		4	Indication [dB]	52.0	49.0	45.0	42.0	39.0	35.0	32.1	29.2
			Error [dB]	0.0	-0.0	0.0	0.0	0.0	0.0	0.1	0.2

3. FREQUENCY RESPONSE (electrical)

1/3 OCTAVE; Filter: HP; Range: 170 dB; input=175 dB;

Calculated Response



Measured Response (f-frequency, An-attenuation in channel n)

f [Hz]	A1[dB]	A2[dB]	A3[dB]	A4[dB]	f [Hz]	A1[dB]	A2 [dB]	A3[dB]	A4[dB]	f [Hz]	A1[dB]	A2[dB]	A3[dB]	A4[dB]
0.8	0.18	0.18	0.18	0.18	5	0.01	0.01	0.01	0.01	500	0.01	0.00	0.00	0.01
1	0.11	0.11	0.11	0.11	6.3	0.01	0.01	0.01	0.01	1000	0.01	0.01	0.01	0.01
1.25	0.08	0.08	0.08	0.08	8	0.00	0.00	0.00	0.00	2000	0.01	0.01	0.01	0.01
1.6	0.06	0.06	0.06	0.06	16	0.00	0.00	0.00	0.00	4000	0.02	0.02	0.02	0.02
2	0.03	0.03	0.03	0.03	31.5	0.00	0.00	0.00	0.00	8000	0.06	0.05	0.05	0.05
2.5	0.02	0.01	0.01	0.01	63	0.00	0.00	0.00	0.00	16000	0.06	0.03	0.03	0.03
3.15	0.02	0.02	0.02	0.02	125	0.00	0.00	0.00	0.00	20000	0.04	0.01	0.01	0.02
4	0.00	-0.01	-0.01	0.00	250	0.00	0.00	0.00	0.00					

All frequencies are nominal center values for the 1/3 octave bands

4. INTERNAL NOISE LEVEL (electrical)

LEVEL METER func.; Range: 145 dB; Back-light – off

	Filter	HP1	HP10	Wd	Wm	Wh
Channel 1	**Indication** [dB]	54.7	52.3	42.2	38.5	36.3
Channel 2	**Indication** [dB]	54.9	52.6	43.1	39.7	37.2
Channel 3	**Indication** [dB]	55.0	52.3	44.6	39.0	36.4
Channel 4	**Indication** [dB]	54.7	52.5	42.8	39.1	36.5

ENVIRONMENTAL CONDITIONS

Temperature	Relative humidity	Ambient pressure
23 °C	41 %	998 hPa

TEST EQUIPMENT

Item	Manufacturer	Model	Serial no.	Description
1.	SVANTEK	SVAN 401	65	Signal generator
2.	SVANTEK	SVAN 912A	4369	Sound &Vibration Analyser
3.	KEITHLEY	2000	0910165	Digital multimeter
4.	SVANTEK	SV30A	7449	Acoustic calibrator
5.	SVANTEK	ST02	-	Microphone equivalent electrical impedance (18pF)
6.	DYTRAN	3233A	450	Reference accelerometer

CONFORMITY & TEST DECLARATION

1. Herewith Svantek company declares that this instrument has been calibrated and tested in compliance with the internal ISO9001 procedures and meets all specification given in the Manual(s) or respectively surpass them.

2. Tracebility of the calibration is guarantied by the above mentioned ISO9001 procedures.

3. The information appearing on this sheet has been compiled specifically for this instrument. This form is produced with advanced equipment & procedures which permit comprehensive quality assurance verification of all data supplied herein.

4. This calibration sheet shall not be reproduced except in full, without written permission of the SVANTEK Ltd.

Calibration specialist: Ryszard Leoniak .....

Test date: 2012-09-14

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 36982

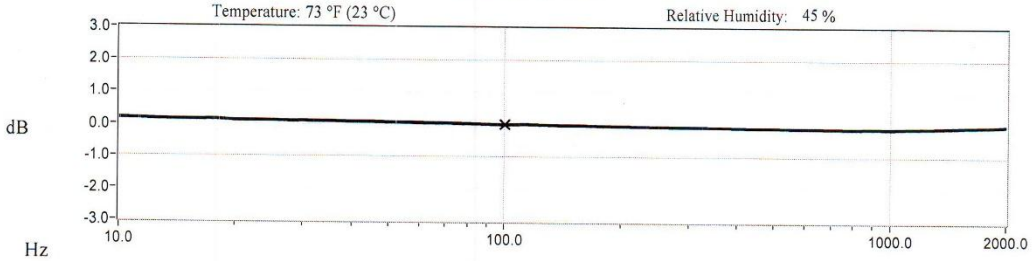
Description: ICP® Accelerometer Method: Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**1008**	**mV/g**	Output Bias	11.0	VDC
	(102.7	**mV/m/s²)**	Transverse Sensitivity	2.7	%
Discharge Time Constant	1.0	seconds	Resonant Frequency	14.3	kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	2.0	300.0	-0.8
15.0	1.5	500.0	-1.2
30.0	1.1	1000.0	-1.5
50.0	0.7	2000.0	-0.4
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 1.00 g (9.81 m/s²)²

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.010 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 681/280472 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Scott Skibniewski Date: 01/23/13

ACCREDITED
CALIBRATION CERT #1862.02

PCB PIEZOTRONICS INC
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

cal57 - 3441803071.01

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 36981

Description: ICP® Accelerometer

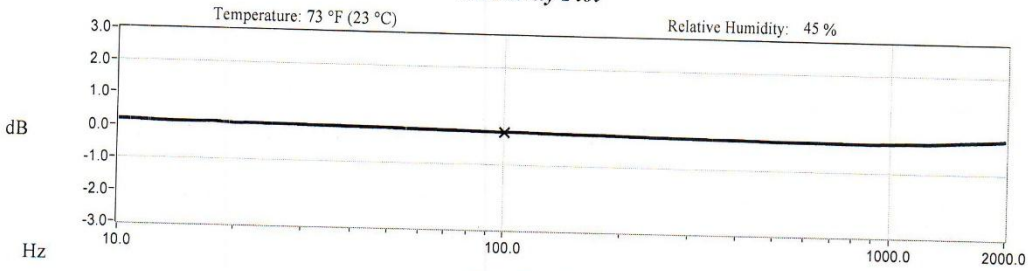
Method: Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**1004**	**mV/g**	Output Bias	10.8	VDC
	(102.4	**mV/m/s²)**	Transverse Sensitivity	1.5	%
Discharge Time Constant	1.2	seconds	Resonant Frequency	13.1	kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	2.0	300.0	-0.7
15.0	1.5	500.0	-1.1
30.0	1.1	1000.0	-1.2
50.0	0.8	2000.0	0.5
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 1.00 g (9.81 m/s²)²

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.010 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 681/280472 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Scott Skibniewski Date: 01/23/13

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cal57 - 3441802883.09

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 37179

Description: ICP® Accelerometer Method: Back-to-Back Comparison (AT401-3)

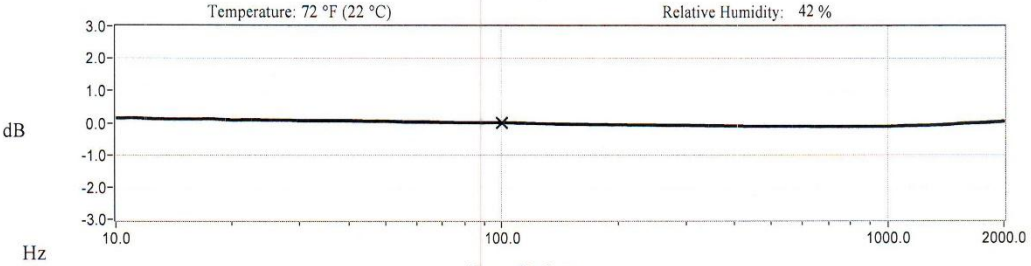
Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**1009**	**mV/g**	Output Bias	10.8	VDC
	(102.9	**mV/m/s²)**	Transverse Sensitivity	2.0	%
Discharge Time Constant	1.1	seconds	Resonant Frequency	12.4	kHz

Sensitivity Plot

Temperature: 72 °F (22 °C) Relative Humidity: 42 %



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	1.7	300.0	-0.9
15.0	1.4	500.0	-1.3
30.0	0.9	1000.0	-1.3
50.0	0.6	2000.0	0.5
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 1.00 g (9.81 m/s²)[2]

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.010 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 681/280472 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Scott Skibniewski Date: 01/22/13

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cal57 - 3441715051.41

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 37189

Description: ICP® Accelerometer

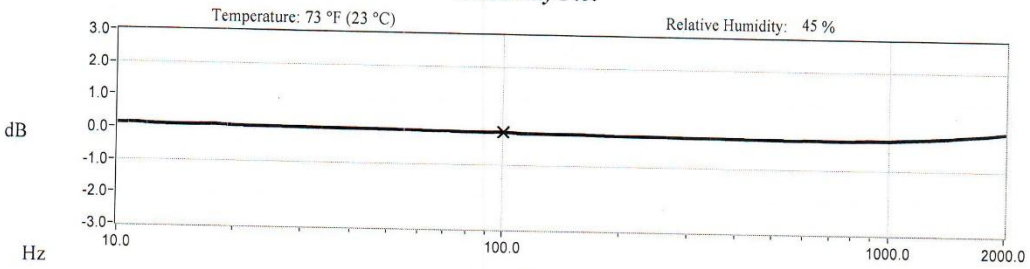
Method: Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**1010**	**mV/g**	Output Bias	11.0	VDC
	(103.0	**mV/m/s²)**	Transverse Sensitivity	5.0	%
Discharge Time Constant	1.1	seconds	Resonant Frequency	10.4	kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	1.4	300.0	-1.0
15.0	1.0	500.0	-1.2
30.0	0.6	1000.0	-1.1
50.0	0.3	2000.0	1.8
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 1.00 g (9.81 m/s²)[2]

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.010 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 681/280472 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Scott Skibniewski Date: 01/23/13

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CALIBRATION CERT #1862.02

PCB PIEZOTRONICS INC.
VIBRATION DIVISION

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cal57 - 3441801779.66

~ *Calibration Certificate* ~

Model Number: 699A02

Serial Number: 989

Description: Portable Handheld Shaker

Manufacturer: IMI
ICS-12

Customer:

P.O. :

Method : Back-to-Back Comparison (AT701-1)

Calibration Data

Operating Frequency:	160.6	Hz.	Test Point Voltage:	100.4	mVAC
Acceleration Level:	1.00	g's rms			
	9.826	m/s^2			
Temperature:	69	°F (21 °C)	Relative Humidity:	49	%

Condition of Unit

As Found: Overload Shut Off Feature Malfunctioning
As Left: In Tolerance, After Repair

Notes

1. Calibration is N.I.S.T. Traceable thru Project 822/267400 and PTB Traceable thru Project 1055.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for reference frequency is +/-1.6%.

Equipment Used For Calibration

Manufacturer	Description	Model#	Serial No.	Cal Date	Due Date
National Instruments	Acquistion Brd	PCI-6052E	1125572	2/5/2012	2/5/2013
PCB Piezotronics	Accelerometer	Y353B34	93740	4/16/2012	4/16/2013
PCB Piezotronics	Power Supply	480C02	CA360	2/2/2012	2/2/2013

Technician: *Luke Rogers* L. R.

Date: 11/22/12

Due Date:

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CALIBRATION CERT #1862.01

IMI SENSORS
A PCB PIEZOTRONICS DIV.
3425 Walden Avenue
Depew, New York 14043
TEL: 888-684-0003 FAX: 716-684-3823
www.imi-sensors.comhh1 2012150606.88

Calibration Certificates for the Measurement and Test at NSR14 and NSR26

MAXLAB

CALIBRATION CERTIFICATE

Certificate Information			
Date of Issue	30-Aug-2013	**Certificate Number**	MLCN131110S

Customer Information	
Company Name	Wilson Accoustics Limited
Address	Unit 601, Block A, Shatin Industrial Centre, Yuen Shun Circuit, Shatin, N. T., Hong Kong

Equipment-under-Test (EUT)	
Description	Sound & Vibration Analyser
Manufacturer	Svantek
Model Number	SVAN 958
Serial Number	14210
Equipment Number	--

Calibration Particular			
Date of Calibration	30-Aug-2013		
Calibration Equipment	4231(MLTE008) / DC120076 / 29-Mar-2014		
Calibration Procedure	MLCG00, MLCG15		
Calibration Conditions	Laboratory	Temperature	23 °C ± 5 °C
		Relative Humidity	55% ± 25%
	EUT	Stabilizing Time	Over 3 hours
		Warm-up Time	10 minutes
		Power Supply	Internal battery
Calibration Results	Calibration data were detailed in the continuation pages.		

Approved By & Date		
	K.O. Lo	30-Aug-2013

Statements

* Calibration equipment used for this calibration are traceable to national / international standards.
* The results on this Calibration Certificate only relate to the values measured at the time of the calibration and the uncertainties quoted will not include allowance for the EUT long term drift, variation with environmental changes, vibration and shock during transportation, overloading, mishandling, misuse, and the capacity of any other laboratory to repeat the measurement.
* MaxLab Calibration Centre Limited shall not be liable for any loss or damage resulting from the use of the EUT.
* The copy of this Certificate is owned by MaxLab Calibration Centre Limited. No part of this Certificate may be reproduced without the prior written approval of MaxLab Calibration Centre Limited.

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MaxLab Calibration Centre Limited
香港新界葵涌華星街 16-18 號保盈工業大廈 9 樓 B2 室
Unit B2, 9/F., Boldwin Industrial Bldg., 16-18 Wah Sing Street, Kwai Chung, N.T., Hong Kong. Tel: (852) 2116 1380 Fax: (852) 2264 6480 Email: info@maxlab.com.hk

MAXLAB

Certificate NoMLCN131110S

Calibration Data

Channel / Mode	Filter / Detector	Range	EUT Reading	Standard Reading	EUT Error	Calibration Uncertainty
CH4 / Sound	A / FAST (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
			113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	C / FAST (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
			113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	LIN / FAST (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
			113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	A / SLOW (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	C / SLOW (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	LIN / SLOW (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	A / IMPULSE (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	C / IMPULSE (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	113.8 dB	114.0 dB	-0.2 dB	0.2 dB
	LIN / IMPULSE (1 kHz Input)	105 dB	93.7 dB	94.0 dB	-0.3 dB	0.2 dB
		130 dB	113.8 dB	114.0 dB	-0.2 dB	0.2 dB

- END -

Calibrated By : Dan
Date : 30-Aug-2013

Checked By : K.O. Lo
Date : 30-Aug-2013

萬儀校正中心有限公司
MaxLab Calibration Centre Limited
香港新界葵涌華星街 16-18 號保盈工業大廈 9 樓 B2 室
Unit B2, 9/F., Boldwin Industrial Bldg., 16-18 Wah Sing Street, Kwai Chung, N.T., Hong Kong. Tel: (852) 2116 1380 Fax: (852) 2264 6480 Email: info@maxlab.com.hk

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 41076

Description: ICP® Accelerometer

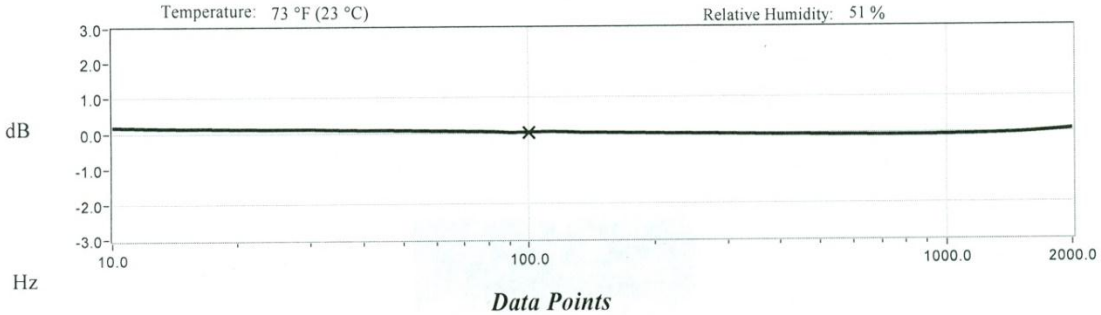
Manufacturer: PCB

Method: Back-to-Back Comparison AT401-3

Calibration Data

Sensitivity @ 100 Hz	**1011 mV/g**	Output Bias	11.4 VDC
	(103.1 mV/m/s²)	Transverse Sensitivity	2.7 %
Discharge Time Constant	1.4 seconds	Resonant Frequency	12.6 kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10	2.0	300	-0.6
15	1.6	500	-1.0
30	1.3	1000	-1.1
50	0.8	2000	0.6
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical
Acceleration Level (pk)[1]: 1.00 g (9.81 m/s²)
[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.008 x (freq)². [2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 683/283498 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Robert Zsebehazy RTZ Date: 5/28/2014

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CALIBRATION CERT #1862.02

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~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 41076

Description: ICP® Accelerometer

Manufacturer: PCB

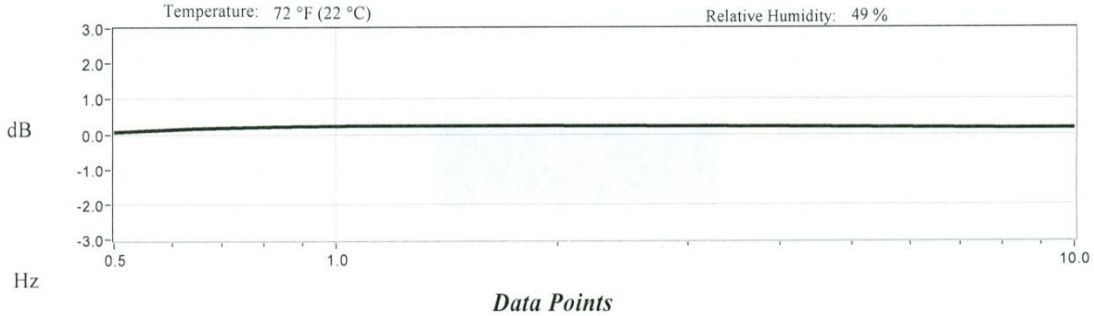
Method: Back-to-Back Comparison AT401-12

Calibration Data

Sensitivity @ 100 Hz **1011 mV/g**

(103.1 mV/m/s²)

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
0.5	0.7	7	2.0
0.7	2.0	10	1.8
1	2.6		
3	2.5		
5	2.2		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical
Acceleration Level (pk)[1]: 1.00 g (9.81 m/s²)
[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.207 x (freq)². [2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is traceable to one or more of the following; PTB 10065, PTB 10066 and NIST 683/283498.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Due to state of art limitations, the test uncertainty ratio is 3:1. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: Robert Zsebehazy RZ. Date: 5/28/2014

ACCREDITED
CALIBRATION CERT #1862.02

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CAL57-3484176158.372+0

ACS-4

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 41076

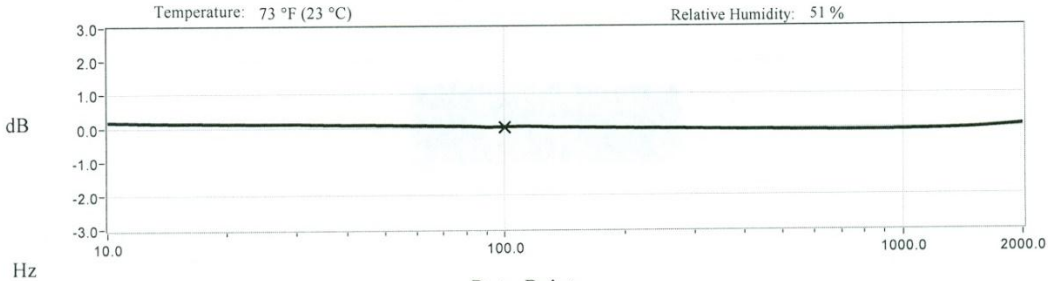
Description: ICP® Accelerometer

Manufacturer: PCB Method: Back-to-Back Comparison AT401-3

Calibration Data

Sensitivity @ 100 Hz	**1011 mV/g**	Output Bias	11.4 VDC
	(103.1 mV/m/s²)	Transverse Sensitivity	2.7 %
Discharge Time Constant	1.4 seconds	Resonant Frequency	12.6 kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10	2.0	300	-0.6
15	1.6	500	-1.0
30	1.3	1000	-1.1
50	0.8	2000	0.6
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical
Acceleration Level (pk)[1]: 1.00 g (9.81 m/s²)
[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.008 x (freq)². [2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 683/283498 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Robert Zsebehazy RZ Date: 5/28/2014

ACCREDITED
CALIBRATION CERT #1862.02

PCB PIEZOTRONICS
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

CAL57-3484165316.396+0

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 41074

Description: ICP® Accelerometer

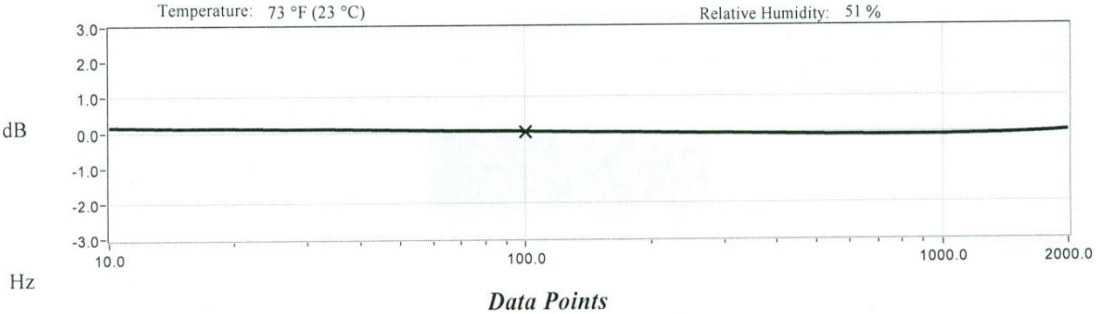
Manufacturer: PCB

Method: Back-to-Back Comparison AT401-3

Calibration Data

Sensitivity @ 100 Hz	**997 mV/g**	Output Bias	11.4 VDC
	(101.7 mV/m/s²)	Transverse Sensitivity	0.6 %
Discharge Time Constant	1.4 seconds	Resonant Frequency	14.0 kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10	1.7	300	-0.7
15	1.4	500	-1.1
30	1.1	1000	-1.2
50	0.8	2000	0.0
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical
Acceleration Level (pk)[1]: 1.00 g (9.81 m/s²)
[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.008 x (freq)². [2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 683/283498 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Robert Zsebehazy RZ. Date: 5/28/2014

ACCREDITED
CALIBRATION CERT #1862.02

PCB PIEZOTRONICS
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

CAL57-3484165058.001+0

ACS-1

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 41074

Description: ICP® Accelerometer

Manufacturer: PCB

Method: Back-to-Back Comparison AT401-12

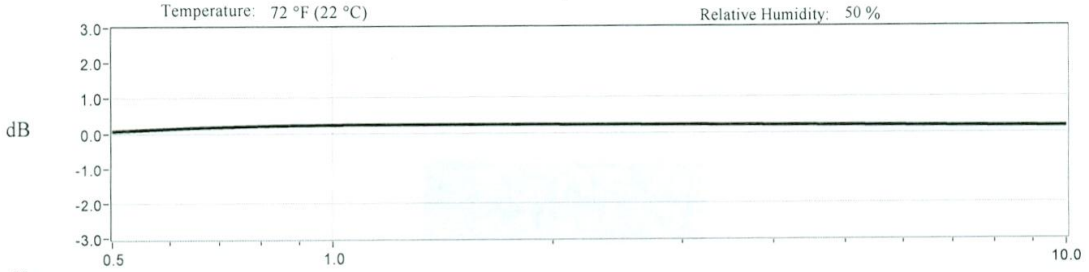
Calibration Data

Sensitivity @ 100 Hz **997 mV/g**

(101.7 mV/m/s²)

Sensitivity Plot

Temperature: 72 °F (22 °C) Relative Humidity: 50 %



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
0.5	0.7	7	2.0
0.7	2.0	10	1.8
1	2.6		
3	2.6		
5	2.3		

Mounting Surface: Stainless Steel w/Silicone Grease Fastener: 1/4-28 Female Fixture Orientation: Vertical
Acceleration Level (pk)[1]: 1.00 g (9.81 m/s²)
[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.207 x (freq)². [2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is traceable to one or more of the following; PTB 10065, PTB 10066 and NIST 683/283498.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Due to state of art limitations, the test uncertainty ratio is 3:1. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: Robert Zsebehazy RZ Date: 5/28/2014

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CALIBRATION CERT #1862.02

PCB PIEZOTRONICS
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

CAL57-3484175623.349+0

ACS-4

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 41074

Description: ICP® Accelerometer

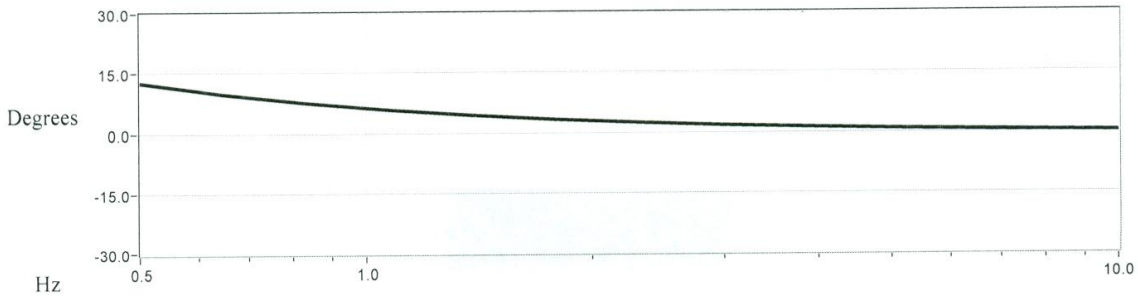
Manufacturer: PCB

Method: Back-to-Back Comparison AT401-12

Calibration Data

Sensitivity @ 100 Hz **997 mV/g** **(101.7 mV/m/s²)**

Phase Plot



Data Points

Frequency (Hz)	Phase (°)
0.5	12.5
0.7	9.0
1	6.2
3	1.6
5	0.7
7	0.3
10	-0.0

Notes

1. Calibration is traceable to one or more of the following; PTB 10065, PTB 10066 and NIST 683/283498.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI Z540.3 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.

Technician: Robert Zsebehazy R.Z. Date: 5/28/2014

PCB PIEZOTRONICS
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

~ Calibration Certificate ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 36982

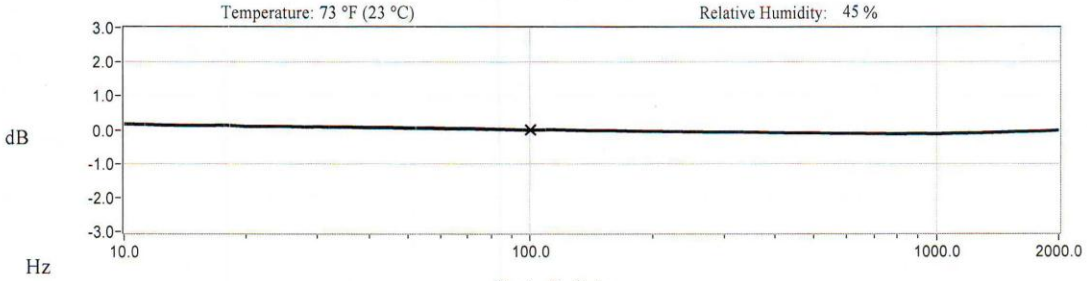
Description: ICP® Accelerometer Method: Back-to-Back Comparison (AT401-3)

Manufacturer: PCB

Calibration Data

Sensitivity @ 100.0 Hz	**1008**	**mV/g**	Output Bias	11.0	VDC
	(102.7	**mV/m/s²)**	Transverse Sensitivity	2.7	%
Discharge Time Constant	1.0	seconds	Resonant Frequency	14.3	kHz

Sensitivity Plot



Data Points

Frequency (Hz)	Dev. (%)	Frequency (Hz)	Dev. (%)
10.0	2.0	300.0	-0.8
15.0	1.5	500.0	-1.2
30.0	1.1	1000.0	-1.5
50.0	0.7	2000.0	-0.4
REF. FREQ.	0.0		

Mounting Surface: Stainless Steel w/Silicone Grease Coating Fastener: Stud Mount Fixture Orientation: Vertical

Acceleration Level (rms)[1]: 1.00 g (9.81 m/s²)[2]

[1]The acceleration level may be limited by shaker displacement at low frequencies. If the listed level cannot be obtained, the calibration system uses the following formula to set the vibration amplitude; Acceleration Level (g) = 0.010 x (freq)².

[2]The gravitational constant used for calculations by the calibration system is; 1 g = 9.80665 m/s².

Condition of Unit

As Found: n/a

As Left: New Unit, In Tolerance

Notes

1. Calibration is NIST Traceable thru Project 681/280472 and PTB Traceable thru Project 10065.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 5-9 Hz; +/- 2.0%, 10-99 Hz; +/- 1.5%, 100-1999 Hz; +/- 1.0%, 2-10 kHz; +/- 2.5%.

Technician: Scott Skibniewski Date: 11/23/13

ACCREDITED
CALIBRATION CERT #1862.02

PCB PIEZOTRONICS INC.
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

cal57 - 3441803071.01

~ Calibration Certificate - Phase ~

Per ISO 16063-21

Model Number: 393A03

Serial Number: 36982

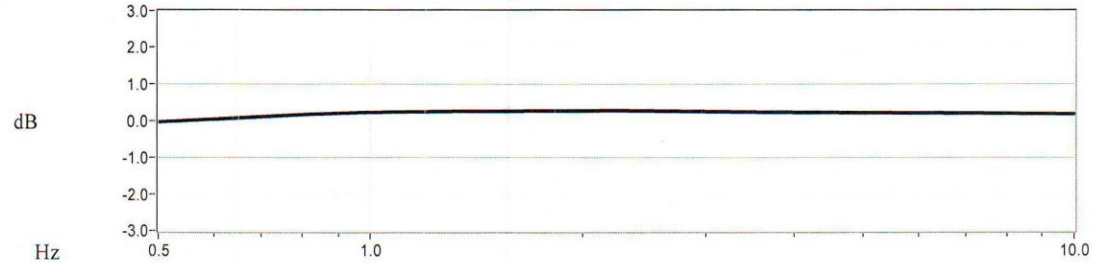
Description: ICP® Accelerometer Method: Back-to-Back Comparison (AT401-12)

Manufacturer: PCB

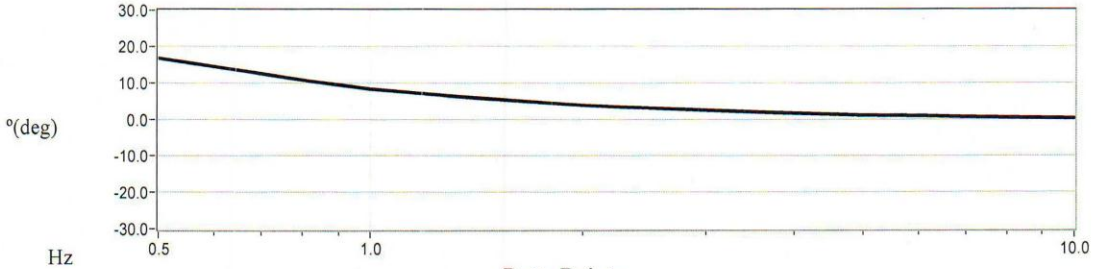
Calibration Data

Sensitivity @ 100.0 Hz **1008 mV/g** **(102.7 mV/m/s²)**

Magnitude Plot



Phase Plot



Data Points

Frequency (Hz)	Deviation (%)	Phase (°)
0.5	-0.4	16.8
1.0	2.6	8.4
2.0	3.1	3.9
5.0	2.5	1.2
7.0	2.3	0.8
10.0	2.0	0.4

Notes

1. Calibration is traceable to one or more of the following; PTB 10065, PTB 10066 and NIST 681/280472.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for frequency ranges tested during calibration are as follows: 0.5-0.99 Hz; +/- 1.8%, 1-30 Hz; +/- 1.0%, 30.01-199 Hz; +/- 1.5%, 200-1 kHz; +/- 3.0%.

Technician: Scott Skibniewski Date: 11/23/13

PCB PIEZOTRONICS INC
VIBRATION DIVISION
Headquarters: 3425 Walden Avenue, Depew, NY 14043
Calibration Performed at: 10869 Highway 903, Halifax, NC 27839
TEL: 888-684-0013 · FAX: 716-685-3886 · www.pcb.com

cal57 - 3441803071.01

~ *Calibration Certificate* ~

Model Number: 699A02

Serial Number: 989

Description: Portable Handheld Shaker

Manufacturer: IMI
ICS-12

Customer:

P.O. : 114542

Method : Back-to-Back Comparison (AT701-1)

Calibration Data

Operating Frequency:	160.6	Hz.	Test Point Voltage:	100.4	mVAC
Acceleration Level:	1.00	g's rms			
	9.826	m/s^2			
Temperature:	69	°F (21 °C)	Relative Humidity:	49	%

Condition of Unit

As Found: Normal Operation Condition

As Left:

Notes

1. Calibration is N.I.S.T. Traceable thru Project 822/267400 and PTB Traceable thru Project 1055.
2. This certificate shall not be reproduced, except in full, without written approval from PCB Piezotronics, Inc.
3. Calibration is performed in compliance with ISO 9001, ISO 10012-1, ANSI/NCSL Z540-1-1994 and ISO 17025.
4. See Manufacturer's Specification Sheet for a detailed listing of performance specifications.
5. Measurement uncertainty (95% confidence level with coverage factor of 2) for reference frequency is +/-1.6%.

Equipment Used For Calibration

Manufacturer	Description	Model#	Serial No.	Cal Date	Due Date
National Instruments	Acquistion Brd	PCI-6052E	1125572	2/5/2013	2/5/2014
PCB Piezotronics	Accelerometer	Y353B34	93740	4/16/2013	4/16/2014
PCB Piezotronics	Power Supply	480C02	CA360	2/2/2013	2/2/2014

Technician: *Luke Rogers* L. R.

Date: 12/21/13

Due Date:

ACCREDITED
CALIBRATION CERT #1862.01

IMI SENSORS
A PCB PIEZOTRONICS DIV.
3425 Walden Avenue
Depew, New York 14043
TEL: 888-684-0003 FAX: 716-684-3823
www.imi-sensors.com

PCB PIEZOTRONICS INC.

CERTIFICATION OF CONFORMANCE

Title Page of Calibration Certificate Documentation

CUSTOMER:

Wilson Acoustics LTD
Room 601,Block A, Shatin Industrial Centre
Yuen Shun Circuit
Shatin NT HONG KONG

PURCHASE ORDER #: 1

PCB ORDER #: 114542

QTY	!TEM	DESCRIPTION
1	699A02	S/N 989

NOTES:

1. This document certifies that the subject item(s) has been manufactured, repaired (if applicable), tested, or inspected in accordance with referenced purchase order and conform(s) to applicable specifications per PCB Quality Policy Manual Rev. E 10/21/2008.
2. Equipment used in validation is traceable to NIST and appropriate records are on file.
3. Calibrations comply with ISO 17025 and ANSI/NCSL Z540-1-1994 except as noted on associated calibration certificate(s).
4. Calibrations are performed using processes having a test uncertainty ratio (TUR) of four or more times greater than the unit calibrated, unless otherwise noted on the calibration certificate. Calibration at 4:1 TUR provides reasonable confidence that the instrument is within product specifications.

Approved by _____ **Date:** 12/21/13

- ISO 9001 Certified / ISO 17025 Accredited -
PCB Piezotronics, Inc.
3425 Walden Avenue Depew, New York 14043-2495
Phone: 716-684-0001 Fax: 716-684-0987

CERTIFICATE OF CALIBRATION
FORCE VERIFICATION OF LOAD CELL

Certificate No. : CM21578 Date of Issue : 27 Aug 2014

STANGERS

HOKLAS 021 TEST CAL

INFORMATION PROVIDED BY CUSTOMER

Customer : Wilson Acoustics Limited
Customer Address : Unit 601, Block A, Shatin Industrial Centre, Yuen Shun Circuit, Shatin. NT.

Customer Ref. No. : N.A.

Load Cell & Display Details

		Load Cell	Display*
Max. Capacity	:	220kN	N.A.
Resolution	:	N.A.	0.01kN (upto 99.99kN) & 0.1kN (upto 220kN)
Manufacturer	:	Futek	Pico Technology
Model No.	:	LCM550	PicoScope 2203
Serial No.	:	520583	VDR63/364
Equipment No.	:	N.A.	N.A.

INFORMATION PROVIDED BY THE LABORATORY

Date of Calibration : 26 Aug 2014
Mode of Calibration : Compression
Location of Calibration : Calibration Lab. Of Stanger Asia Limited
Calibrated By : M.K. Leung & Y.W. Ho

RESULTS

In accordance with in house procedure CAL1006

Applied Force (kN)	Mean Indicated Force (kN)	Error (%)	Repeatability (%)	Uncertainty (± %)	Coverage Factor
20	20.72	3.60	0.60	1.00	1.96
40	40.10	0.24	0.55	0.40	1.96
60	59.52	-0.80	0.03	0.40	1.96
80	82.83	3.54	0.05	0.40	1.96
100	102.20	2.20	0.00	0.40	1.96
120	121.60	1.33	0.00	0.40	1.96
140	141.03	0.74	0.07	0.64	1.96
160	160.40	0.25	0.00	0.64	1.96
180	179.80	-0.11	0.11	0.64	1.96
200	199.23	-0.38	0.05	0.63	1.96
220	222.50	1.14	0.00	0.64	1.96

The quoted expanded uncertainties are for a level of confidence of 95%.

Remarks

1) Reference load device used for range 20kN to 220kN:- 700kN load cell, serial no.33862 & 1000029732
2) Temperature range during the verification : 20.6 to 20.8 °C
3) Maximum zero force error : 0.0%.
4) Results are traceable to the International System of Units (S.I.) or recognised measurement standards.
5) *Loadcell was connected to a Futek amplifer module; model no. CSG 110; serial no. 267397 and the signal was outputted through the PicoScope and displayed on the provided laptop computer.

Certified by,

Pang Ying Yam
Approved Signatory
On Behalf of Stanger Asia Limited

---- End of Report ----

Laboratory Address : Room 308-309, 705-706, Fuk Shing Commercial Building, 28 On Lok Mun Street, On Lok Tsuen, Fanling, New Territories, HONG KONG. / DD83 Lot 549, 553, 556 Sha Tau Kok Road, Ko Po Village Fanling, New Territories.
Correspondence Address : Room 705-706, 7/F., Fuk Shing Commercial Building, 28 On Lok Mun Street, On Lok Tsuen, Fanling, New Territories, HONG KONG. Tel: 852-2682 1203 Fax: 852-2682 0046