

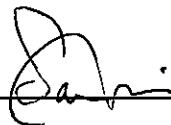
MTR Corporation Limited

South Island Line (East)

Operational Ground-borne Noise
Performance Test Report

March 2016

Verified by:



Sam Tsoi

Independent Environmental Checker

Date:

11 April 2016


MTR Corporation Limited

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Operational Ground-borne Noise
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**SOUTH ISLAND LINE (EAST) CONTRACT 913
OPERATIONAL GROUND-BORNE NOISE PERFORMANCE TEST REPORT**

Report No.: 14328-16

For

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SOUTH ISLAND LINE (EAST) CONTRACT 913 OPERATIONAL GROUND-BORNE NOISE PERFORMANCE TEST REPORT

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1. Introduction

The South Island Line (East) (SIL(E)) comprises a new medium-capacity railway system with an approximate total route length of 7km from Admiralty (ADM) to South Horizons (SOH), via three intermediate stations at Ocean Park (OCP), Wong Chuk Hang (WCH) and Lei Tung (LET). The SIL(E) Environmental Impact Assessment (EIA) report (Register No.: AEIAR-155/2010) was approved on 26 October 2010.

According to the Condition 2.30 of Environmental Permit (EP) EP-407/2010/E “*At least one month before commencement of operation of the Project, the Permit Holder shall carry out noise performance test and deposit with the Director four hard copies and one electronic copy of a Noise Performance Test Report to confirm the compliance of the operational air-borne and ground-noise levels in accordance with the approved EIA Report. Before submission to the Director, the Noise Performance Test Report shall be certified by the ET Leader and verified by the IEC as conforming to the information and recommendations contained in the approved EIA Report. Any necessary measure(s) as recommended in the Noise Performance Test Report shall be fully and properly implemented.*”

Wilson Acoustics Limited (WAL) is commissioned by Alstom Hong Kong Limited to conduct operational ground-borne noise (GBN) performance test for the commissioning of SIL(E) for MTR Corporation Ltd. (MTRCL).

The GBN measurement details have been proposed in the *South Island Line Contract 913 Operational Ground-borne Noise Performance Test Proposal (Test Proposal, Appendix E)* for discussion with EPD prior to the test.

This noise performance test was conducted on 16 and 17 Oct 2015, according to the Test Proposal.

This report presents the SIL(E) operational GBN performance test result accordingly.



2. Operational GBN Performance Test Locations

In the operational GBN performance test, two GBN sensitive receivers (GBNSRs) were selected as representatives for measurement, which are Yue On Court - Shan On House (Block F) (YOC4) and South Horizons Block 23A, Mei Ka Court (SOH6). The two GBNSRs cover the potentially worst affected locations in different geologies.

The principle of the representative GBNSRs selection is that for adjacent GBNSRs with similar ground condition, the worst affected GBNSR would be selected where possible. The factors affecting consideration are the geology situations, EIA assessment results, accessibility of GBNSRs, and etc. The details of GBNSR selection were described in the Test Proposal (**Appendix E**).

To obtain the worst case GBN level induced by train passby for each GBNSR, the GBN measurements were conducted at the suitable and accessible lowest floors of GBNSRs. Both measurement points are lower than the lowest noise sensitive uses in the building and the indoor environments are similar with the noise sensitive uses.

Geological conditions and photos for the measurements at GBNSRs are shown in **Appendix A**. The information of GBNSRs and measurement points are summarized in **Table 2.1**.

Table 2.1 Information of Operational GBN Measurement Points

NSR ID	NSR name	Land use	Geology	Distance from pile to track ⁽¹⁾ (m)	Lowest affect floor	Measurement point	Slant distance from measurement point to nearest track (m)
YOC4	Yue On Court - Shan On House (Block F)	Residential	Rock	12.2	1/F	G/F Storage Room ⁽²⁾	29.6
SOH6	South Horizons Block 23A, Mei Ka Court	Residential	Mixed	8	1/F	G/F Lobby	18

Remark

- (1) Shortest distance between nearside track and foundation/bottom of pile, based on EIA.
- (2) The exact measurement point at YOC4 was around 0.5m away from the proposed point to allow night shift workers to return the tools and access the lavatory at midnight.



3. Operational GBN Criteria for the GBNSRs

With reference to the *Technical Memorandum for Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites (IND-TM)*, the criteria for noise transmitted primarily through the structural elements of the building should be 10dB(A) less than the relevant ANL.

The operational ground-borne noise criteria for the representative GBNSRs (YOC4 and SOH6) along SIL(E) alignment are tabulated in **Table 3.1** below (refer to **Table 3.5** and **Table 3.7** in the approved SIL(E) EIA report).

Table 3.1 Operational GBN Criteria for Representative GBNSRs (YOC4 and SOH6)

GBNSR	GBN Criteria, $L_{eq,30mins}$, dB(A)	
	Day & Evening (0700 to 2300 hrs)	Night (2300 to 0700 hrs)
YOC4 and SOH6	55	45

4. Testing Arrangement

4.1 Date and Timeline

The performance test was conducted on 16 and 17 Oct 2015, from 2315 to 0030 hrs. The timeline of the test activities are shown in **Table 4.1**.

Table 4.1 Measurement Timeline and Activities

Date	Time	Activity
16/10/2015	2130 to 2150 hrs	Setup at YOC4
16/10/2015	2210 to 2230 hrs	Setup at SOH6
16 and 17/10/2015	2315 to 0030 hrs	Conduct operational GBN performance test

The background noise level for 10minutes (2225 to 2235 hrs) prior to the test at YOC4 was 51dB(A) and that at SOH6 (2238 to 2248 hrs) was 65dB(A). These showed the background noise levels at both GBNSRs were above the operational GBN criterion of 45dB(A) in nighttime.

According to Section 6 of the Test Proposal, *“If the background noise level already exceed the statutory requirement, a maximum of -3dB(A) background correction would be allowed to avoid over correction and for conservative results. In case the corrected measured noise (BG-3dB(A)) still exceeds statutory requirement, a portable noise enclosure box will be employed to insulate extraneous background noise and measure the train induced GBN.”*

Therefore, a single layer noise enclosure and a double layer noise enclosure were employed to insulate extraneous background noise for YOC4 and SOH6, respectively. Two microphones were set at outside and inside the noise enclosures respectively, as shown in **Appendix A2** and **A3**.

4.2 Personnel

The setting up of equipment at each measurement point was conducted by WAL and witnessed by MTRCL.

4.3 Train Arrangement

Two three-car S-Stock trains were employed in the test. During the test, the trains were running in Fully Automatic Operation (FAO) mode, operated at the normal operation speed and running between South Horizons Station (SOH) and Wong Chuk Hang Station (WCH), via Lei Tung Station (LET).

For WCH Station, trains departed from WCH to SOH direction on Up track (UP) and arrived at WCH from SOH on Down track (DN).

For SOH Station, it was designed that trains would approach and depart on both DN and UP. In the test, both DN and UP of SOH were tested.

4.4 Train Passby Identification

Both GBNSRs are adjacent to the roads. The YOC4 is 42m from a transportation junction, 20m from Lei Tung Estate Road and only 12m from Yue On Court Road; SOH6 is 13.5m from Yi Nam Road and 45m from a bus terminus. Due to the heavy traffic around YOC4 and SOH6, vibration levels were significantly affected by vehicle passbys and other intrusive interferences.

The fluctuation of background noise and vibration increased the difficulty to identify the train passbys. In order to accurately identify train passbys, the time of all employed devices, including analyzers, watches and mobile phones were synchronized and instant messaging tool was employed for measurement team to communicate and record the time at both GBNSRs. After the measurements, MTRCL's signaling logsheet was cross-checked with the vibration levels to assure there was no misidentification of train passbys.

It was found that the train passby induced vibrations were relatively distinct at 125Hz of YOC4 and 63Hz at SOH6. As such, the 125Hz and 63Hz were represented to identify the train passbys for YOC4 and SOH6, respectively. Each passby was recognized as shown in **Appendix B**.

4.5 Measurement Instrument and Setup

A total of two sets of measurement equipment were deployed during test. All sound level meters comply with the International Electrotechnical Commission Publications 651:1979 (Type 1) and 804:1985 (Type 1) specifications. Vibration sensors were placed on floor to determine the train passby.

The instrument information and the calibration expiry dates are tabulated in **Table D1** of **Appendix D**.

According to the IND-TM, "*Immediately prior to and following each noise measurement the accuracy of sound level meter shall be checked using an acoustic calibrator generating a known sound pressure level at a known frequency. Measurements may be accepted as valid only if the calibration levels from before and after the noise measurement agree to within 1.0dB.*"

Following the procedure described above, the calibration levels from before and after the measurements at both GBNSRs were within 0.1dB and indicated the measurements at both GBNSRs were valid.

4.6 Measurement Parameters

Train passby noise and vibration were logged at 1 second interval including L_{eq} and L_{max} . Background adjusted $L_{eq,30mins}$ in the full audible frequency range (20 to 20,000Hz) was used to compare with GBN criteria.

Detailed data analysis process is described in **Section 5**.

5. Assessment Procedures

The calculation of the Noise Levels ($L_{eq,30min}$) for comparing with the operational GBN criteria follows Section 6 of the Test Proposal, and is presented below.

5.1 Background Noise Level

It was proposed to use the noise level over 60 seconds averaging from the measurement data of 30 seconds ahead of each passby for determining the background noise level.

As a conservative approach, for those consecutive measurements with the time period when there was no train noise less than 60s, the background noise level will be determined by the measured L_{eq} noise level over at least 60s either 30s ahead of the 1st measurement (which is the background noise level of the 1st measurement) or 30s after the 2nd measurement, whichever is lower.

For example, the interval between the end of S1(23:16:34) and the beginning of S2(23:17:48) was 73 seconds (refer to **Appendix B3**), which means the latter method for background noise level determination should be applied. The background noise level of S1 was 32.3dB(A); and the measured L_{eq} noise level over 60s from 30s after the end of S2 was 32.2dB(A). Therefore, 32.2dB(A) would be adopted as the background noise level for S2.

The latter method mentioned above was employed for background calculation of 15 passbys, which were Y5, Y7, Y9, Y11, Y15, Y19, S2, S4, S6, S8, S10 S14, S16, S18 and S20 respectively.

5.2 Train Passby Noise

Based on the recorded vibration level, the train passby data were extracted accordingly. The train passby sound exposure level is determined by applying background correction for entire audible frequency ranging from 20 to 20,000Hz. Background corrected noise level $L_{eq,passby}$ is determined by

$$L_{eq,passby} = 10 \times \log(10^{L_{eq,during\ passby}/10} - 10^{L_{eq,background}/10})$$

Where $L_{eq,during\ passby}$ is the noise level during train passby

$L_{eq,background}$ is the background noise level

$L_{eq,passby}$ is the background corrected noise level

The duration of train passby is taken according to the actual vibration signal, including the head-tail period.

The noises induced by train passbys at both GBNSRs were barely noticeable and mostly lower than the noises induced by vehicle passbys, ventilation fans and other ambient noises. The corresponding $L_{eq,background}$ was sometimes higher than $L_{eq,during\ passby}$, under such circumstances, a maximum of -3dB background correction would be applied.

The Sound Exposure Level arising from Down track and Up track train operation in 30 minutes was determined by



$$SEL_{DN} = L_{eq,passby,DN} + 10 \times \log(T_{DN}) + 10 \times \log(N_{DN})$$
$$SEL_{UP} = L_{eq,passby,UP} + 10 \times \log(T_{UP}) + 10 \times \log(N_{UP})$$

Where, T is the train passby duration and N is number of passby in 30 minutes, which is 15 passbys during day and evening time, and 8 passbys during nighttime in 30 minutes in each direction. Subscript DN denotes Down track and UP denotes Up track.

$L_{eq,30min}$ was determined by the formula below.

$$L_{eq,30min} = 10 \times \log(10^{SEL_{DN}/10} + 10^{SEL_{UP}/10}) - 10 \times \log(1800)$$



6. Assessment Results

The assessment results are summarized in **Table 6.1**. The time history of train passbys at each GBNSR is shown in **Appendix B**. The history of the most representative vibration frequency is shown for train passby recognition.

Total 21 passbys were recorded for each GBNSR. For SOH6, the 21 passbys were labelled as S1(D) to S21(NX), wherein, the D in the bracket indicates DN, U indicates UP, X indicates the trains passed through the crossover. In the same way, the 21 passbys for YOC4 were labelled as Y1(D) to Y21(U).

Detailed calculations are shown in **Table C1 to C7** of **Appendix C**.

Table 6.1 Train Operational GBN Assessment Result

NSR ID	NSR name	Land use	Predicted $L_{eq, 30min}$ dB(A) Day and evening time / Nighttime	Assessed $L_{eq, 30min}$ dB(A) Day and evening time / Nighttime	GBN criteria Day and evening time / Nighttime $L_{eq, 30min}$ dB(A)
YOC4	Yue On Court - Shan On House (Block F)	Residential	42 / 39 ⁽¹⁾	32 / 30	55 / 45
SOH6	South Horizons Block 23A, Mei Ka Court	Residential	27 / 25 ⁽²⁾	29 / 26	55 / 45

Remarks:

- (1) Reference to Table 3.64 of the SIL(E) EIA
- (2) Reference to Table 6.2 of the Operational Ground-borne Noise Review Plan submitted to EPD under SIL(E) EP-407/2010/D Condition 2.25 in July 2014

The assessed $L_{eq, 30mins}$ presented above are 32/30dB(A) (day and evening time/nighttime) for YOC4 and 29/26dB(A) for SOH6. The results show that the operational groundborne noise levels comply with GBN criteria.



7. Conclusion

Operational ground-borne noise performance test for the operation of SIL(E) were conducted at two selected represented GBNSRs on 16 and 17 Oct 2015.

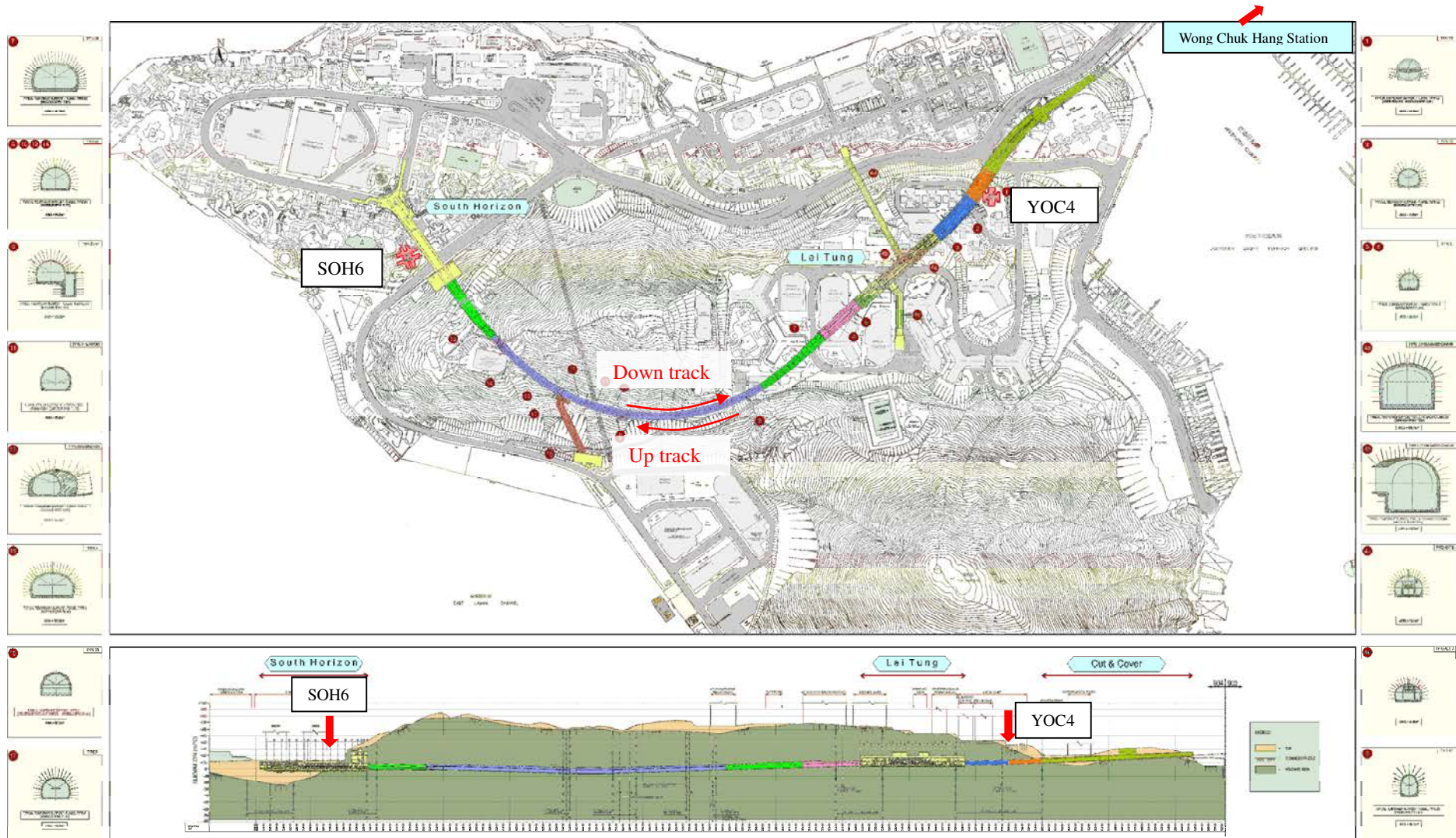
Following the conservative assessment procedures, the operational GBN at the two representative GBNSRs complied with the operational GBN criteria in the approved EIA Report.



Appendix A. Measurement Locations and Setup Photos

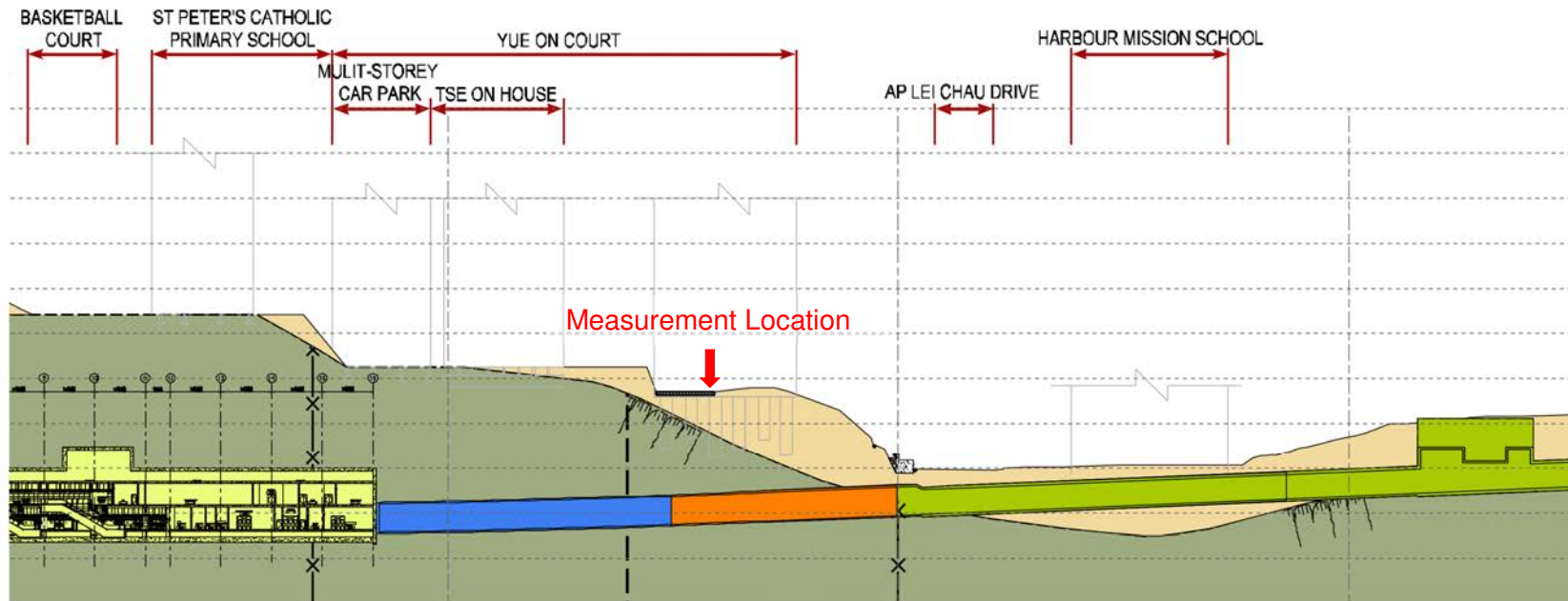


Appendix A1. Overview of Measurement Locations

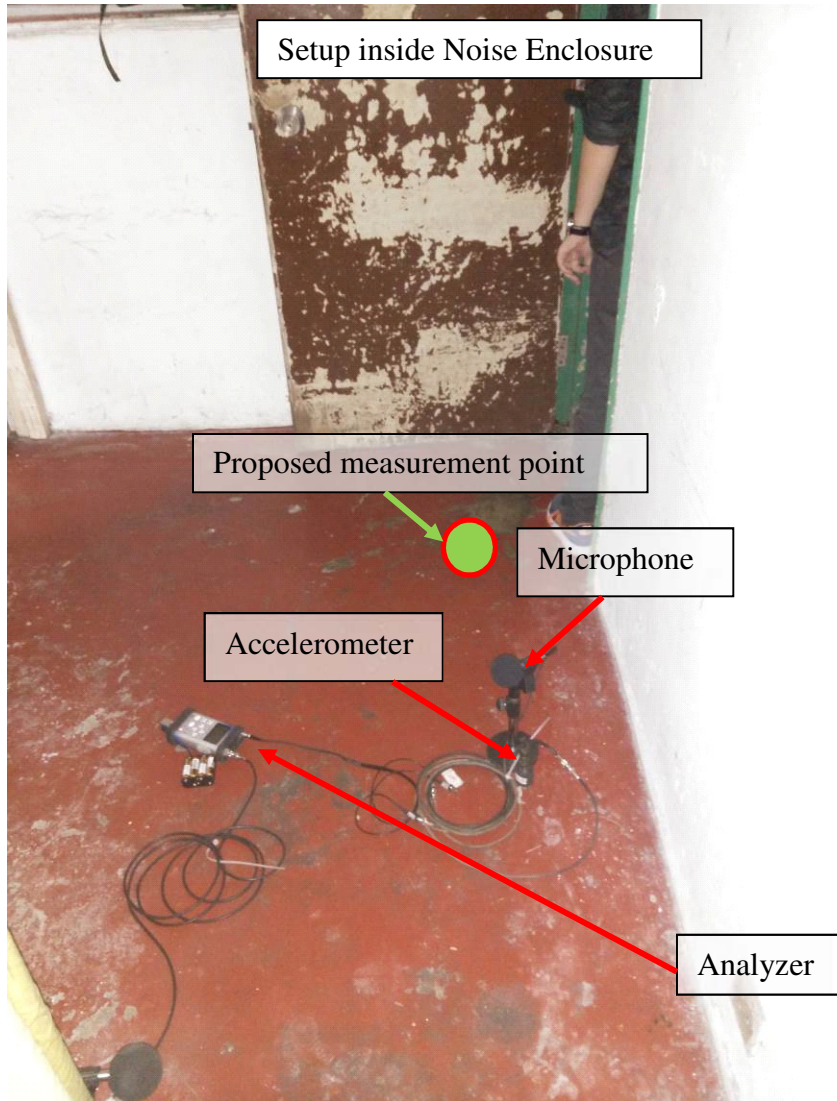




Appendix A2. Measurement Pictures of YOC4 - G/F Storage Room, Shan On House (Block F), Yue On Court



(a)

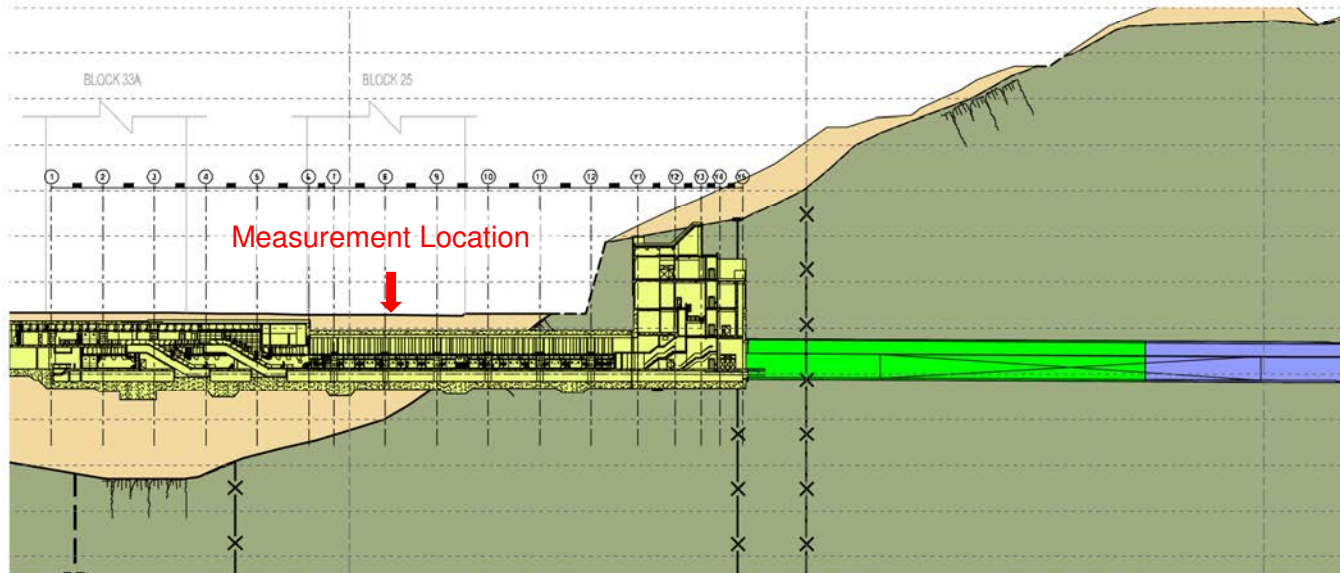
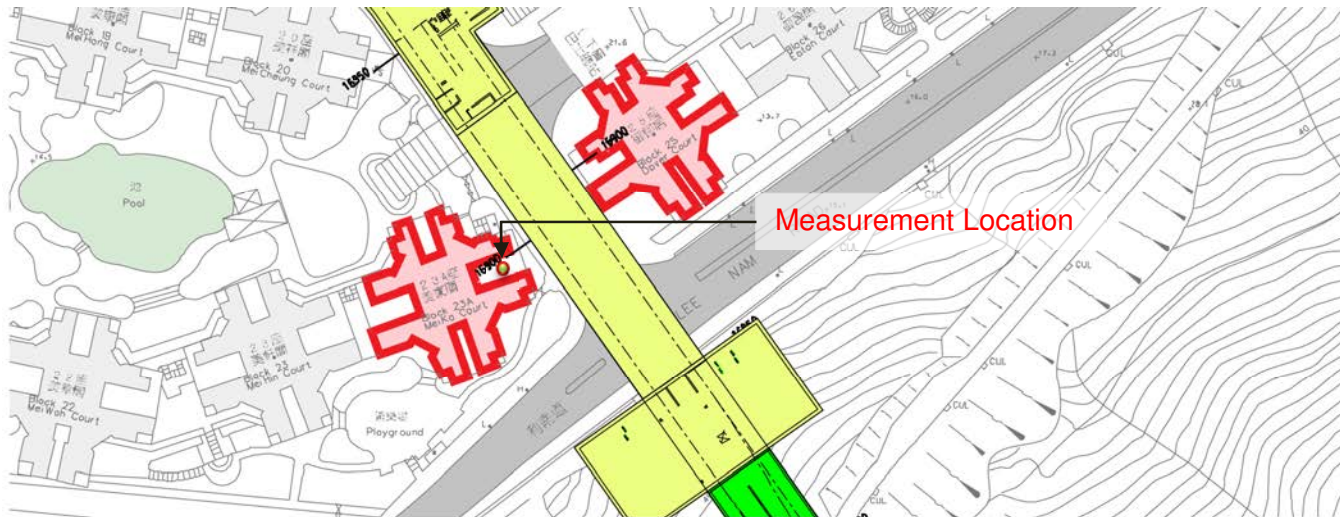


(b)

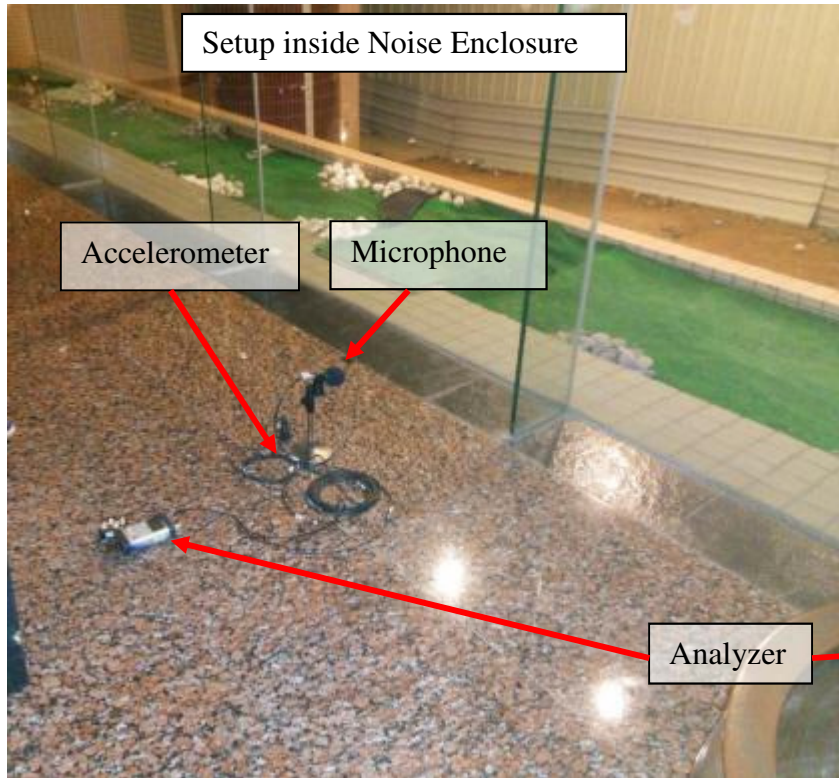


(c)

Appendix A3. Measurement Picture of SOH6 - G/F Lobby, South Horizons Block 23A, Mei Ka Court



(a)



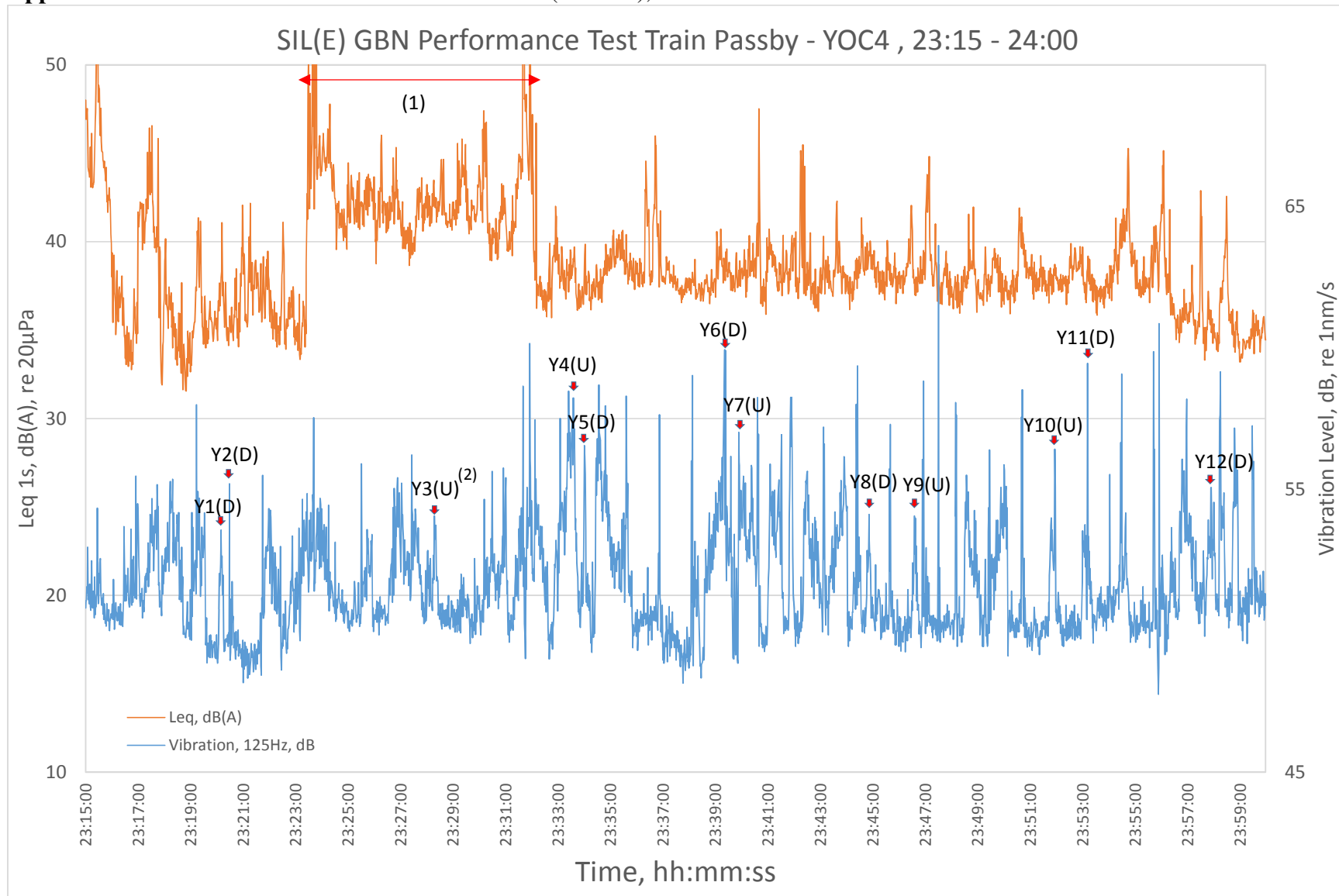
(b)



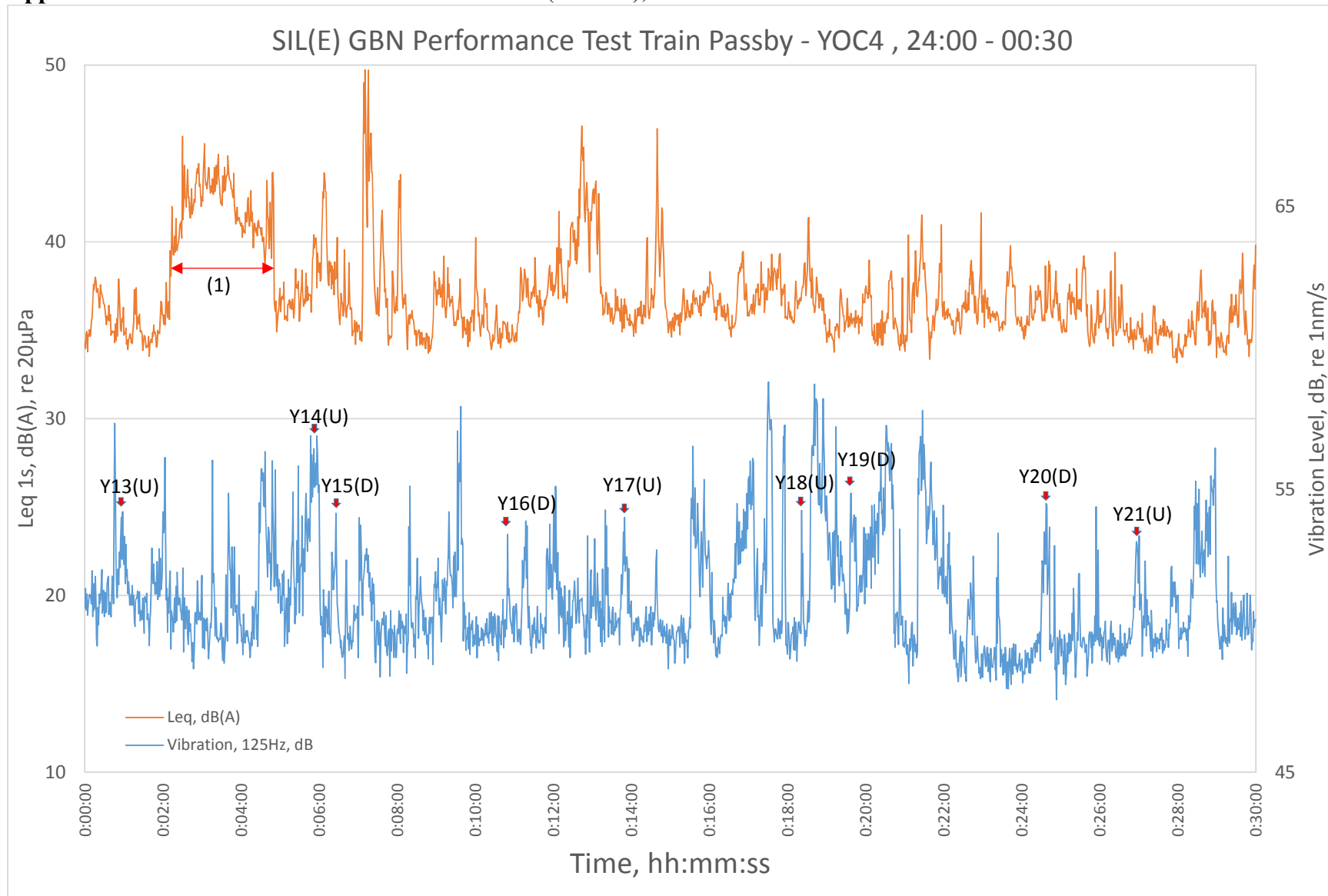
(c)



Appendix B. Time History of Train Passbys at NSRs

**Appendix B1. YOC4 - Yue On Court-Shan On House (Block F), 23:15-24:00**

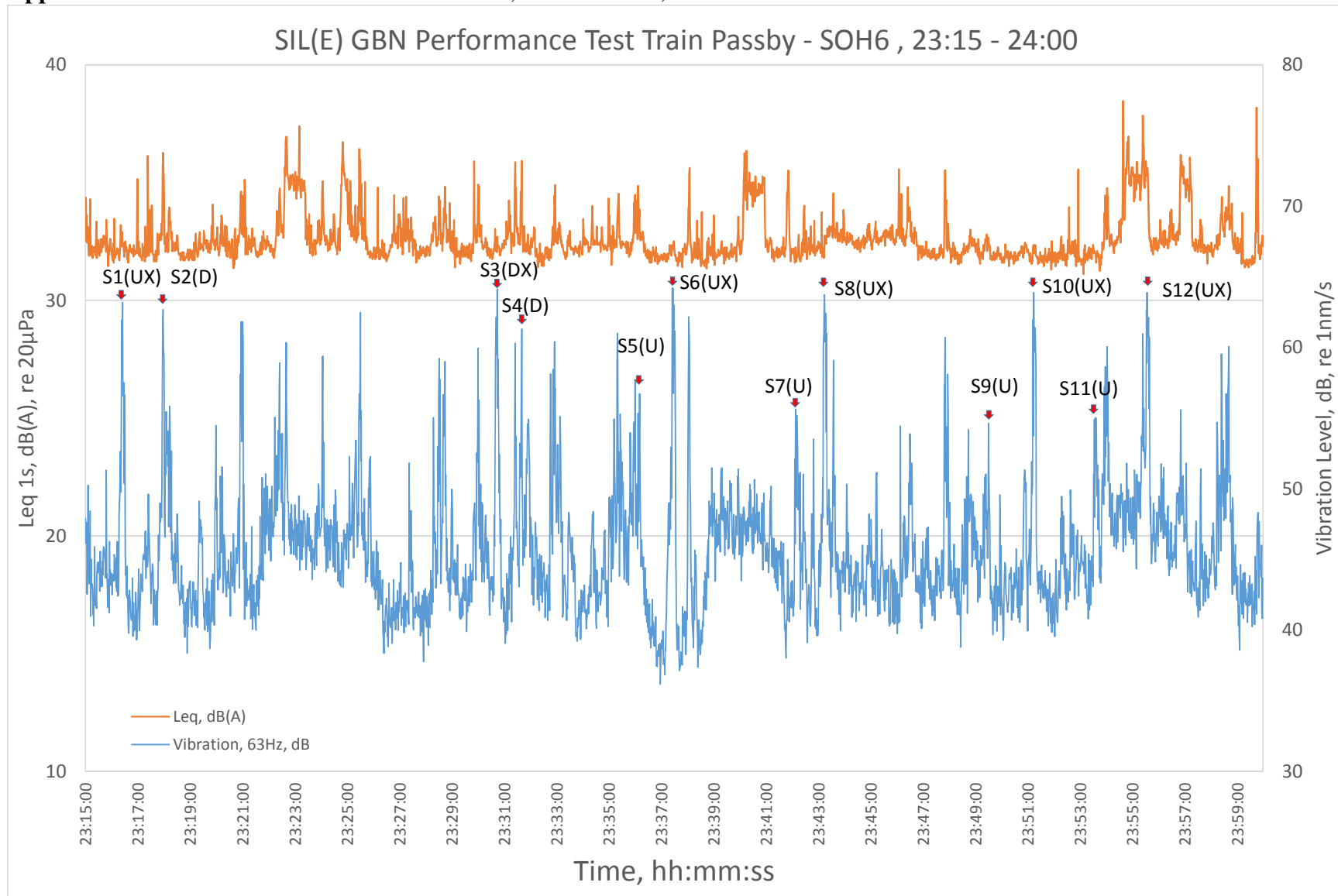
Remark: (1) Affected by workers returned tools to storage room and use of lavatory next to the measurement point.
(2) Y3(U) was affected by extraneous noise, results of this measurement will not be included in the calculation.

**Appendix B2. YOC4 - Yue On Court-Shan On House (Block F), 24:00-00:30**

Remark: (1) Affected by workers returned tools to storage room and use of lavatory next to the measurement point.

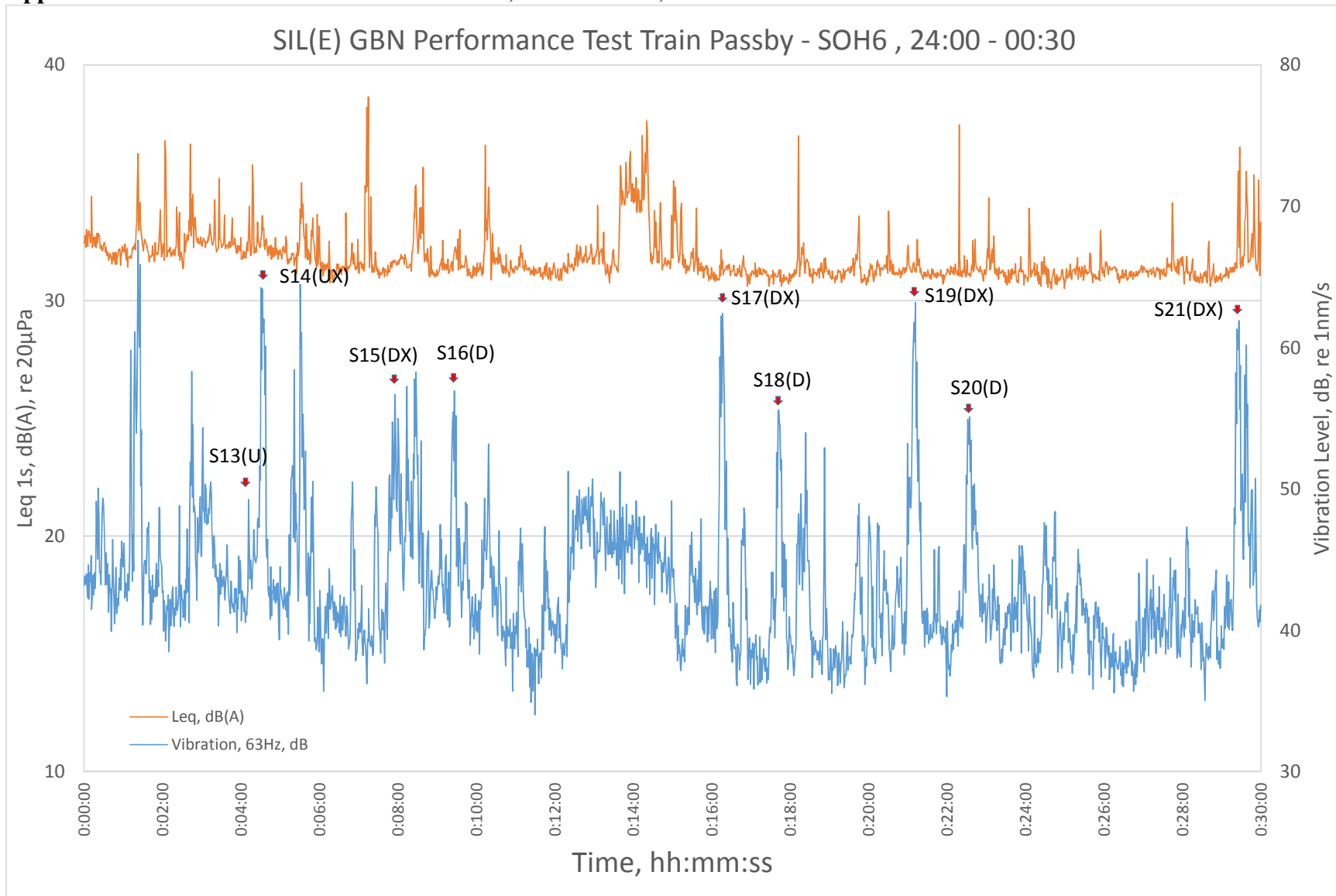


Appendix B3. SOH6 - South Horizons Block 23A, Mei Ka Court, 23:15-24:00





Appendix B4. SOH6 - South Horizons Block 23A, Mei Ka Court, 24:00-00:30





Appendix C. GBN Assessment Calculation and Background Noise Level



Table C1 Calculation of Background Corrected Train Passby Noise Level, $L_{eq,passby}$

	Passby	(1) D/U*		(2) D/D		(3) U/D		(4) U/D		(5) D/U		(6) D/U		(7) U/U		(8) D/U		(9) U/U		(10) U/U					
	NSR	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg		
Recorded Train Passby Noise Level & Background Noise Level, dB(A)	YOC4	37.7	36.6	37.7	37.2	- ⁽⁴⁾	- ⁽⁴⁾	37.7	39.6	37.4	39.2	38.2	37.5	38.8	37.5	39.1	38.3	38.8	37.8	37.9	38.7				
	SOH6	32.3	32.3	33.2	32.2	32.3	32.5	32.3	32.5	33.0	32.5	32.0	32.1	32.0	33.3	32.5	32.1	32.2	32.3	31.9	32.0				
	Passby	(11) D/U	(12) D/U		(13) U/U		(14) U/U		(15) D/D		(16) D/D		(17) U/D		(18) U/D		(19) D/D		(20) D/D		(21) U/D				
	NSR	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg	Leq	Lbkg		
	YOC4	37.9	38.7	35.4	36.3	35.3	35.3	38.4	40.1	38.0	40.1	37.4	35.6	35.8	41.4	37.2	37.3	35.5	33.0	36.9	36.5	34.7	36.3		
	SOH6	31.9	32.1	34.5	34.0	32.3	32.9	32.6	32.2	31.6	32.4	31.9	32.0	31.4	32.2	31.0	31.2	31.5	31.4	31.5	31.2	32.5	31.4		
Background Corrected Train Passby Noise Level, dB(A)	Passby	(1) D/U	(2) D/D		(3) U/D		(4) U/D		(5) D/U		(6) D/U		(7) U/U		(8) D/U		(9) U/U		(10) U/U						
	YOC4	34.7	34.7		-		34.7		34.4		35.2		35.8		36.1		35.8		34.9						
	SOH6	29.3	30.2		29.3		29.3		30.0		29.0		29.0		29.5		29.2		28.9						
	Passby	(11) D/U	(12) D/U		(13) U/U		(14) U/U		(15) D/D		(16) D/D		(17) U/D		(18) U/D		(19) D/D		(20) D/D		(21) U/D		Max, DN	Max, UP	
	YOC4	34.9	32.4		32.3		35.4		35.0		34.4		32.8		34.2		32.5		33.9		31.7		36.1	35.8	
	SOH6	28.9	31.5		29.3		29.6		28.6		28.9		28.4		28.0		28.5		28.5		29.5		30.2	31.5	

Remark

1. The numbering (1) stands for the first passby of each GBNSR and so on. 'D' stands for Down track and 'U' stands for Up track.
2. D/U stands for Down track of YOC4 and Up track of SOH6, and so on.
3. Leq: $L_{eq, during passby}$; Lbkg: $L_{eq, background}$.
4. Y3(U) was affected by extraneous noise, results of this measurement will not be included in the calculation.

Table C2.1 – 2.3 Calculation of Maximum $L_{eq,30min}$, day and evening time

Table C2.1 Calculation of Maximum SEL_{DN} , day and evening time

NSR	Maximum Background Corrected Train Passby Noise Level, dB(A) [Ad]	Duration* of event, s	No. of Passby	Corrections, dB(A)		Max. SEL, dB(A) [Ad]+[Bd]+[Cd]=[Ed]
				Duration correction [Bd]	Passby correction [Cd]	
YOC4	36.1	28	15	14.5	11.8	62.4
SOH6	30.2	44	15	16.4	11.8	58.4

* The maximum recorded duration



Table C2.2 Calculation of Maximum SEL_{UP} , day and evening time

NSR	Maximum Background Corrected Train Passby Noise Level, dB(A) [Au]	Duration* of event, s	No. of Passby	Corrections, dB(A)		Max. SEL, dB(A) [Au]+[Bu]+[Cu]=[Eu]
				Duration correction [Bu]	Passby correction [Cu]	
YOC4	35.8	25	15	14.0	11.8	61.6
SOH6	31.5	35	15	15.4	11.8	58.7

* The maximum recorded duration

Table C2.3 Calculation of Maximum Leq_{30min} , day and evening time

NSR	Max. SEL, dB(A)*		No. of Seconds in 30 min, s	Time Correction, dB(A) [G]	Leq_{30min} , dB(A) $10 * \text{Log}(10^{[Ed]}/10) + 10^{[Eu]}/10) - [G]^*$
	DN [Ed]	UP [Eu]			
YOC4	62.4	61.6	1800	32.6	32
SOH6	58.7		1800	32.6	29

* Since the train can approach and depart from both UP and DN of SOH, the SEL_{UP} is considered to be the worst case in the calculation to keep conservative.

Table C3.1 – 3.3 Calculation of Maximum Leq_{30min} , nighttime

Table C3.1 Calculation of Maximum SEL_{DN} , nighttime

NSR	Maximum Background Corrected Train Passby Noise Level, dB(A) [Ad]	Duration* of event, s	No. of Passby	Corrections, dB(A)		Max. SEL, dB(A) [Ad]+[Bd]+[Cd]=[Ed]
				Duration [Bd]	No. of Passby [Cd]	
YOC4	36.1	28	8	14.5	9.0	59.6
SOH6	30.2	44	8	16.4	9.0	55.6

* The maximum recorded duration



Table C3.2 Calculation of Maximum SEL_{UP} , nighttime

NSR	Maximum Background Corrected Train Passby Noise Level, dB(A) [Au]	Duration* of event, s	No. of Passby	Corrections, dB(A)		Max. SEL, dB(A) [Au]+[Bu]+[Cu]=[Eu]
				Duration correction [Bu]	Passby correction [Cu]	
YOC4	35.8	25	8	14.0	9.0	58.8
SOH6	31.5	35	8	15.4	9.0	55.9

* The maximum recorded duration

Table C3.3 Calculation of Maximum Leq_{30min} , nighttime

NSR	Max. SEL, dB(A)*		No. of Seconds in 30 min, s	Time Correction, [G]	Leq _{30min} , dB(A) $10 \cdot \log(10^{[Ed]/10} + 10^{[Eu]/10}) - [G]^*$
	DN [Ed]	UP [Eu]			
YOC4	59.6	58.8	1800	32.6	30
SOH6	55.9		1800	32.6	26

* Since the train can approach and depart from both UP and DN of SOH, the SEL_{UP} is considered to be the worst case in the calculation to keep conservative.



Appendix D. Measurement Instruments and Calibration Information

**Table D1** Measurement Instruments and Calibration Information

Instrument	Brand	Model Type	SN	Calibration Expiry Date (DD/MM/YYYY)
Sound & Vibration Analyzer	Svantek	SVAN 958	20890	04/05/2017
Sound & Vibration Analyzer	Svantek	SVAN 958	23412	07/05/2017
Microphone	PCB	378B02	112506	19/03/2016
Microphone	PCB	378B02	LW109791	19/03/2016
Microphone	B&K	4189	2117396	20/04/2016
Microphone	B&K	4189	2117397	20/04/2016
Accelerometer	PCB	393A03	41074	9/10/2016
Accelerometer	PCB	393A03	41076	28/05/2016
Acoustic Calibrator	Svantek	SV30A	10814	04/05/2017
Vibration Calibrator	IMI	699A02	989	10/25/2016



Appendix E. Operational Ground-borne Noise Performance Test Proposal



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**SOUTH ISLAND LINE CONTRACT 913
GROUND-BORNE NOISE PERFORMANCE TEST PROPOSAL**

Report No.: 14328-9

For

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**SOUTH ISLAND LINE CONTRACT 913
GROUND-BORNE NOISE PERFORMANCE TEST PROPOSAL**

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1. Introduction

The South Island Line (East) (SIL(E)) comprises a new medium-capacity railway system with an approximate total route length of 7km from Admiralty (ADM) to South Horizons (SOH), via three intermediate stations at Ocean Park (OCP), Wong Chuk Hang (WCH) and Lei Tung (LET). Environmental Impact Assessment (EIA) report (AEIAR-155/2010) has been conducted and approved with conditions on 8 Dec 2010.

According to the Condition 2.30 of Environmental Permit (EP) EP-407/2010/E. "At least one month before commencement of operation of the Project, the Permit Holder shall carry out noise performance test and deposit with the Director four hard copies and one electronic copy of a Noise Performance Test Report to confirm the compliance of the operational air-borne and ground-noise levels in accordance with the approved EIA Report. Before submission to the Director, the Noise Performance Test Report shall be certified by the ET Leader and verified by the IEC as conforming to the information and recommendations contained in the approved EIA Report. Any necessary measure(s) as recommended in the Noise Performance Test Report shall be fully and properly implemented."

Wilson Acoustics Limited (WAL) is commissioned by Alstom Hong Kong Limited to conduct ground-borne noise performance test for the commissioning of SIL(E) for MTR Corporation Ltd. (MTRCL).

This document presents the methodology of ground-borne noise (GBN) performance test for agreement with EPD.

2. Railway Ground-borne Noise Criteria

For the railway operational ground-borne noise, the acceptable noise level (ANL) for the NSRs are determined based on the Area Sensitivity Rating (ASR).

ASR is defined in the *Technical Memorandum for Assessment of Noise from Places other than Domestic Premises, Public Places or Construction Sites* (IND-TM) issued under *Noise Control Ordinance* (NCO), and depends on the type of area and the degree of impact that Influencing Factors (IFs) have on the NSRs. The ASR is determined from **Table 2.1** below.

Table 2.1 Area Sensitivity Rating (ASR)

Type of Area Containing NSR	Degree to which NSR is affected by IF		
	Not Affected	Indirectly Affected	Directly Affected
(i) Rural area, including country parks or village type developments	A	B	B
(ii) Low density residential area consisting of low-rise or isolated high-rise developments	A	B	C
(iii) Urban area	B	C	C
(iv) Area other than those above	B	B	C

With reference to the IND-TM, the criteria for noise transmitted primarily through the structural elements of the building should be 10dB(A) less than the relevant ANL.

The operation ground-borne noise criteria for the representative NSRs along SIL(E) alignment are tabulated in **Table 2.2** below (refer to Table 3.5 in approved EIA report).

Table 2.2 Acceptable Noise Level for Railway Operation Ground-borne Noise, $L_{Aeq,30min}$

Time Period	Area Sensitivity Rating (ASR)		
	A	B	C
Day and Evening (0700- 2300)	50	55	60
Night (2300-0700)	40	45	50

The ASRs of the selected NSRs for commissioning test are all rated as B, indicating that $L_{Aeq,30min}$ 55/45 dB(A) for day and evening / night would be applicable.



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3. Proposed Testing Locations

In accordance with the approved SIL(E) EM&A Manual, it is recommended that “ET should perform a noise commissioning test at selected key noise sensitive receivers, say YOC4 (Yue On Court) and SOH8 (South Horizons Dover Court)” to ensure compliance of the operational ground-borne noise levels with the EIAO-TM noise criteria.

The selection of GBNSRs for performance test is to cover the worst affected locations. The principle is that for adjacent GBNSRs with similar ground condition, the worst affected GBNSR would be selected where possible. The factors affecting consideration are the geology situation, EIA assessment results, circumstances accessibility of NSRs and etc.

According to ELA, there are total 28 representative GBNSRs sitting along the SIL(E). GBN predictions for all of the NSRs are lower than stipulated criteria. Apart from non-residential buildings and schools, 8 NSRs are considered to be relatively critical. Which are YOC1, YOC2, YOC4, CPHH(G/F of LTE1), LTE2, LTE4 SOH6 and SOH8, as shown in **Appendix A**.

YOC1, YOC2, YOC4, CPHH, LTE2 and LTE4 are sitting along the rock section. The bottom of the piles of YOC4 are 12.2m to the tunnel, which is the shortest distance among the NSRs. Referring to the approved ELA, GBN of YOC4 is calculated to be the highest among the NSRs. Though LTE4 and CPHH are sitting directly above the tunnel, YOC4 is considered to be the worst case NSR for rock section monitoring.

SOH6 and SOH8 are sitting at mixed ground and very close to the tunnel. Referring to the *South Island Line (East): Ground-borne Noise Review Plan (GBN Review Plan)* submitted under EP condition 2.25 and approved in July 2014, the updated GBN prediction of SOH6 is higher than the GBN of SOH8. Therefore, SOH6 is considered to be the worst case NSR for mixed section monitoring.

The information summary for the 8 critical NSRs are listed in **Table 3.1**.

Table 3.1 Summary of NSR Candidates for GBN Test

NSR ID	Description	Usage	Geology	Distance ⁽¹⁾ from Pile to Track, m	Slant distance to nearest track	Lowest GBN affect floor	Train speed ⁽⁵⁾ , km/h	Predicted ground-borne noise level, dB(A) ⁽⁶⁾	
								Day and evening	Night
YOC1	Yue On Court - Pile On House (Block C)	Residential	Rock	34.6	37.5 ⁽²⁾	1/F	55	33	36
YOC2	Yue On Court - The On House (Block D)	Residential	Rock	35.8	36.5 ⁽²⁾	1/F	55	32	36
YOC4	Yue On Court - Shua On House (Block F)	Residential	Rock	12.2	29.9 ⁽²⁾	1/F	55	42	39
CPHH (G/F of LTE1)	Cheng Fui Hing Hostel for the Elderly at G/F of Tung Yip House	Elderly Centre	Rock	61.6	68 ⁽³⁾	G/F	70	36	33
LTE2	Tung Hing House	Residential	Rock	45.4	57 ⁽³⁾	1/F	70	33	36



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LTE4	Lei Tang Estate - Tung Min House	Residential	Rock	56.3	62.8 ⁽²⁾	1/F	35	33	31
SOH6	South Horizons Block 23A, Mei Ka Court	Residential	Mixed	8	18 ⁽³⁾	1/F	30	27	25
SOH8	South Horizons Block 25, Dover Court	Residential	Mixed	4.5	23.6 ⁽²⁾	1/F	35	26	23

Remark

- (1) Shortest distance between nearside track and foundation/bottom of pile, based on EIA.
- (2) Slant distance from proposed measurement location to nearest track.
- (3) Slant distance from closed edge of G/F to nearest track.
- (4) Slant distance from closed edge of 1/F to nearest track.
- (5) Train speed according to Appendix 3.6 - Target Train Speed profile in the approved EIA Report.
- (6) Predicted GBN levels for YOC1, YOC2, YOC4, CPHH, LTE2 and LTE4 are based on EIA, SOH6 and SOH8 are based on the updated GBN Review Plan.

Based on above discussion, YOC4 and SOH6 are selected for monitoring. To obtain the worst case GBN, the measurement is proposed to be conducted lower than or at the lowest resident level and with similar indoor noise environment.

At YOC4, the storage room at G/F are selected for testing, which is lower than the resident level and is the closest measurement point of the building.

At SOH6, there is no accessible room for measurement at residential level. With approval by the Estate Management Office, the lobby is selected for measurement, which is lower than the resident level and the closest measurement point that could be accessed in SOH 6.

The preliminary site survey for YOC4 was conducted during daytime on 16th Apr, 2015. For SOH6, site survey and baseline measurement was conducted during daytime of 10th Aug and nighttime of 30th Sep, 2015 respectively. **Table 3.2** summarises the information of selected measurement locations and preliminary background noise measurement results.

Table 3.2 Proposed test Locations and Background Noise Level

NSR ID	Lowest affect floor	Measurement location	Background noise reading, dB(A)
YOC4	1/F	Storage room at G/F (1 floor lower than 1/F)	46 ⁽¹⁾
SOH6	1/F	Lobby, G/F (1 floor lower than 1/F)	36 ⁽²⁾

Remark:

- (1) The background noise measurement at YOC4 was conducted at daytime. The background level is expected to be lower at night time.
- (2) The background noise measurement at SOH6 was conducted at nighttime, with a double layer noise enclosure employed.

Overview of the updated geology profile and NSR locations is shown in **Appendix A**. Drawings and photos showing the exact test locations are provided in **Appendix B**.

4. Train Type for Noise Performance Test

S-Stock train (3-car) will be deployed for the operation of SIL(E) and the ground-borne noise performance test instead of K-Stock train stipulated in EP condition 2.24. According to EP condition 2.24, a *Noise Performance Report for S-Stock Train (3-Car)* was prepared by ET leader and verified by IEC in January 2015, which concluded the ground-borne noise performance of the 3-car S-Stock train is equivalent or better than relevant EIA requirement of K-Stock train.

As it is suggested in various literatures that train loading has little effect on vibration in audible frequency range (ref: *Track-Based Control Measures for Ground Vibration – The Influence of Quasi-Static Loads and Dynamic Excitation*”, and *Ground Vibration Induced by Railway Traffic – The Influence of Vehicle Parameters*”, Noise and Vibration Mitigation for Rail Transit System, NFM 118, Springer 2012), the trains employed for test will be unloaded.

Measurement data of trains running along existing operating lines of MTR Corporation also indicate that train load has no significant effect on vibration as shown in **Figure 4.1** and **4.2**, which are the averaged M-stock train passby vibration and the projected GBN near Heng Fa Chuen Station of Island Line, respectively.

Red solid line and green solid line represent the spectra averaged from at least 30 train passbys during peak hours (i.e. loaded trains) and non-peak hours (i.e. less loaded trains), respectively. Red dash lines and green dash lines are the spectra +/- standard deviation respectively. Taken into account the variations, there is no significant difference for vibration level during peak and non-peak hours, despite the difference in train loading. There would also be no significant difference for their ground-borne noise levels.

Figure 4.1 Train Passby Vibration Level of M-stock Train during Peak and Non-peak Hours

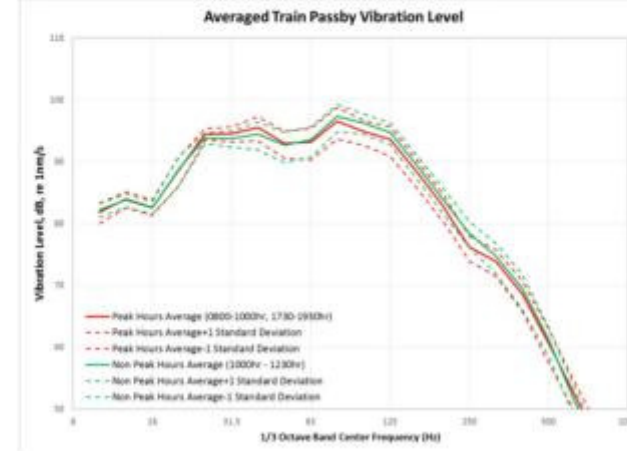
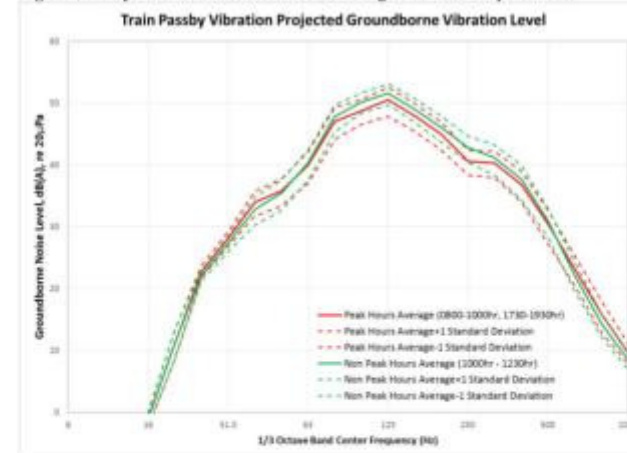


Figure 4.2 Projected GBN of M-stock Train during Peak and Non-peak Hours



5. Ground-borne Noise Performance Test Plan

5.1 Measurement Instrument & Setup

Measurement will be conducted at the two NSRs listed in Table 3.1 during the test.

Referring to Section 2.2.1.2 of the approved SIL(E) EM&A Manual, "As refer to the Technical Memorandum (TM) issued under the Noise Control Ordinance (NCO), sound level metres in compliance with the International Electrotechnical Commission Publications 651: 1979 (Type 1) and 804: 1985 (Type 1) specifications should be used for carrying out the noise monitoring. The calibration of the sound level meters and their respective calibrators should be carried out in accordance with the manufacturer's requirements". Prior to and following the noise measurement, the accuracy of the sound level meter would be verified using an acoustic calibrator. Measurements may be accepted as valid only if the calibration levels from before and after the noise measurement agree to within 1.0dB.

Table 5.1 Proposed Measurement Instrument

Instrument	Model No.	Qty.
Sound & Vibration Analyzer	SVAN 958 or equivalent	2
Microphone	B&K 378B02 or equivalent	2
Acoustic Calibrator	Svantek SV30A	2
Accelerometer	PCB 393A03	2
Vibration Calibrator	IMI 699A02	1

At each NSR, one microphone would be placed at around 1.2m above floor level inside a designated room with windows closed and one vibration sensor would be placed on floor at each NSR.

The vibration levels picked from vibration sensors would be used to determine the train passby. Actual measurement location and height of microphone may be varied subjected to room environment and requirement of the premises owner. Exemplary setup is shown in **Figure 5.1**.

In the case of the background noise level could not meet the measurement requirement (refer to section 6 for details), portable noise enclosure box will be employed to insulate extraneous background noise. Exemplary setup of GBN monitoring with noise enclosure box are shown in **Figure 5.2** and **5.3**.

Figure 5.1 Exemplary GBN Monitoring Setup



Figure 5.2 Exemplary GBN Monitoring Setup, with Noise Enclosure Box Employed



Figure 5.3 Exemplary GBN Monitoring Setup inside Noise Enclosure Box



5.2 Tentative Test Schedule

Operational GBN performance test is proposed to be conducted in Q4 2015 tentatively, subject to availability of possession of tracks.

From **Table 3.2**, preliminary daytime background noise levels of YOC4 and SOH6 are 46dB(A) and 45dB(A) respectively, which are considered to be relatively high. Besides, the SOH6 is very close to a bus terminus. In order to minimize the intrusive noise and vibration from buses passby, the measurement is proposed to be scheduled at nighttime as shown in **Table 5.2**.

To minimize the interference of intrusive noise, the measurement will be conducted during midnight.

For each NSR location, GBN would be measured for train operation in both Northbound (NB) and Southbound (SB) to assess the cumulative impact. Non-service S-trains would be arranged for the operational test. The S-trains would be run at design operational speed according to the speed profile (target train speed at NSRs refer to Table 3.1). No less than three passbys would be measured at NB and SB respectively (total 6 or more passbys would be recorded). Among the GBN readings of passbys, the maximum $L_{eq,passby}$ will be adopted for the conservative assessment.

Tentative test schedule is proposed as **Table 5.2**, subject to the operation arrangement of test train.

Table 5.2 Tentative Test Schedule

Time	Activity
2200 – 0200	Setup at the proposed measurement locations.
0200 – 0400	Conduct noise performance test at measurement locations
0400 – 0600	Collect measurement equipment from NSRs.

5.3 Measurement Parameters

Train passby noise and vibration would be logged at 1 second interval including L_{eq} and L_{max} .

Typically, vibration frequency spectra from train operation peaked in the spectra from 40 Hz to 80 Hz and groundborne noise normally exists at the frequency range lower than 400Hz. For conservation purpose, noise spectra from 20-500Hz would be extracted to study whether noise environment is affected by train generated GBN. Furthermore, background adjusted L_{Aeq} in the full audible frequency range would be used to compare with the noise criteria in IND-TM.

In order to avoid head-tail effect affecting the background noise measurement result, an over 60sec averaged background noise level would be exacted from the measurement data, at 30sec ahead of each passby. For example, if train passby is recorded from 03:00:00 to 03:00:15, then the background noise level would be averaged from 02:58:30 to 02:59:30.

Detailed data analysis process will follow the procedure that described in **Section 6**.



6. Assessment Procedures

The assessment procedure of the NCO Criterion Noise Level ($L_{eq,30min}$) against train passbys of SIL(E) would follow the steps presented below.

- 1) A pre-test noise survey would be conducted to identify a suitable and accessible measurement location within the specified NSRs, as addressed in Section 3.
- 2) Background noise level will be measured at around 1 hr prior to the test to determine whether the background noise level is suitable for measurement. If the background noise level already exceed the statutory requirement, a maximum of -3dB(A) background correction would be allowed to avoid over correction and for conservative results.
- 3) In case the corrected measured noise (BG-3dB(A)) still exceeds statutory requirement, a portable noise enclosure box will be employed to insulate extraneous background noise and measure the train induced GBN.
- 4) Based on the recorded vibration level and train running schedule provided by MTRCL, extract the train passby data for further analysis.
- 5) Background noise level is determined from averaging the noise level of over 60 seconds' measurement, 30sec ahead of each passby.
- 6) Determine the background corrected noise level during train passby. This applies to the entire audible frequency ranging from 20 to 20000Hz.
- 7) Train passby duration would be determined from vibration sensors placed at the testing location, and make reference to train running schedule provided by MTR Corporation. Vibration above background indicates train passage. The duration will include the head-tail period.
- 8) The background corrected noise level is determined by

$$L_{eq,passby} = 10 \times \log(10^{L_{eq,during\ passby}/10} - 10^{L_{eq,background}/10})$$

Where $L_{eq,during\ passby}$ is the noise level during train passby

$L_{eq,background}$ is the background noise level

$L_{eq,passby}$ is the background corrected noise level

- 9) Obtain the train operation headway during worst case 30 minute operation. Determine the Sound Exposure Level (SEL) arising from SB and NB train operation in 30 minutes.

$$SEL_{SB} = L_{eq,passby,SB} + 10 \times \log(T_{SB}) + 10 \times \log(N_{SB})$$

$$SEL_{NB} = L_{eq,passby,NB} + 10 \times \log(T_{NB}) + 10 \times \log(N_{NB})$$

Where T is the train passby duration and N is number of passby in 30 minutes.

- 10) Determine $L_{eq,30min}$ and compare with statutory requirements.

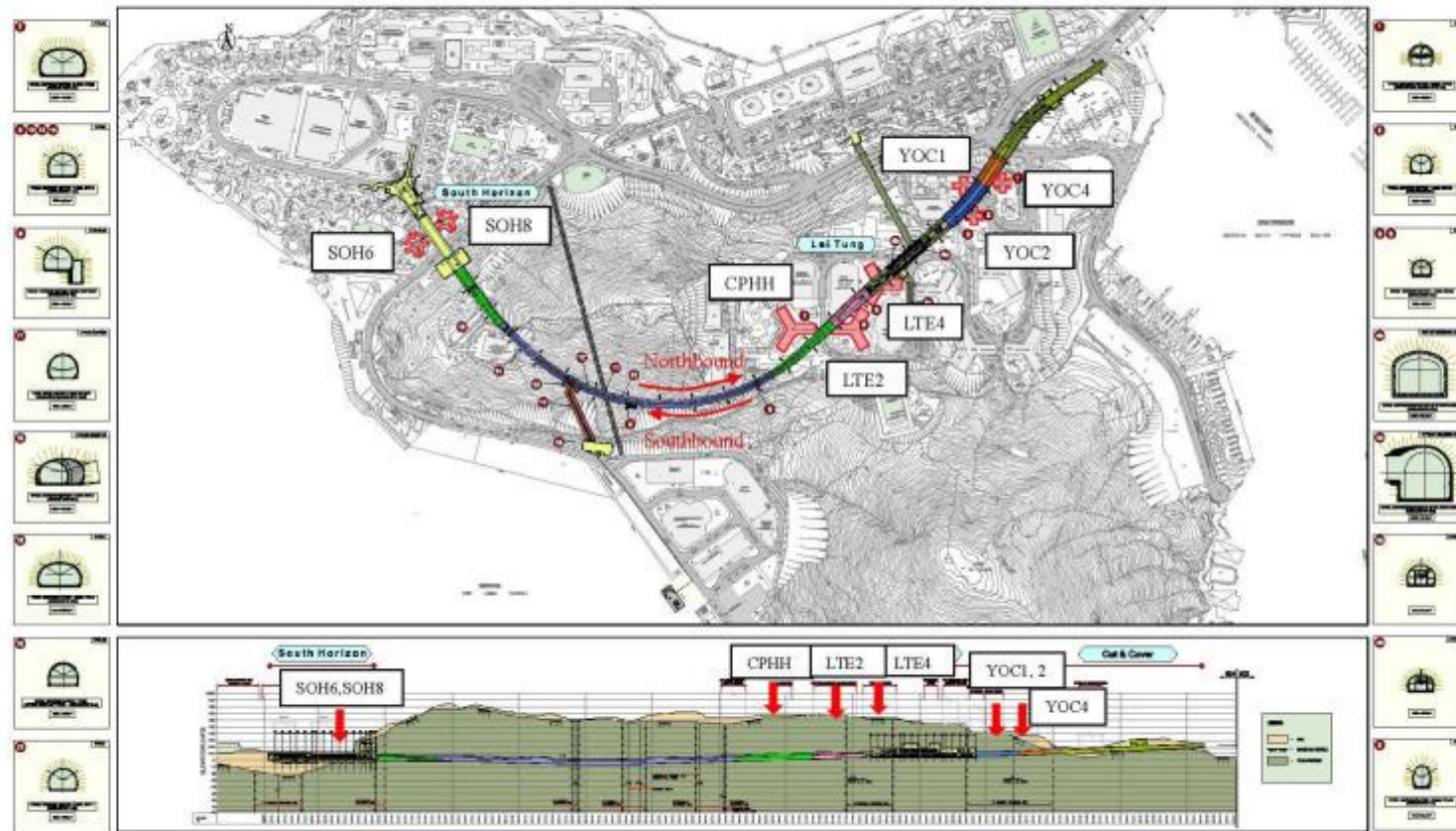


$$L_{eq,30min} = 10 \times \log(10^{SEL_{SB}/10} + 10^{SEL_{NB}/10}) - 10 \times \log(1800)$$



Appendix A Overview of Geology Profile and Critical NSRs

Figure A1. Geology Profile and Critical NSRs





Appendix B Details of Proposed Test Locations

Figure B1. Proposed Test Location at YOC4



Figure B2. Proposed Storage Room for Test at YOC4



Figure B3. Proposed Test Point inside Storage Room at YOC4



Figure B4. Proposed Test Location at SOH6

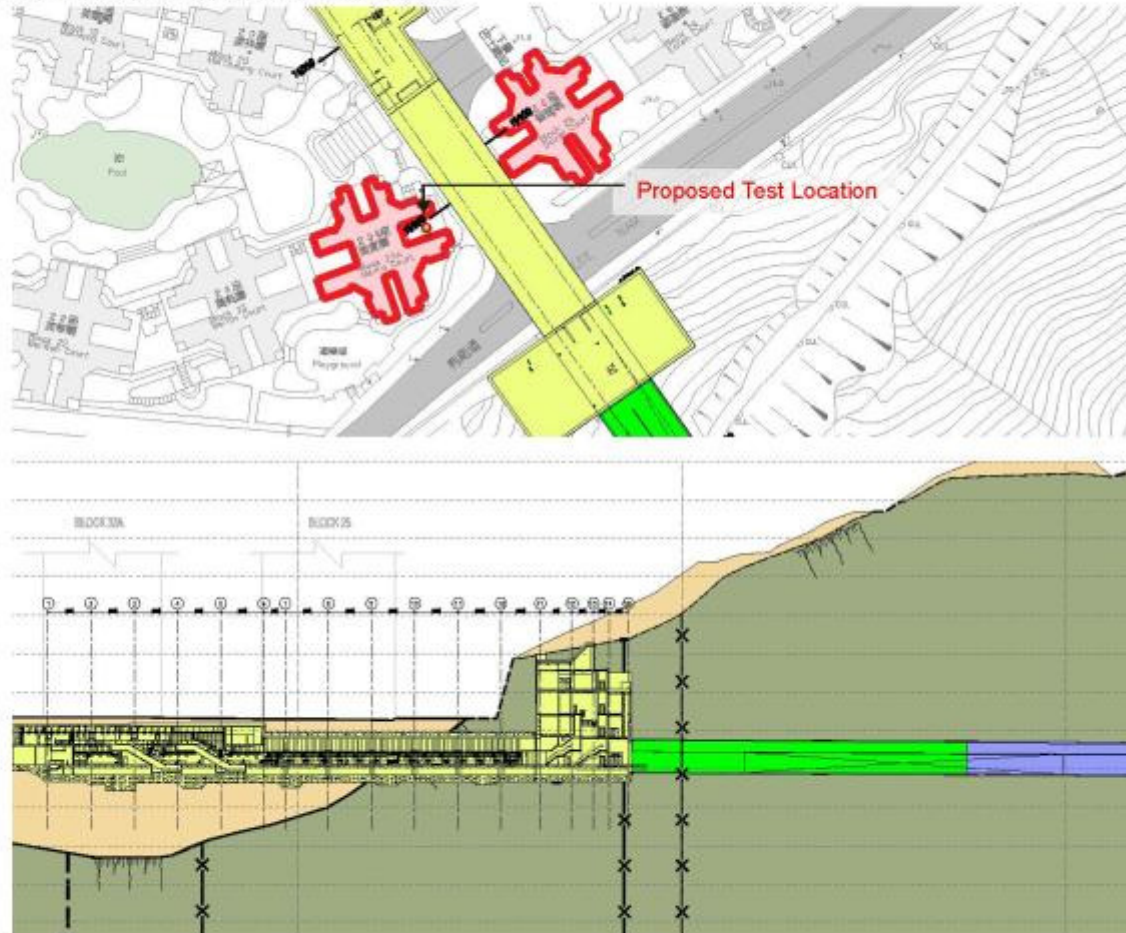


Figure B5. Proposed Test Location at Lobby for SOH6 Test



Figure B6. Proposed Test Point at Lobby of SOH6



Figure B7. Baseline Measurement at SOH6 on 30-Sep-2015, with Double Layer Noise Enclosure Employed



- END -