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Liverpool Hospital Stage 2 - Multi-Storey Carpark

Noise, Vibration and Dust Monitoring Report #1

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1 INTRODUCTION

This report presents the results of our monitoring of vibration, noise and dust generation from demolition works associated with the construction of the stage 2 multi-storey carpark located at Liverpool Hospital.

Specifically, vibration monitoring has been conducted to quantify the level of vibration impacts on the users of the Ingham Institute (Animal Research and Electron Microscope) and Anatomical Pathology (Analysers) given the sensitivity of these spaces to construction vibration.

In addition, noise and dust monitoring has been conducted to monitor the noise levels and dust generation on the Liverpool Girls High School located along the western boundary.

The noise management levels and vibration level limits have been derived from the Construction Noise and Vibration Management report and the EPA Interim Construction Noise Guideline. The dust particulate levels are calculated to the National Environment Protection (Ambient Air Quality) Measure (Air NEPM).

The vibration, noise and dust monitoring data presented in this report is for the period of the 18th October 2022 to the 16th November, 2022.*

*We note that the three (3) vibration monitors in the respective locations were installed on the 2nd November 2022, therefore; vibration events from this date are presented from this period.

2 SITE DESCRIPTION

During this monitoring period there are construction works associated with the following:

- Demolition of the existing multi-storey carpark located at Liverpool Hospital which forms Stage 2 of the redevelopment of the multi-storey carpark.

The nearest developments in the vicinity of the proposed work zone are as follows below:

- Existing Liverpool Hospital development to the south.
- Ingham Institute located at 1 Campbell Street to the north-west.
- Liverpool Girls High School located at 96 Forbes Street to the north.

The most vibration sensitive receiver monitored in this report is the users of the Ingham Institute (Animal Research and Electron Microscope) and Anatomical Pathology (Analysers).

See Figure 1 below for a site survey and noise, vibration and dust monitoring location(s).

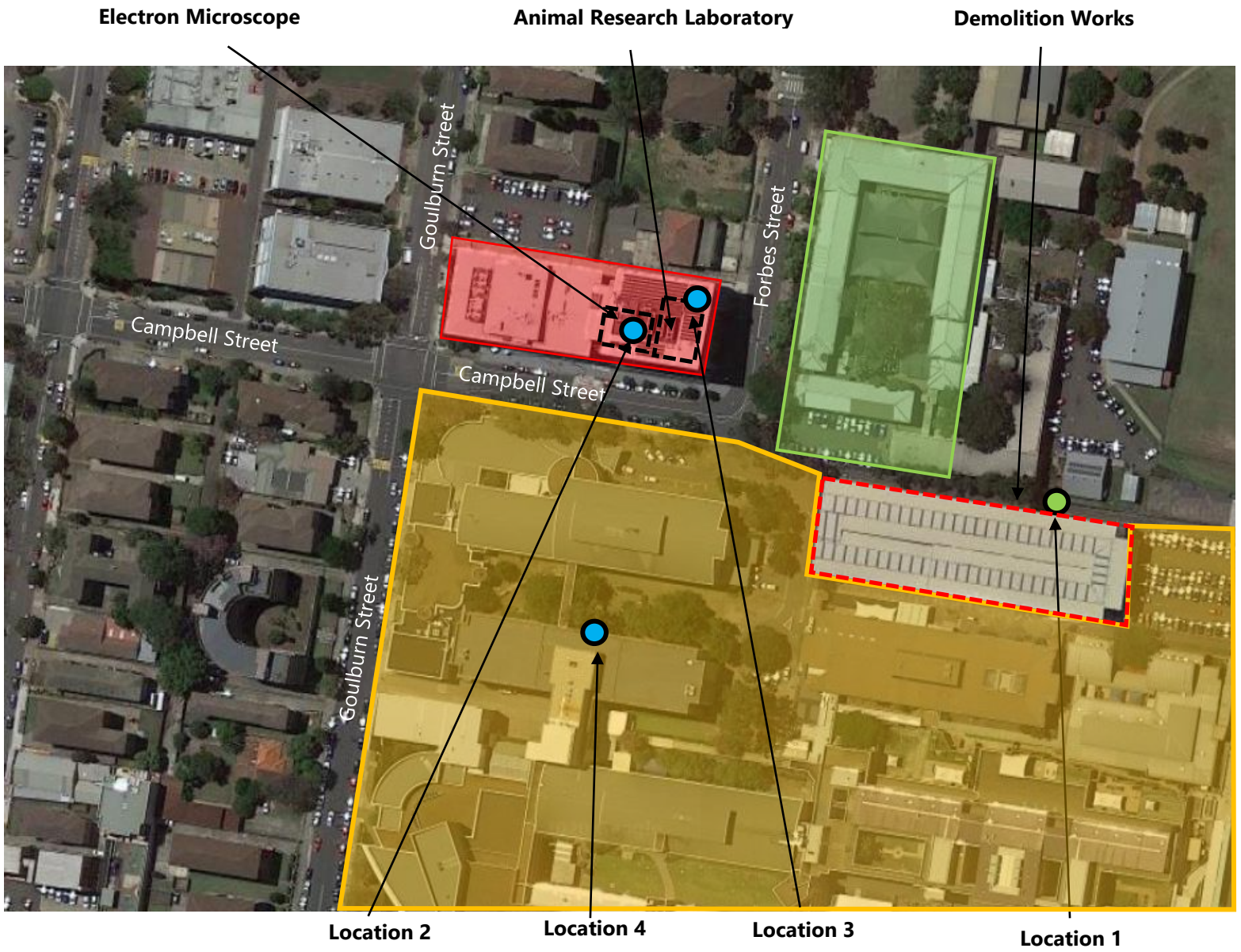

Figure 1: Aerial Map and Vibration Monitor Locations

3 VIBRATION EMISSION CRITERIA

Vibration criteria for the nearest and most affected receivers will be based on the following documents:

- DIN 4150-3 (1999-02);
- EPA "Assessing Vibration: A technical guideline";
- Ingham Institute Users vibration specification for electron microscope;
- AL experience with respect to vibration targets for animal research laboratories; and
- Baseline ambient vibration measurements undertaken within the Anatomical Pathology department of Liverpool Hospital.

3.1 DIN 4150

German Standard DIN 4150-3 (1999-02) provides vibration velocity guideline levels for use in evaluating the effects of vibration on structures. The criteria presented in DIN 4150-3 (1999-02) are presented in the table below.

It is noted that the peak velocity is the absolute value of the maximum of any of the three orthogonal component particle velocities as measured at the foundation, and the maximum levels measured in the x- and y-horizontal directions in the plane of the floor of the uppermost storey.

Table 1 – DIN 4150-3 (1999-02) Safe Limits for Building Vibration

TYPE OF STRUCTURE		PEAK PARTICLE VELOCITY (mms^{-1})			
		At Foundation at a Frequency of			Plane of Floor of Uppermost Storey
		< 10Hz	10Hz to 50Hz	50Hz to 100Hz	All Frequencies
1	Buildings used in commercial purposes, industrial buildings and buildings of similar design	20	20 to 40	40 to 50	40
2	Dwellings and buildings of similar design and/or use	5	5 to 15	15 to 20	15
3	Structures that because of their particular sensitivity to vibration, do not correspond to those listed in Lines 1 or 2 and have intrinsic value (e.g. buildings that are under a preservation order)	3	3 to 8	8 to 10	8

3.2 ASSESSING AMENITY

Table 2.2 of EPA "Assessing Vibration: A technical guideline" specified the following vibration goal for human comfort:

Table 2 – Preferred and Maximum Weighted RMS Values for Vibration Acceleration (m/s^2) 1-80 Hz

Location	Assessment Period	Preferred Values Z-axis	Preferred Values X & Y-axis	Maximum Values Z-axis	Maximum Values X & Y-axis
Continuous Vibration					
Critical Areas	Day time	0.005	0.0036	0.010	0.0072
Residences	Day time	0.010	0.0071	0.020	0.014
Office	Day time	0.020	0.014	0.040	0.028
Impulsive Vibration					
Critical Areas	Day time	0.005	0.0036	0.010	0.0072
Residence	Day time	0.3	0.21	0.6	0.42
Office	Day time	0.64	0.46	1.28	0.92

Acceptable values for intermittent vibration shall comply with the requirements in Table 2.4 of EPA "Assessing Vibration: A technical guideline" detailed as below.

Table 3 - Acceptable Vibration Dose Values for Intermittent Vibration ($m/s^{1.75}$)

Location	Day time preferred value	Day time maximum value
Critical Areas	0.10	0.20
Residences	0.20	0.40
Office	0.40	0.80

3.3 INGHAM INSTITUTE

3.3.1 Animal Research Lab

In our experience vibration impacts of 0.1-0.15mm/s Peak Particle Velocity have been generated without users of a facility advising of adverse impact on the animals (disruption of breeding cycle).

In the event that acoustic pads (Embelton Supershearflex) are placed below the feet/wheels of the animal hold racks, vibration levels of approximately 0.2mm/s (as measured on the floor) could be accommodated without adverse impact on the animals.

3.3.2 Electron Microscope

The ASHRAE Handbook specifies vibration levels associated with potential disruption to the use of sensitive equipment within a building. The maximum vibration velocities [$mm.s^{-1}$] recommended from 1-80Hz is given in Figure 37 of the ASHRAE used in conjunction with recommended equipment requirements curves given in Table 46. Figure 37 and Table 46 from the ASHRAE document is presented below in Figure 2 and Table 4 respectively.

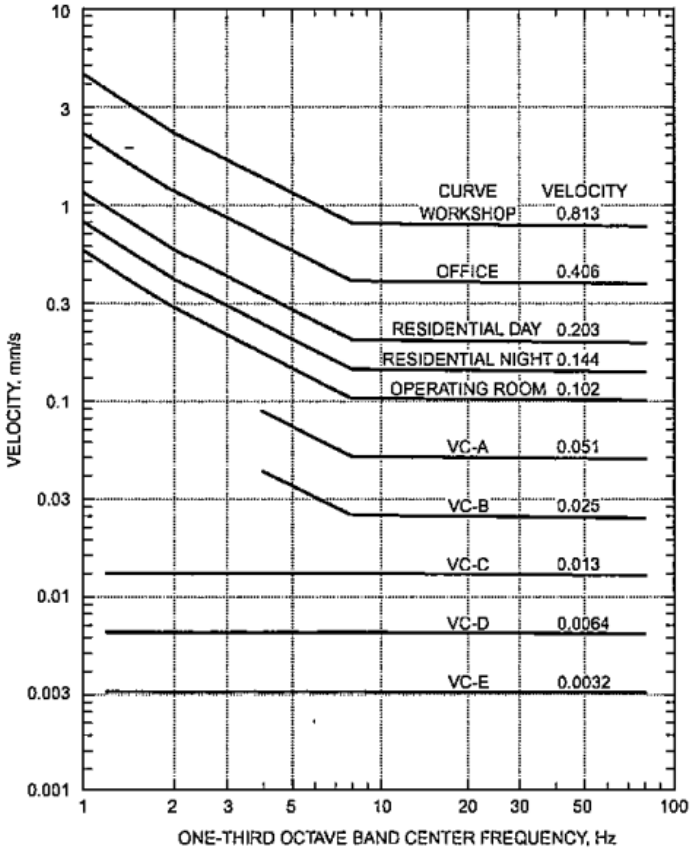

Fig. 37 Building Vibration Criteria for Vibration Measured on Building Structure

Figure 2 – Fig. 37 from 2007 ASHRAE Handbook: Vibration Criteria Curves

Table 4 – Tab. 46 from 2007 ASHRAE Handbook: Equipment Vibration Criteria

Equipment Requirements	Curve
Adequate for computer equipment, probe test equipment, and microscopes less than 40x magnification	0.203 (Residential – day)
Bench Microscopes up to 100x magnification; laboratory robots	0.102 (Operating Room)
Bench microscopes up to 400x magnification; optical and other precision balances; coordinate measuring machines; metrology laboratories; optical comparators; microelectronics manufacturing equipment; proximity and projection aligners, etc.	0.051 (VC – A)
Microsurgery, eye surgery, neurosurgery; bench microscopes at magnification greater than 400x magnification; optical equipment on isolation tables; microelectronic manufacturing equipment, such as inspection and lithography equipment (including steppers) to 3mm line widths	0.025 (VC – B)
Electron microscopes up to 30,000x magnification; microtomes; magnetic resonance imagers; microelectronics manufacturing equipment, such as lithography and inspection equipment to 1mm detail size	0.013 (VC – C)
Electron microscopes at magnification greater than 30,000x magnification; mass spectrometers; cell implant equipment; microelectronic manufacturing equipment such as, aligners, steppers and other critical equipment for photolithography with line widths of 1/2μm; includes electron beam systems	0.0064 (VC – D)
Un-isolated laser and optical research systems; microelectronics manufacturing equipment, such as aligners, steppers and other critical equipment for photolithography with line widths of 1/4μm; includes electron beam systems	0.0032 (VC – E)

*See Figure 2 for corresponding vibration curve.

We have since obtained the electron microscope manufacturer's vibration criteria. Critical frequency for operation of the equipment appears to be 10Hz for vertical vibration, with an acceptable range of 20uG-70uG. This is approximately equivalent to a VC-D to VC-C if comparing to Table 4 above.

3.4 HOSPITAL SPECIFIC VIBRATION LIMITS – ANATOMICAL PATHOLOGY (ANALYSERS)

Based on the ambient baseline vibration measurements carried out by this office during the *'Stage 2 - Construction Noise and Vibration Management Plan'* (Ref: 20200931.9/2704A/R0/SN) dated 27/04/2022 the following vibration limit is recommended:

Analysers: 0.05mm/s Peak Particle Velocity (PPV).

3.4.1 Summarised Recommended Vibration Limits

The summarised vibration criteria are presented in the table below.

Table 5 – Recommended Vibration Limit

Vibration Receiver	Recommended Vibration Limits PPV (mm/s)
Animal Research	0.1-0.2
Electron Microscope(1)	0.01-0.02 or equal to the existing ambient vibration levels
Anatomical Pathology Analysers	0.05

Note 1: Since we have obtained the manufactures vibration criteria for the installed electron microscope, we will use this as the preferred criteria in lieu of the assumed project criteria. The manufactures vibration criteria (preferred criteria) for the electron microscope is frequency dependant so we will use this data as it is stricter at the lower frequencies and in the higher frequencies it is more lenient than the assumed project criteria. The electron microscope criteria in terms of 1/3 octave acceleration criteria has been converted to 1/3 velocity to be consistent with the VC criteria presented in Section 4.1.3.2 (ASHRAE Handbook criteria).

4 VIBRATION MONITORING ASSESSMENT

4.1 VIBRATION MONITORING PROCEDURE

4.1.1 Animal Research lab

One (1) Texcel - ETM vibration monitor with external Tri-axial Geophones. The monitor is programmed to store statistical vibration data after every 5-minute period, along with any 'triggered' events that occur throughout the monitoring period. The trigger level has been set at 0.1mm/s PPV.

Location 3 – *Fire Stairs (Level 1 Basement)*

Vibration Monitor – ETM 7418: Geophone fixed to the floor within the Basement 1 Fire Stairs located adjacent to the Animal research lab and representative of the vibration impacts on the animal research lab from construction works.

Figure 3 – Location 3 vibration monitor installation (ETM 7418)

4.1.2 Electron Microscope

One (1) Bruel and Kjaer vibration monitor with external Tri-axial Geophones. The monitors are programmed to store statistical vibration data after every 1-second period.

Location 2 – *Electron Microscope*

Vibration Monitor – Bruel & Kjaer: Geophone fixed to the floor within the B.31 Archive Storeroom located adjacent to the electron microscope room.

Figure 4 – Location 3 vibration monitor installation (Bruel & Kjaer)

4.1.3 Anatomical Pathology - Analysers

One (1) Texcel - ETM vibration monitor with external Tri-axial Geophones. The monitor is programmed to store statistical vibration data after every 5-minute period, along with any 'triggered' events that occur throughout the monitoring period. The trigger level has been set at 0.05mm/s PPV.

Location 4 – Anatomical Pathology (Analysers)

Vibration Monitor – ETM 7436: Geophone fixed to the floor within the Anatomical Pathology adjacent to the analysers.

Figure 5 – Location 1 vibration monitor installation (ETM 7436)

4.2 VIBRATION MONITORING RESULTS

4.2.1 Animal Research Lab

The PPV vibration monitoring results for the vibration monitor at location 3 are presented in Appendix B.

The highest vibration levels – Peak Particle Velocity (PPV) mm/s of the monitor for each day during the measurement period have been presented in the table below.

Table 6 – Vibration Monitor (Location 4) – Measured PPV

Date	Maximum Measured Vibration Level PPV (mm/s)	Criteria Vibration Level	Complies
2nd November 2022	≤0.2	0.2mm/s	Yes
3rd November 2022	≤0.2		Yes
4th November 2022	0.21*		Yes
5th November 2022	0.25*		Yes
6th November 2022	≤0.2		Yes
7th November 2022	≤0.2		Yes
8th November 2022	0.23*		Yes
9th November 2022	0.22*		Yes
10th November 2022	0.22*		Yes
11th November 2022	0.20		Yes
12th November 2022	0.21		Yes
13th November 2022	≤0.2		Yes
14th November 2022	≤0.2		Yes
15th November 2022	≤0.2		Yes
16th November 2022	≤0.2		Yes

*Based on analysis of the vibration exceedances presented above, the exceedances are not typical of construction activity at the project site and are isolated events.

4.2.2 Electron Microscope

The daily charted vibration monitoring results are presented in Appendix C against the ASHRAE Handbook VC curves (Figure 2) and the preferred criteria taken from the electron microscope manufacturers data sheet (Appendix A).

The vibration monitor data is in the form of 1/3 octave RMS velocity (1s). There are 86,400 results per frequency per day our daily graph shows the highest level reached in each 1/3 octave band per day. If this maximum result is below the criteria, then all the results within that 1/3 octave band are below the criteria. Where the maximum level has exceeded the 1/3 octave band criteria, further investigation was carried out using time analysis to determine the number of events.

Based on the data sheet (Appendix A) we have assumed that there is a preferred vibration criteria (Type 1) and a maximum criteria (Type 2). The data sheet states if two or more points (events) exceed the preferred criteria but are under the maximum criteria we can assume that the vibration event is unacceptable.

Table 7 presents the further analyses of the maximum daily event exceedances of the monitoring data presented in Appendix C. Table below shows at what times the vibration level exceeded the criteria set out in the electron microscope manufacturers data sheet (Appendix A) and on which axis the event(s) occurred. This has been done so the events can be compared to the builder's work schedule and staffing rotations in the electron microscope room to verify which events are caused by construction works. All other vibration monitoring results comply with the preferred acceptable criteria.

Table 7 –Exceedance of 1/3 Octave RMS Velocity Criteria

Date	Time (24hr)	Vertical	Front/Back	Sideways
2nd November 2022	-	-	-	-
3rd November 2022	-	-	-	-
4th November 2022	-	-	-	-
5th November 2022	21:46	-	19.4	18.9
6th November 2022	-	-	-	-
7th November 2022	-	-	-	-
8th November 2022	-	-	-	-
9th November 2022	20:55	14.8	-	-
10th November 2022	-	-	-	-
11th November 2022	-	-	-	-
12th November 2022	-	-	-	-
13th November 2022	-	-	-	-
14th November 2022	-	-	-	-
15th November 2022	-	-	-	-
16th November 2022	-	-	-	-

*Note: The duration of each event recorded in table above is 1 second.

4.2.3 Anatomical Pathology (Analysers)

The PPV vibration monitoring results are presented in Appendix D.

The highest vibration levels – Peak Particle Velocity (PPV) mm/s of the monitor for each day during the measurement period have been presented in the table below.

Table 8 – Vibration Monitor (Location 1) – Measured PPV

Date	Maximum Measured Vibration Level PPV (mm/s)	Criteria Vibration Level	Complies
2nd November 2022	0.12	0.05mm/s	See discussion below*
3rd November 2022	0.13		
4th November 2022	0.11		
5th November 2022	0.11		
6th November 2022	0.09		
7th November 2022	0.3		
8th November 2022	0.09		
9th November 2022	0.15		
10th November 2022	0.08		
11th November 2022	0.09		
12th November 2022	0.10		
13th November 2022	0.04		
14th November 2022	0.20		
15th November 2022	0.15		
16th November 2022	0.10		

*Based on review of the vibration monitoring data inclusive of event dates, time period and specifically vibration events measured on Sunday 6th November when construction work was not undertaken at the project site, the recorded vibration exceedances of the vibration criteria are associated with department staff likely footsteps/footfall events and operation of the analyser equipment.

5 CONSTRUCTION NOISE MANAGEMENT LEVEL

The Noise Management Levels (NMLs) for this project are presented in the Table below. The NMLs were established in the *'Stage 2 - Construction Noise and Vibration Management Plan'* (Ref: 20200931.9/2704A/R0/SN) dated 27/04/2022 previously issued by this office.

5.2.1.2 To Educational Receivers

Table 3 of the ICNG outlines the following management noise levels to internal areas of classrooms at schools and other educational institutions:

Table 2 – Noise Management Level for Educational Buildings (ICNG)

Space	Internal Management Level dB(A)$L_{eq\ (15\ min)}$
Within Classrooms at schools and other educational institutions	45

6 DUST EMISSIONS CRITERIA

There are dust emissions criteria for respirable dust and for nuisance dust which make up the total suspended particulates (TSP). For respirable dust the PM2.5 and PM10 particulate matter sizes which are linked to adverse health effects are typically monitored in real-time and electronic warnings issued when hourly levels are excessive.

The NSW EPA air pollutants Impact assessment criterion applicable to the project site with regards to health concerns is shown in Table 9 below.

Table 9 - Dust Impact Criterion

Pollutant	Averaging Period	Concentration
$PM_{2.5}$	24 hours	25 µg/m^3
PM_{10}		50 µg/m^3

7 REAL TIME NOISE & DUST MONITORING

Combined noise and dust monitoring was conducted using one (1) Site Hive monitor. The monitor was programmed to store statistical noise and dust data over every 15-minute period, along with any 'triggered' events that occur throughout the monitoring period.

The noise/dust monitor installation location is shown in Figure 1. See Figure 6 below for a photo of the installed Site Hive noise monitor.

Figure 6 – Location 1 noise and dust monitor installation (SiteHive Hexanode 000108)

Dust generating works carried out on site during this period include:

- Demolition of the existing Liverpool Hospital multi-storey carpark structure.

8 RESULTS

8.1 DUST MONITORING RESULTS

The dust monitoring results are stored at 15-minute intervals and the diurnal plots for the $PM_{2.5}$ and PM_{10} particulate are attached in Appendix E.

Table 10 - $PM_{2.5}$ - 24 Hour Dust Concentrations

Date	Pollutant	Measured Concentration µg/m³	Allowable Concentration µg/m³	Complies
18th October 2022	$PM_{2.5}$	6	25	Yes
19th October 2022		8		Yes
20th October 2022		9		Yes
21st October 2022		10		Yes
22nd October 2022		7		Yes
23rd October 2022		6		Yes
24th October 2022		3		Yes
25th October 2022		5		Yes
26th October 2022		2		Yes
27th October 2022		2		Yes
28th October 2022		3		Yes
29th October 2022		2		Yes
30th October 2022		3		Yes
31st October 2022		5		Yes
1st November 2022		3		Yes
2nd November 2022		3		Yes
3rd November 2022		7		Yes
4th November 2022		9		Yes
5th November 2022		7		Yes
6th November 2022		6		Yes
7th November 2022		6		Yes
8th November 2022		5		Yes
9th November 2022		7		Yes
10th November 2022		6		Yes
11th November 2022		9		Yes
12th November 2022		7		Yes
13th November 2022		7		Yes
14th November 2022		6		Yes
15th November 2022		7		Yes
16th November 2022		7		Yes

Table 11 - PM_{10}- 24 Hour Dust Concentrations

Date	Pollutant	Measured Concentration µg/m³	Allowable Concentration µg/m³	Complies
18th October 2022	PM_{10}	16	50	Yes
19th October 2022		24		Yes
20th October 2022		19		Yes
21st October 2022		20		Yes
22nd October 2022		14		Yes
23rd October 2022		12		Yes
24th October 2022		6		Yes
25th October 2022		11		Yes
26th October 2022		8		Yes
27th October 2022		8		Yes
28th October 2022		11		Yes
29th October 2022		9		Yes
30th October 2022		6		Yes
31st October 2022		25		Yes
1st November 2022		7		Yes
2nd November 2022		10		Yes
3rd November 2022		32		Yes
4th November 2022		34		Yes
5th November 2022		35		Yes
6th November 2022		12		Yes
7th November 2022		20		Yes
8th November 2022		19		Yes
9th November 2022		32		Yes
10th November 2022		40		Yes
11th November 2022		50		Yes
12th November 2022		49		Yes
13th November 2022		17		Yes
14th November 2022		38		Yes
15th November 2022		35		Yes
16th November 2022		36		Yes

8.2 NOISE MONITORING RESULTS

Refer to Appendix F for the daily graphs of the noise monitoring along the boundary of the Liverpool Girls High School.

- Given that the noise management level for educational receivers is internal, we have assumed a 10dB(A) correction (through an open window). This results in an external noise management level of 55dB(A)$L_{eq(15min)}$ which will be used to reference against the noise monitoring results.
- Based on the measured noise levels, the trend seems to indicate that during the daytime period, the noise levels are between 50 to 70 dB(A)$L_{eq.}$
- Notwithstanding, in the event that the surrounding receivers raised an issue with regards to the construction noise, construction methodologies are to be reviewed and modified to prevent or mitigate the likelihood of recurrence.
- The noise monitoring results are stored at 15-minute intervals and the diurnal plots for the noise monitor are presented in Appendix F. Table 12 presents the results in a statistical table that show the percentage of time the noise levels at the receivers were below the Noise Management Level and the percentages of time where the NML was exceeded at different band levels in increments of 5dB.
- It must be noted the NML only applies to a ground level receiver. Noise levels at first floor receivers are typically higher.

Table 12 - Summary of Compliance to Noise Management Levels

Date	≤ NML	NML to (NML+5dB)	(NML+5dB) to (NML+10dB)	(NML+10dB) to (NML+15dB)
18th October 2022	50%	31%	19%	0%
19th October 2022	57%	44%	0%	0%
20th October 2022	89%	9%	2%	0%
21st October 2022	52%	36%	11%	0%
22nd October 2022	95%	5%	0%	0%
24th October 2022	57%	41%	2%	0%
25th October 2022	68%	32%	0%	0%
26th October 2022	25%	57%	18%	0%
27th October 2022	80%	21%	0%	0%
28th October 2022	75%	25%	0%	0%
29th October 2022	65%	35%	0%	0%
31st October 2022	36%	46%	16%	2%
1st November 2022	66%	34%	0%	0%
2nd November 2022	66%	2%	2%	0%
3rd November 2022	59%	40%	2%	0%
4th November 2022	61%	29%	4%	6%
5th November 2022	15%	15%	20%	10%
7th November 2022	52%	18%	21%	9%
8th November 2022	50%	25%	11%	7%
9th November 2022	36%	16%	16%	16%
10th November 2022	25%	7%	11%	25%
11th November 2022	16%	18%	16%	14%
12th November 2022	10%	5%	10%	70%
14th November 2022	21%	11%	39%	25%
15th November 2022	20%	9%	33%	33%
16th November 2022	23%	7%	14%	39%

9 CONCLUSION

Acoustic Logic has been engaged to conduct a noise, vibration and dust monitoring service during the demolition phase of the existing multi-storey carpark of Liverpool Hospital.

This report includes noise, vibration and dust monitoring results between the 18th October 2022 to the 16th November 2022.

Measured vibration levels during the monitoring period are presented in section 4.2 of this report and have been referenced to the vibration criteria detailed in section 3.4.1.

Measured noise levels during the monitoring period are presented in section 8.2 of this report and have been referenced to the noise management levels detailed in section 5.

Measured dust levels during the monitoring period are presented in section 8.1 of this report and have been referenced to the dust emission criteria detailed in section 6.

In addition, it is recommended to review the *'Ameliorative Measures'* detailed in the *'Stage 2 - Construction Noise and Vibration Management Plan'* (Ref: 20200931.9/2704A/R0/SN) prepared by this office for ongoing construction works to be undertaken at the project site.

We trust this information is satisfactory. Please contact us should you have any further queries.

Yours faithfully,

Acoustic Logic Pty Ltd
Shane Nichols

APPENDIX A – ELECTRON MICROSCOPE DATA SHEET

FEI COMPANY™

THE STRUCTURAL PROCESS MANAGEMENT COMPANY

FP 5005; Morgagni Series
Pre-Installation Instructions

4022 190 50071
Release date: 15-Apr-2002

Order code: 4022 190 50071
Revision date: 15-Apr-2002

Printed in The Netherlands

Safety instructions

Before starting any service task on an FEI Company product, such as an electron microscope or ion beam equipment, or any related accessories or third party equipment, the service engineer concerned must first have read and understood the relevant sections of the FEI Service Safety Manual.

The FEI Service Safety Manual, order code number 4022 190 50058, contains explicit instructions on safe working methods, descriptions of the various warning symbols and labels used on FEI equipment, and Material Safety Data Sheets for all toxic gases and materials which may be present.

A hardcopy of the FEI Service Safety Manual is shipped with every FEI Company electron microscope or ion beam instrument, and it is also present in electronic form on the FEI Customer Service CD-ROM.

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List of Illustrations

1 Introduction

This section gives physical details of the room, services to be present and ambient conditions required to accommodate an electron microscope type Morgagni and to allow it to produce the high performance it is designed to give. It must be emphasized that the time and expense devoted to a proper survey for siting the microscope is amply rewarded by the consequent trouble-free, consistent operation, and the resulting reduction in down-time.

1.1 Delegation of responsibilities

The customer is responsible for the pre-installation. Pre-installation means all the work to be done to prepare the room and make it suitable for installation and operation of the microscope system*. In addition, preparation of the route within the customers premises for the transportation of the crated microscope is the responsibility of the customer. The requirements are laid down in this handbook. The National Service Organization is responsible for the pre-installation site survey. SC Eindhoven can advise on general suitable locations. The pre-installation site survey must be a part of the negotiations before finalization of the order.

NOTE: The microscope does not include water, air or Nitrogen hoses, or electrical mains supply cable; these must be supplied by the customer or N.S.O.

A check list of the principal conditions is provided in section 11.
This list should be completed during the site survey.

NOTE: Measurements are given in metric units. Useful conversion are:

1 l	= 0.26 U.S. gallon;	1 U.S. gallon	= 3.79 l
1 l	= 0.22 Imp. gallon;	1 Imp. gallon	= 4.55 l
1 kg	= 2.2 lb;	1 lb	= 455 gm
1 cm	= 0.4 in;	1 in	= 2.54 cm
Temp. °C	= 5/9 x (°F - 32);	°F	= (9/5 x °C) +32.

2 Specifications

The Morgagni electron microscopes conform to the following standards and normative documents:

- EN55011 Group 1 class A — EMC emission, industrial, scientific and medical equipment. (March 1991).
- EN50082-2 — EMC immunity, residential, commercial and light industry (January 1992).
- IEC 1010-1 — Safety requirements for electrical equipment for measurement, control and laboratory use.

Also the EM208 conforms to the following provisions:

- 89/336/EEC — Electromagnetic compatibility directive.
- 73/023/EEC — Low voltage directive.
- X-Ray safety — The X ray emission is below 1µSv/hour at a distance of 10 cm.

3 General requirements of the microscope site

The following points should be taken into account when choosing a site for the microscope. It is not possible in this document to cover all the situations liable to be met. Should you have any doubts regarding the suitability of your proposed site, our team of experienced engineers will gladly advise you as to the best course of action.

Take the following factors into consideration:

- Avoid rooms subject to heavy vibrations, e.g. near lift-shafts, over underground installations producing vibrations, adjacent to busy roads, near rooms housing heavy machines (see 8 “Vibrations”).
- Avoid rooms subject to high levels of stray magnetic fields, e.g. near large electric motors or transformers, overlooking electric railways or tramways (see 7 “Magnetic fields”).
- The microscope site must be at least 3 metres (10 feet) distant from any other electron microscope.
- Means must be provided to entirely eliminate natural lighting.
- If the ambient conditions are liable to vary from those detailed in 6 “Ambient conditions”, a dust-free, air-conditioned room is strongly recommended for the installation.
- To assist the microscope operation, attention should also be paid to reducing the ambient noise level if this is above average.
- Special attention must be paid to the space requirements regarding the location of the microscope in relation to other equipment - especially equipment generating magnetic fields or mechanical vibrations (see 7 “Magnetic fields” and 8 “Vibrations”).
- If a closed-circuit cooling unit is to be used in conjunction with the microscope (see 9.3.3 “Closed loop cooling units”.), there must be provision for it to stand at least 3 metres (10 feet) from the microscope (preferably in an adjoining room which can be ventilated).

4 Dimensions and weights of the microscope

(See Figure 1-1 to Figure 1-6).

	Weight crated (kg)	**Dimensions** (w x d x h) (cm)	**Weight** unpacked (kg)	**Dimensions** (w x d x h) (cm)
Morgagni console + HT tank	950	191x122x215	800	168x85x195
Morgagni small items	180	80x120x102	125	
Morgagni ext. cabinet + small items	150	80x120x102	50 50	60x68x80

5 Space and floor loading requirements

(See Figure 1-1 to Figure 1-5)
The principal physical data of the microscope are as follows:

- Maximum depth of microscope : 85 cm
  incl. ext. cabinet (front to back) : 128 cm
- Maximum width of microscope : 168 cm
  incl. ext. cabinet : 211 cm
- Preferred minimum door width : 90 cm
- Absolute minimum door width : 82 cm **(*)**
- Minimum door height : 197 cm
- Maximum height of microscope : 235 cm
  (high tension cable fitted)
- Minimum ceiling clearance : 20 cm
  over High Tension cable
- Minimum ceiling height : 235 cm
  (255 cm recommended, with thin HT cable)
- Minimum clearance at right : 40 cm
  side of microscope
  (for service purposes)
- Minimum clearance at left : 42 cm
  side of console
  (for service purposes)
- Minimum clearance at rear of : 56 cm
  microscope (for service purposes)
- Minimum clearance at front of : 60 cm
  microscope (for operator)
- Minimum overall floor space
  operation and servicing
  (width x depth)
  With Extension cabinet : 250 x 300 cm
  Without Extension cabinet : 200 x 250 cm
- Weight of console incl. column : 700 kg
- Weight of H.T. generator : 78 kg
- Weight distribution : 580 kg/m^2
- Total weight of Morgagni : 925 kg
- Surface micr. console : 1.65 m^2
- Feet supporting main desk : LB 112 cm^2, R 201 cm^2, LF 162 cm^2
- Surface area of microscope foot : 475 cm^2
- Maximum point loading : 1.97 kg/cm^2
- Expected centre of gravity : approx. 3 cm behind centre of column and approx. 112 cm above the floor.

(*)If the door is of the absolute minimum width, before the microscope can enter, the main switch, PC door hinges and rear transport wheels must first be removed. To get the microscope into the room, additional transport materials should be organized!

6 Ambient conditions

General: the room in which the microscope is housed should have:

- no extraneous vibrations;
- low acoustical noise level;
- good ventilation;
- an absolutely dust-free atmosphere; this is helped if the wall covering is washable;
- a floor covering (not carpet) which is easily cleaned, impervious to oil and chemicals and non-flammable;
- no unnecessary items in the room;
- Air conditioning.
  The air conditioning temperature regulation system must not be an on off (i.e. switched) system but must be a proportional system.

Special consideration must be given to the surroundings with regard to stray magnetic fields and mechanical vibrations (see 7 “Magnetic fields” and 8 “Vibrations”).

- Heat dissipated into the ambient air: Morgagni, 100 kV, max. 2,3 kVA outputs fully loaded
- Heat dissipated in the cooling water: approx. 900 W (inlet temp. 20 °C, max. load).
- Recommended ambient temperature (for operator) : 23 °C
- Relative humidity at 20 °C (for operator) : 80%, dew point below 18 °C
- Maximum ambient temperature range for operation within specification : 12 °C to 30 °C
- Maximum permissible rate of temperature change (for instrument) : < 3 °C/hour

7 Magnetic fields

It is important when placing the microscope to avoid locations subject to strong magnetic fields. The microscope is most affected by stray fields in the horizontal plane.

For measuring magnetic fields, we strongly advise the use of the Bartington magnetic field sensor. This sensor is capable of measuring magnetic fields down to DC level, thus making it much more reliable than the test coil which was unable to measure magnetic fields at low frequencies.

The maximum tolerable **horizontal** interfering stray field (measured at the position of the objective lens) at which the guaranteed resolving power can be achieved is:

Morgagni $125nT_{p-p}$ (Both X, Y)

The maximum tolerable **vertical** interfering stray field (measured at the position of the objective lens) at which the guaranteed resolving power can be achieved is:

Morgagni $660nT_{p-p}$ (Z)

Measuring units
The fundamental equation describing the relationship between magnetic field H, magnetic flux density B and the permeability of free space μ is:

$B = \mu \times H \quad \mu = \mu o \times \mu_r$

B = Magnetic flux density, in Tesla (Wb/m^2) is 10^4 Gauss (old symbol)
μ = Permeability, in H/m (kg * m)
μo = $4\pi \times 10^{-7}$, in H/m (kg * m)
μ_r = 1 in vacuum and air
H = Magnetic field strength, in A/m

Example: $B = \mu o \times \mu r \times H = 4\pi \times 10^{-7} \times 1 \times 0.1 = 125nT$
$5.53\mu T = 1V_{p-p}$ /50 Hz when using the Philips measuring coil

Conversions from SI to the old system:

SI		**cgs**
1 Tesla	=	10kGauss
1 mT	=	10G
1μT	=	10mG
1nT	=	10μG

7.1 Magnetic field measurements

For the magnetic field measurement the following measuring equipment must be present:

- Bartington meter,
- The Hewlett and Packard analyzer model HP3560A

For information on the measuring equipment required, specification and typical test results, refer for Hewlett and Packard to the Quick Reference Manual or the “FEI Customer Service - Service manual CD” chapter “Site Data”

The template which should be used for the measurements of the magnetic fields is printed below.

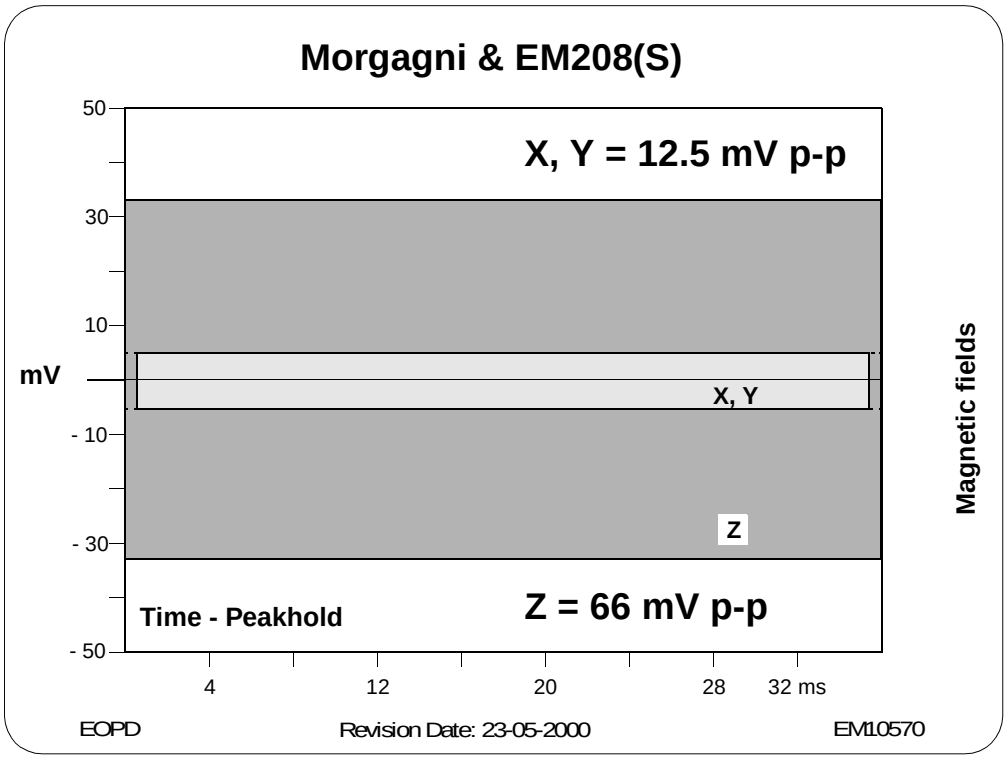


Fig. 7-1 Magnetic field template

8 Vibrations

8.1 Mechanical vibrations

As excessive mechanical vibrations seriously affect the performance of the microscope, it is important when choosing a site to make sure that this type of interference is not normally present.
For information on the measuring equipment required, specification and typical test results, refer for Hewlett and Packard to the Quick Reference Manual or the “FEI Customer Service - Service manual CD” chapter “Site Data”

All measurements must be carried out using the HP 3560A analyzer. Recommendations

- Always install the microscope directly on the concrete floor, and not on a sub-floor or tiles (there may be cavities or "spongy" regions between the tile or sub-floor surface and the concrete floor).
- The concrete floor must be rigid and at least 25 cm thick.
- In the case of a sub-floor or tiles, holes of 250 mm Ø can be drilled through to the concrete base. Steel studs can then be inserted in the holes so as to stand just a little higher than the subfloor or tile level (see Figure 8-1).
  The microscope feet may now be placed on these three studs, ensuring good mechanical contact with the concrete floor.

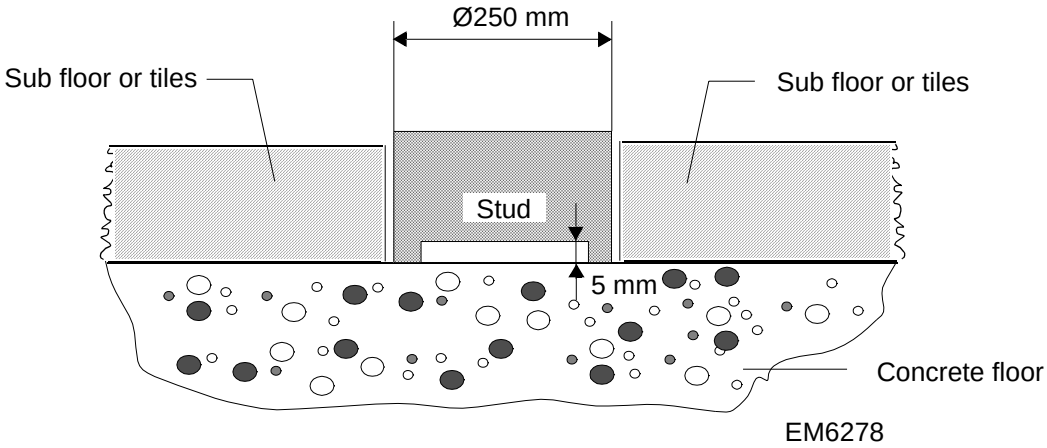


Fig. 8-1 Use of stud with sub-floor

8.1.1 Mechanical vibration evaluation and interpretation

The proposed procedure at the site is to measure a 1/3 octave vibration spectrum during a sufficiently long time to get enough low frequency information. Then the graphical specification of this direction is compared to this measurement. Now one of the following conclusions can be drawn:

1. In all points the measured level is clearly below curve I. This means the **site is appropriate!**
2. In only one point the level is below curve II, but in *all other points* at least a factor three lower. This means the **site is appropriate!**

3. When two or more points are below curve II consultation of an expert is required! (This situation is not likely to occur in practise very often, but it is the most critical one: the several points do not necessarily have to be *over the limit* to result in an inappropriate site!)
4. One or more points are clearly above curve III. This means the **site is NOT appropriate**.

8.1.2 Mechanical vibration measurements

For the mechanical vibration measurement the following measuring equipment must be present:

- Sensor,
- The Hewlett and Packard analyzer model HP3560A

For information on the measuring equipment required, specification and typical test results, refer for Hewlett and Packard to the Quick Reference Manual or the “FEI Customer Service - Service manual CD” chapter “Site Data”

The templates which should be used for the measurements of the mechanical measurements are printed below.

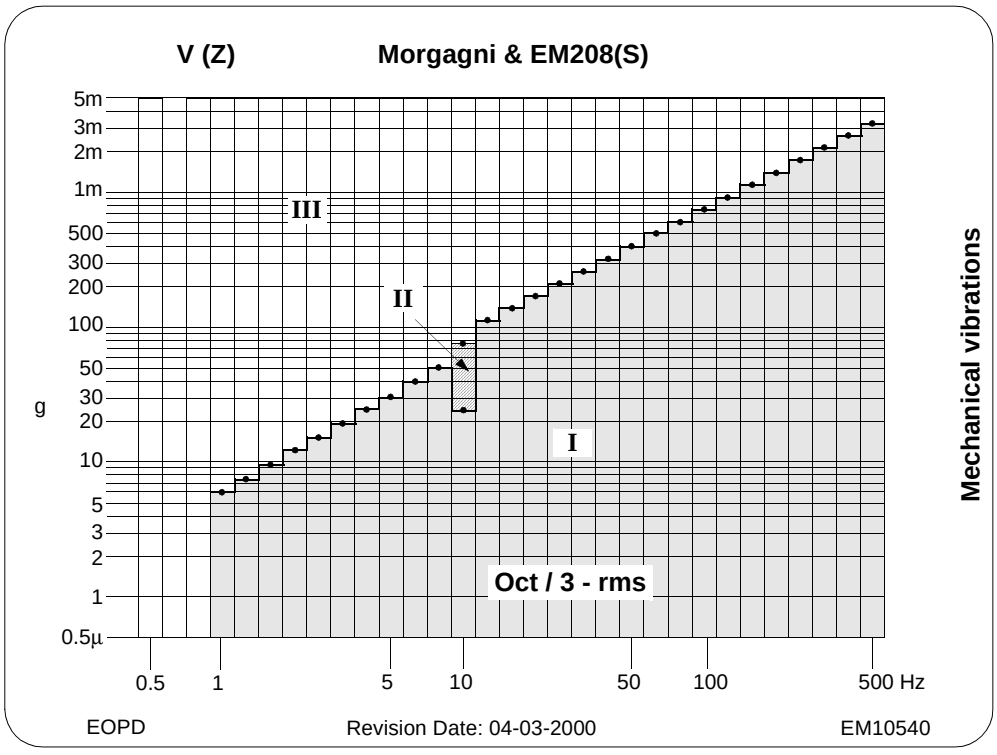


Fig. 8-2 Mechanical vertical vibration template

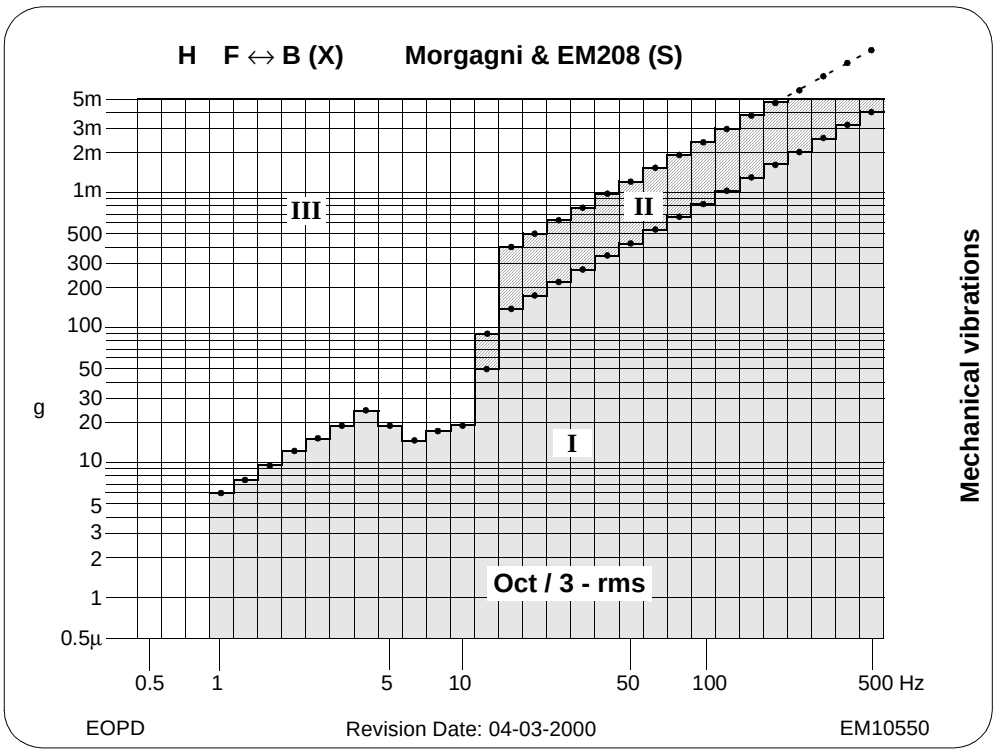


Fig. 8-3 Mechanical horizontal front to back vibration template

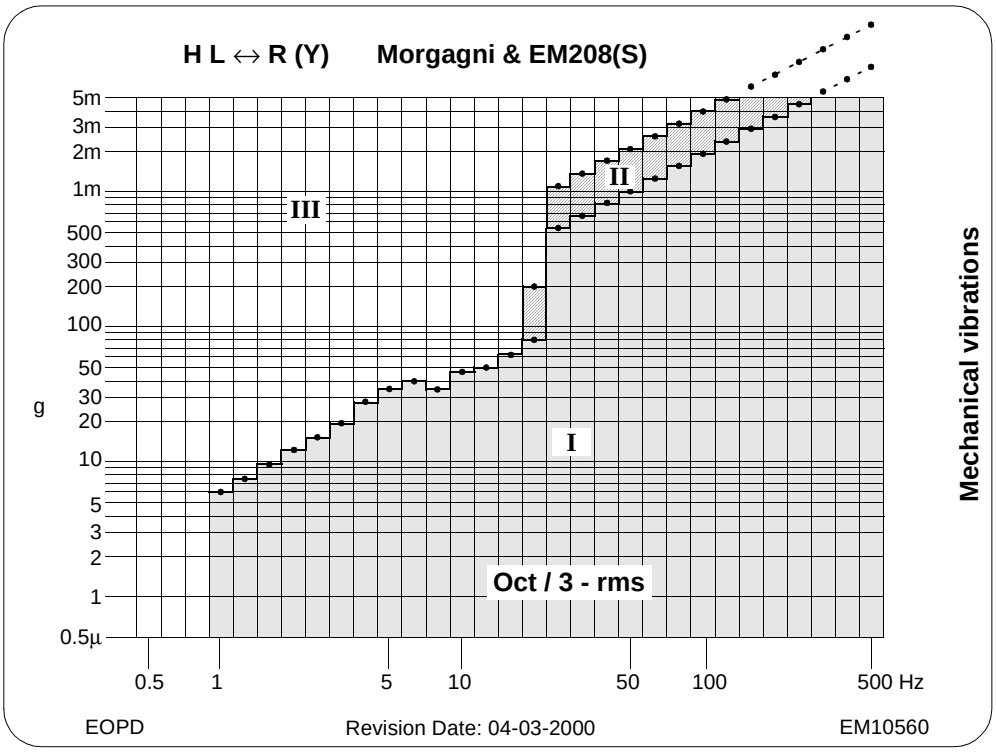


Fig. 8-4 Mechanical horizontal left to right vibration template

8.2 Acoustical vibration

Acoustical noise will affect the high resolution performance of the microscope. The acoustical noise level must be as low as possible. Ambient noise must be <70dB for the whole spectrum and <55dB per individual third octave band for the frequency range between 10 Hz and 10 kHz.

The following recommendations may help in achieving this:

- Cover the floor (and if necessary also the walls) with short-pile carpet that is easily cleaned, impervious to oil and chemicals, and non-flammable;
- The Zephyr unit, the air compressor and the mains matching transformer should be located behind a curtain;
- One of two opposite walls must be covered with an acoustic absorbing material;
- The air-conditioning must be absolutely silent. See also section 3 and Figure 1-5 and Figure 1-6 in the back of this manual.

8.2.1 Acoustical vibration measurements

For the acoustical vibration measurement the following measuring equipment must be present:

- Sensor,
- The Hewlett and Packard analyzer model HP3560A

For information on the measuring equipment required, specification and typical test results, refer for Hewlett and Packard to the Quick Reference Manual or the “FEI Customer Service - Service manual CD” chapter “Site Data”

The template which should be used for the measurements of the acoustical measurements are printed below.

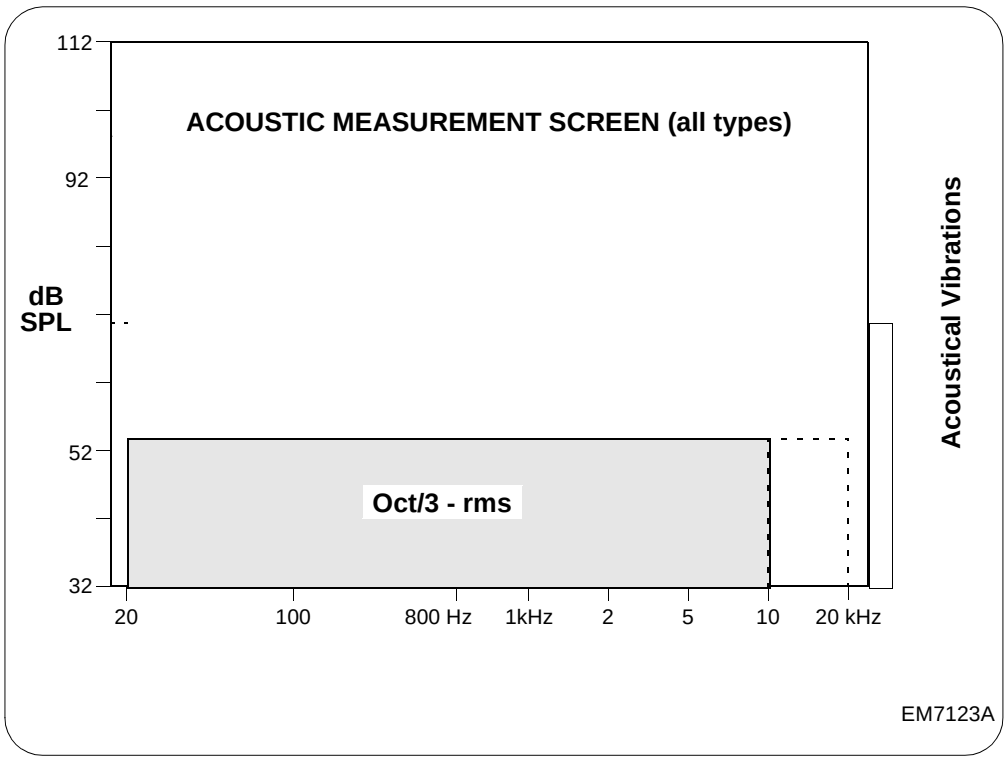


Fig. 8-5 All types Acoustic measurement template

9 Services required

9.1 Compressed air supply

(Figure 1-7)
An air supply at a overpressure of 4.0 to 7.0 x 10^5 Pa (4 to 7 Bar) must be connected to the microscope via an 8.5 mm hose pillar. The type of hose recommended has high pressure walls and an internal diameter of 8 mm. The supply may be made from a compressor unit or a cylinder of compressed air (or nitrogen) and should have an oil content of not more than 0.08 mg/ml.
If a separate compressor unit is used, it must be placed outside the microscope room and, to prevent switching transients of the compressor motor affecting the microscope electronics, the unit should be connected to a mains supply different from the microscope mains supply.
The working pressure of a separate compressor should be between 4.0 and 7.0 x 10^5 Pa (4 and 7 Bar).

9.2 N_2 Air inlet

(Figure 1-9)
The use of dry nitrogen for the air inlet is recommended, preferably from a cylinder of dry compressed nitrogen with a reduction valve and a clean supply tube with filter. The hose pillar has a diameter of 6.5 mm suitable for hoses with an internal diameter of 6 mm.
The nitrogen pressure should be 1.1 x 10^5 Pa (i.e. 0.1 Bar over-pressure). The content of H_20 should be less than 10 ppm.

9.3 Cooling water supply

(Figure 1-8)
The microscope requires a cooling-water supply which meets the following specification.
If the water supply available does not continuously meet these requirements the use of a Zephyr cooling water pre-heater or closed-circuit cooling unit is strongly recommended.

- Quality of cooling water: see 9.4 “Quality of cooling water”
- Water flow: max. 3 l/min.
- nom. 1.9 l/min.
- Water pressure:
  - minimum operating pressure: 2.0 x 10^5 Pa (2 Bar)
  - maximum tolerable pressure: 6.0 x 10^5 Pa (6 Bar)
- Water pressure stability:
  - pulses: better than 0.1 x 10^5 Pa (0.1 Bar)
- Input water temperature: 20 °C ± 0.5 °C

- Water temperature stability:
  - pulses: less than 0.2 °C/min. and long term < 1 °C/hour
- Relative humidity: > 20% and < 80%, dew point below 18 °C
- Connections to microscope: via 2 hose pillars 10.5 mm and 12.5 mm dia.
- Recommended hose internal dia.: 10 mm (high pressure)

The accessories described in Sects. 9.3.1 to 9.3.3 are recommended (see Figure 1-9).

9.3.1 Water filter assembly

(see Figure 1-8).
Contents:

- Water filter
- Electromagnetic water cut-off valve with timer (15 minutes)
- Two manometers to check the water flow or, from the difference indicated, the cleanliness of the filter.

9.3.2 Cooling water temperature stabilizer

ZEM 500 WW - 9432 909 96211
Data for ZEM 500 WW :

- Water flow: 2.4 litres/minute
- Water temperature in: min. 6 °C, max. 20 °C
- Water temperature out: 20 °C ± 0.2 °C
- Water connections: via 4 hose pillars for 10 mm high pressure hose
- Dimensions: 360 x 150 x 200 mm (w x d x h).
- Weight: 10 kg.

9.3.3 Closed loop cooling units

If a closed-circuit cooling unit is to be used in conjunction with the microscope it must preferably be placed in an adjoining room which can be ventilated.
Five different types of closed-loop cooling units can be ordered, depending on the cooling possibilities, i.e. air or water.

ZEM 1000 S	9432 909 96301 -50 Hz, 220 V air cooled max. 43 °C
ZEM 1000 S	9432 909 96311 -60 Hz, 220 V air cooled max. 43 °C
ZEM 1000 S Spare part kit	9432 909 96321
ZEM 1000 CT	9432 909 96191 -50 Hz, 220 V air cooled max. 55 °C
ZEM 1000 CW	9432 909 96201 -50 Hz, 220 V water cooled.
ZEM 1000 CW	9432 909 96241 -60 Hz, 220 V water cooled.

EM 1000 CT/CW Spare part kit	9432 909 96321

Data for ZEM 1000 S

Dimensions:	750 x 945 x 550 mm (w x h x d)
Weight:	108 kg (unpacked)
Water connections:	2 hose pillars 15 mm dia suitable for 10 mm high pressure hose are supplied, also connectors with clamping couplings and olive rings Ø 15 mm for copper pipes are provided.
Power:	230 V - 1 phase - 50 Hz 230 V - 1 phase - 60 Hz
Power consumption:	1.9 kW 50 Hz 2.3 kW 60 Hz
Cooling capacity:	3 kW at 20 °C water output and 35 °C air intake
Cooling water range:	+ 9 °C to 21 °C
Air flow:	2600 m^3 /hr (max.)
Temperature stability:	< 0.1 °C/min. at constant load
Temperature range:	-15 °C to 43 °C max.
Water flow:	26 l/min at 4 Bar
Cooling medium:	Freon 22 ($CHCLF_2$)

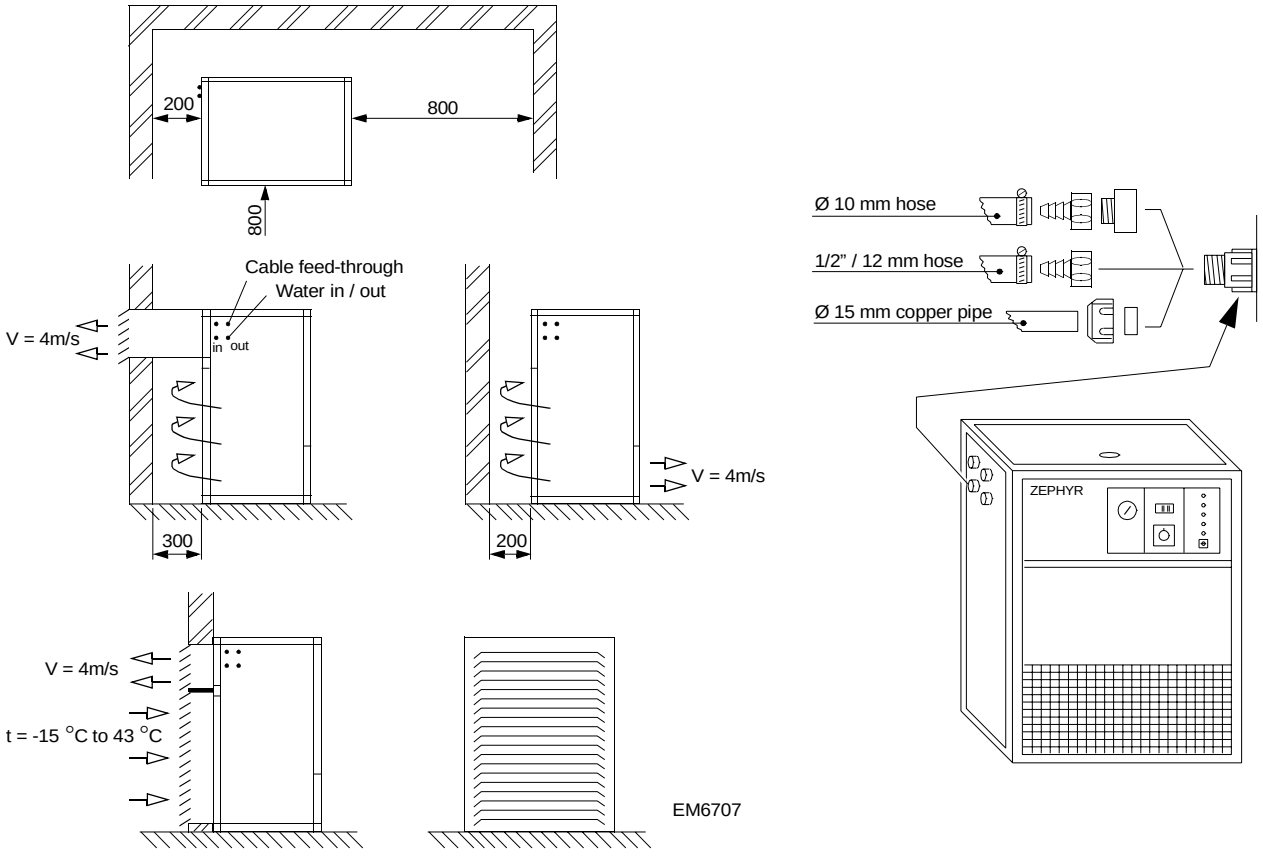


Fig. 9-1 Dimension sketch of the ZEM 1000 S versions

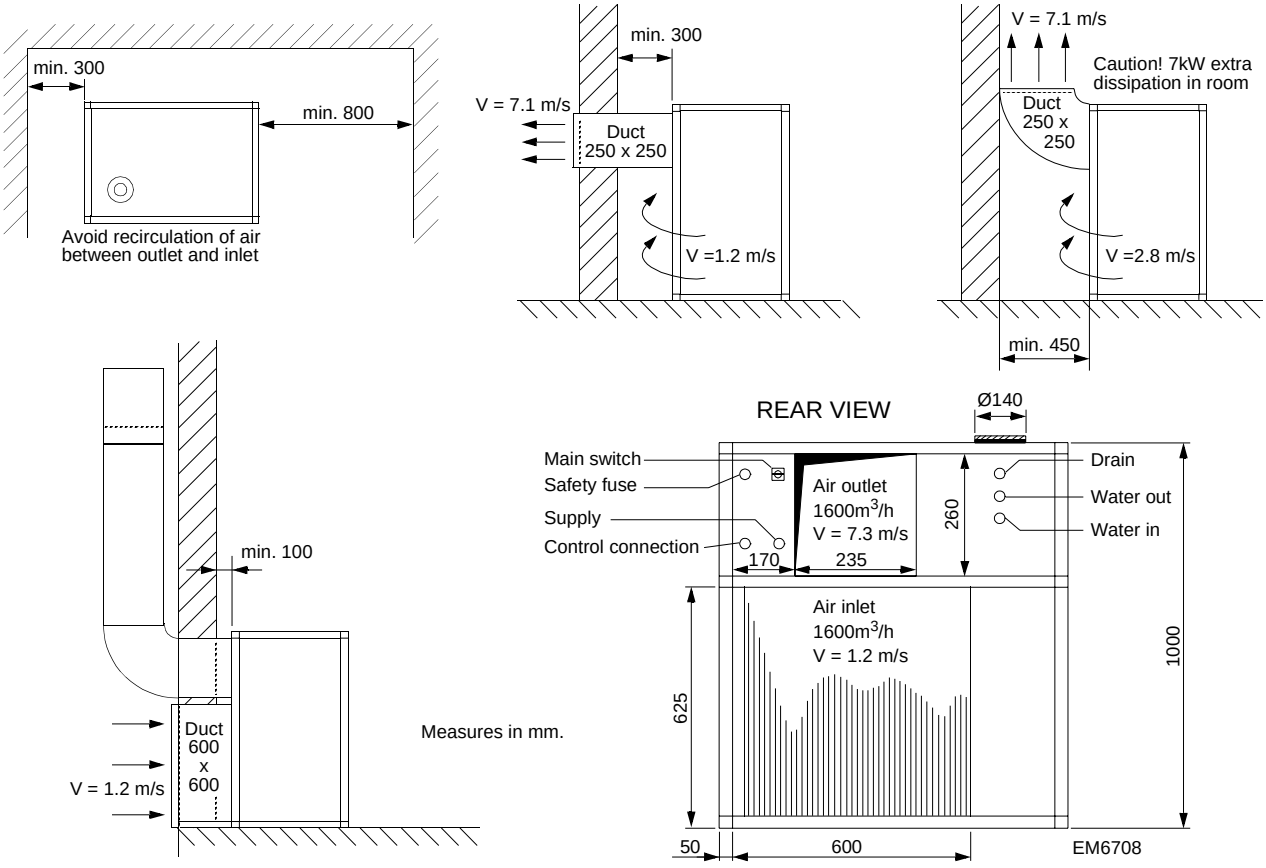


Fig. 9-2 Dimensioned sketch of ZEM 1000 CT versions

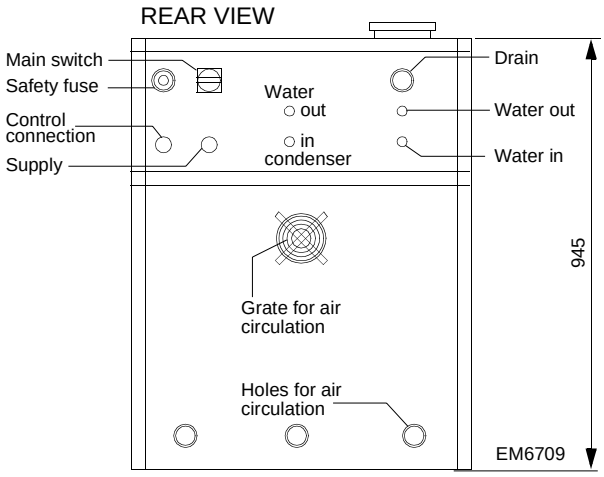


Fig. 9-3 Dimensioned sketch of ZEM 1000 CW versions

Data for ZEM 1000 CT/CW

Dimensions:	750 x 940 x 550 mm (w x h x d)
Weight:	135 kg (unpacked)
Water connections:	2 hose pillars 10 or 15 mm dia suitable for 10 mm high pressure hose are supplied, also connectors with clamping couplings and olive rings Ø 15 mm for copper pipes are provided.
Power :	230V - 1 phase - 50 Hz 230V - 1 phase - 60 Hz
Power consumption:	2.16 kW 50 Hz 2.37 kW 60 Hz
Cooling capacity:	3 kW at 20 ^{o}C water output and 35 ^{o}C air intake
Cooling water range:	+ 9 ^{o}C to 21 ^{o}C
Air flow *:	2600 m^3 /hr (max.)
Water consumption**:	300 l/hour at inlet temperature 10 ^{o}C and water outlet 30 ^{o}C 600 l/hour at inlet temperature 20 ^{o}C and water outlet 30 ^{o}C
Temperature stability:	< 0.3 ^{o}C/min. at constant load
Temperature range:	+ 5 ^{o}C to 55 ^{o}C max.
Water flow:	18 l/min at 4 Bar
Cooling medium:	Freon 22 ($CHCLF_2$)

The iron content of the cooling water may not exceed 0.2 mg/l.
Otherwise, a closed-loop cooling system is recommended.

* For ZEM 1000 CT only
** For ZEM 1000 CW only

9.4 Quality of cooling water

Precautions must be taken as necessary to ensure that the water circulated in the microscope is not harmful. The following general rules should be observed:

1. Open-loop (once-through) system :

Floating particles:
Particles such as dirt from the supply pipes, clay, sand, iron, hydroxides, etc. must be filtered out.
One of the following filters is recommended:

- Water filter type number PW6971/0: see 9.3.1 “Water filter assembly”.
- Water filter + element SMC 200-35-120, obtainable from:

  W&R Balston Ltd.
  Springfield Mill
  MAIDSTONE
  England

NOTE: The use of ceramic filters is not recommended as these very quickly become clogged (even if the water looks clean).

Water hardness:

- Hardness below 6 °D: no precautions necessary.
- 6 °D to 12 °D: use a polyphosphate agent to prevent calcium deposits forming.

  60 to 120 ppm CaO

  (1 °D = 10 ppm CaO)
- 12 °D to 25 °D: use a liquid organic polyphosphate***** agent (e.g. Nalco 345) to prevent calcium deposits forming. The water can also be softened by using a sodium exchange unit.
- Above 25 °D or with very acidic water (pH < 6 and/or chloride content > 200 ppm) the amounts of softening agents required become excessive, therefore a closed-loop cooling system is recommended under these circumstances.

***** As organic phosphates contribute to water pollution, the use of e.g. Poly-electrolyte Ameroyal is recommended.

Iron content:
The iron content of the cooling water may not exceed 0.2 mg/l.
If otherwise, a closed-loop cooling system is recommended.

2. Closed-loop (re-circulation) system: see 9.3 “Cooling water supply”.

Such a system should be used if:

- The water contains floating particles.
- The cooling water temperature is above 20.5 °C.
- The water pressure fluctuations are above 0.1×10^5 Pa (0.1 Bar)
- The water hardness is above 25 °D.
- The water is very acidic (i.e. pH < 6 and/or chloride content > 200 ppm).
- The water contains more than 0.2 mg iron per litre.
- Distilled water treated with 0.4% Drewgard 100, or tap water treated with 0.1% sodium borate with sodium nitrite (Na_3BO_3 and $NaNO_3$) can be used as a coolant. To stop bacterial growth, 1% sodium hypochloride (NaOCl) or Biosperse 250 in a proportion of 100 ppm can be added to the water.

NOTE: A cooling system that has become clogged by calcium or iron hydroxide deposits can be cleaned by circulating an inorganic acid such as hydrochloric acid (4% HCl) or an organic acid such as amino-sulphonic acid; sulphamine acid (HSO_3NH_2). Afterwards, flushing with plenty of running tap water is necessary.

9.5 Electrical

(See Figure 1-7)
The microscope can be connected directly to the local mains supply single or three-phase system via the built-in mains matching and isolating transformer. However, first contact your local mains supplier for installation recommendations such as max. permissible load and fusing.
If the microscope is connected to any other mains supply than 210, 220, 230,

240 or 250 V, an accessory mains matching transformer PW6345/51 is necessary (8 kVA). For connection see Figure 1-7.

NOTE: The transformer must be installed at least 3 metres distant from the microscope column to minimise stray fields.

- Mains supply required: 210 to 250 V, 50Hz single phase
  2 x 110V, 60 Hz two phase
- Power consumed by microscope: Morgagni Nom. 2,0 kVA
- Power consumed by microscope,: Morgagni Nom. 2.3 kVA including accessories and outlets fully loaded.
- Power factor: not specified
- Line voltage permitted: +6% -10% (slow variations or short duration transients)
- External fusing: 16 A slow-blow at 230 V
- Outlets loading: max. 270 VA
- Connections: 3-wire (1.5 mm^2 conductors),
  2 phases and earth
- Earthing A fixed, permanently installed earth conductor is required (shipped with the microscope)
- Earth resistance: Less than 0.1 Ohm
- Earth loops: earth loops must be avoided:
  - do not allow the microscope to touch external metal pipes or conduit.
  - water connections must be terminated with at least 15 cm of rubber hose, fitted after the main shut-off valve.

9.6 Earthing

As the leakage current allowed is > 3.5 mA, the microscope must be connected with a permanent protective earth. Therefore before any other connection is made, the instrument shall be connected permanently to this protective earth conductor.
The mains plug shall preferable be inserted into a socket outlet that is provided with a protective earth contact. However, the separate safety earth must remain permanently connected.
The safety provisions shall not be negated by the use of an extension cord without protective conductor.

WARNING! Any interruption of the protective conductor inside or outside the instrument, or disconnection of the protective earth terminal, is likely to make the to instrument dangerous. The local safety earth connection should meet local safety requirements. Have this checked during pre-installation survey.

9.7 Room lighting

(See Figure 1-7)
The room housing of the microscope should be well lit to assist microscope maintenance. When the lights are switched off it should be possible to put the room in total darkness by excluding natural light.
A dim light is required for microscope operation. The level of light provided by the dim light should be continuously adjustable by a thyristor unit or variable transformer. First check the magnetic field radiation of the unit to be used (see Chapter 7).
A separate power supply is required for the dim light in accordance with International Safety Requirements.
A foot-switch and impulse relay (not supplied as standard with the microscope) should be wired in parallel with the dimmer (see Figure 1-7).
An alternative to the foot switch for dim-light control is a pull switch mounted in the ceiling.

9.8 Panel lighting

The panel of the microscope can be illuminated by means of a spotlight which can be dimmed.

9.9 Dissipation data

Heat dissipated into the ambient air at max HT.

Microscope	Dissipation into the air Max.	Dissipation into the water Max.	Total dissipation Max.	Dissipation including outlets
Morgagni	1.4 kW	900 W	2,3 kW	2.6 kW

9.10 Air conditioning

The air conditioning temperature must be adjustable between 19 °C and 25 °C. The air conditioning temperature regulation system must not be an on off (i.e. switched) system but must be a proportional system.

10 Installation materials and tools

10.1 Installation materials

The following is a list of the materials required to install an electron microscope type EM208.
The materials may be either ordered separately or obtained locally.

Description	Ordering number	Remarks
Hose, dia. 6 mm int.	5322 530 20591	State req. length
Hose, dia. 8 mm int.	5322 530 20598	State req. length
Hose, dia. 10 mm int.	5322 530 20592	State req. length
Hose, dia. 15 mm int.	5322 530 20879	State req. length
Hose clamp, max. 14 mm	4822 401 10257	
Hose clamp, max. 20 mm	4822 401 10492	
Loctite 542, 50 ml	5322 390 34007	
Foot switch	5322 695 15172	not required for microscope
Impulse relay	5322 280 40278	not required for microscope
Spotlight lamp 24 V, 20 W	5322 134 10057	Halogen G4 (EM208S)
2 core cable for room light	5322 323 30026	State req. length
4 core cable for Zephyr unit	5322 323 40027	State req. length
N_2 filter	5322 480 20066	Grade 0.3 mm

10.2 Installation tools

To be able to install the microscope several tools must be present. Depending on the local situation these things must be available at customers site or the service engineers must take them with him. Make sure the customer knows which things he should provide.

- (Service engineer's) tool case.

  The set should contain a minimum of:
  - Set of screwdrivers, 1-2-3-4-5
  - Screwdriver posidrive, 1-2-3-4
  - Long-nosed pliers
  - Side-cutting pliers
  - Wire stripper
  - Polygrip pliers
  - Tweezers

  - AMP clamp plier, 0.25 / 6.6 mm^2
  - Box and open-ended spanners, 5-5.5-6-7-**8**-10-13-14-**17**-19-24 mm
  - Ratchet, 1/2" type
  - Sockets, **17** and **30** mm
  - Drill head adapter and socket, **8** mm
  - Set of sockets with ratchet, etc, 4 to 13 mm
  - Set of bits, pozidrive 1-2-3-4; hexagonal key, 6-8-10 mm. and adapter
  - Set of hexagonal keys, 1.5-2-2.5-3-3.5-4-4.5-5-5.5-6-8-10 mm
  - Ball-headed screwdriver, 2.5-3-4-6 mm
  - Hacksaw with spare blades
  - Hammer, 200 gm
  - Nylon-headed hammer
  - Crowbar, small 50 cm
  - Spirit level, 0.5 mm/m
  - Steel rule, 30 cm
  - Flexible steel rule, 2 m
  - Cable knife
  - Small flashlight
  - Nylon gloves
  - Thermometer, 5 °C to 50 °C
  - Solder set, iron 50W; solder sucker; copper braid; solder
- ESD field service kit
- Electrical hand drill: left/right rotation, with adj. speed
- Pallet truck; min. 1000 kg
- Multimeter / Oscilloscope
- Stable (clean) ladder 2m
- Stable (clean) table
- Cleaning materials
- High quality Ethanol or IsopropanolAluminum foil (without grease)
- Disposable handgloves (not powdered)
- Cleaning tissues (Dust free, eg Kimwipes)
- Clean plastic bags
- Wash bottle
- Hairdryer
- Light microscope with bright lenses (for positioning filaments)
- Vacuum cleaner (Only to be used for cleaning the microscope)
- Power extension box incl. cable

11 Pre-installation check list

Subject	Min. / Max. value	Checked and ok yes	no	Remarks
Door opening	Pref. min. 90 cm width min. 197 cm height			Absolute min. door width 82 cm see Chapter 5
Ceiling height	min. 235 cm			255 cm recommended
Overall floor space	Pref.min. 250 x 300 cm Abs. min. 200 x 250 cm			incl. extension cabinet ext. cabinet NOT used
Room temperature	recommended 23 °C			min. 12 °C max. 30 °C
Room temperature variations	3 °C / hour			
Relative humidity	< 80 % and > 20 %			
Pneumatic air supply pressure	min. > 4.0 x 10^5 Pa (4 bar) max <7.0 x 10^5 Pa (7 bar) oil contents < 0.08 mg/cm^3			Connected via 8.5 mm hose pillars
Mechanical vibrations	see Chapter 8 ' Vibrations'			
Magnetic fields (horizontal)	Morgagni < 125nT			
Magnetic fields (vertical)	Morgagni < 660nT			
Water pressure	min. > 2.0 x 10^5 Pa (2 bar) max < 6.0 x 10^5 Pa (6 bar)			Minimum total water flow 114l/hour (1.9 liter/min)
Water pressure stability at input	Pulses max. < 0.1 x 10^5 Pa (0.1 bar)			
Water temperature at input	max 20 °C ± 0.5 °C			
Water temperature stability	< 0.2 °C / min			
Nitrogen supply over-pressure	max. 0.1 x10^5 Pa (0.1 bar) Water contents < 10 ppm			Connected via 6.0 mm hose pillars
Mains supply	210V, 220V, 230V, 240V, 250/ 50 Hz one phase 2x110V/ 60 Hz two phase			Other voltages via transformer PW 6345/01
Power consumption	Morgagni 2.3 kW incl. acc. 2.6 kW			
Line voltage	+6% -10%			including transients**
Mains connection	according to section 9.5			1.5 mm^2 conductors
Fusing and earthing	according to section 9.5			
Room lighting	according to section 9.6			

****NOTE:** In the case of voltages of - 6% with a duration of more than 1 min., a mains stabilizer PE1403 (850 VA) must be used to feed the heating element of the ODP

NOTE: Any deviation from these installation and safety requirements may cause deterioration in Instrument Specification.

Service Acceptance.....

User Acceptance.....

12 Material Safety Data Sheets (MSDS)

12.1 Introduction

CAUTION! The engineer/user must be aware that the information in an MSDS can vary depending on the country they are in and on the supplier. The following MSDSs should be consulted before installation.

12.2 Greases

- "Tradename : MOLYKOTE BR 2 PLUS, 01"
- "Tradename : SILICONE PASTE P 4"
- "Tradename : FOMBLIN RT 15"
- "Tradename : BRAYCOTE MICRONIC 1613"

12.3 Oils

- "Tradename : SHELL DIALA OIL B" (insulating oil)
- "Tradename : SANTOVAC 5, 65 ML" (vacuum pump oil)
- "Tradename : ULTRAGRADE 19" (lubricating oil)

12.4 Gases

- "Tradename : SULPHUR HEXAFLUORIDE" (SF_6)
- "Tradename : NITROGEN 10, LIQUID, 01"

12.5 Cleaning Chemicals

- "Tradename : CYCLOHEXANE" (C_6H_{12})
- "Chemical name : ETHANOL" (C_2H_5OH)
- "Chemical name : HYDROGEN PEROXIDE, SOLUTION, 20.0-60.0%" (H_2O_2, min. 27%)
- "Chemical name : ISOPROPYL ALCOHOL" ($CH_3CH0HCH_3$)
- "Chemical name : POTASSIUM HYDROXIDE" (KOH)
- "Chemical name : SODIUM HYDROXIDE" (NaOH)
- "Chemical name : ACETONE" (CH3COCH3)

12.6 Fluorescent Powder

- "Tradename : LUMILUX YELLOW-GREEN B 20-10 B (RIEDEL 54021)"

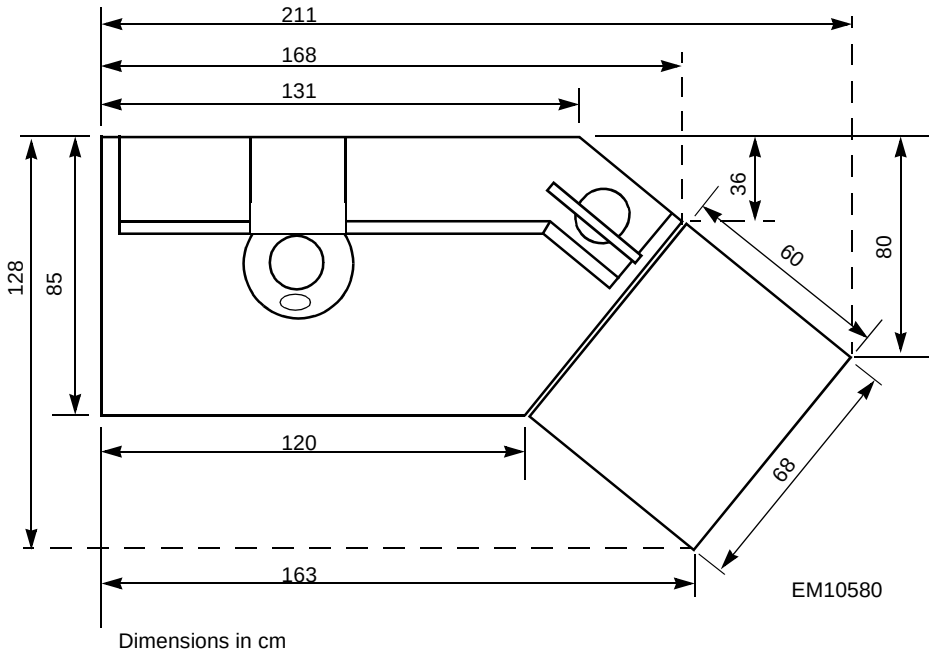


Fig. 1-1 Microscope dimensions

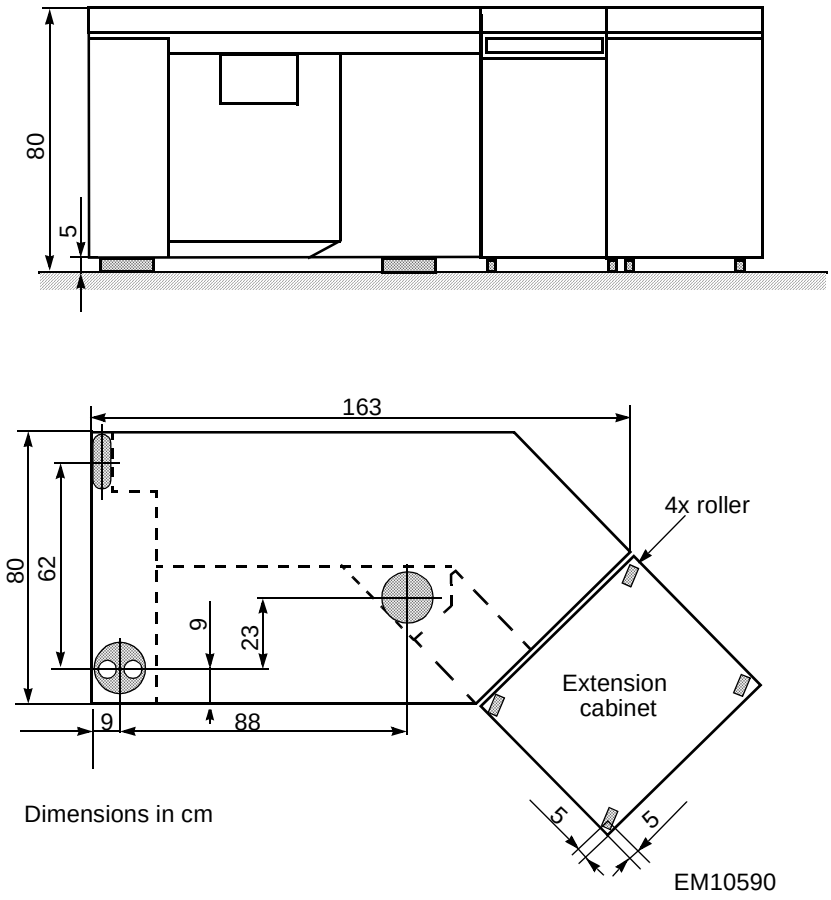


Fig. 1-2 Feet locations

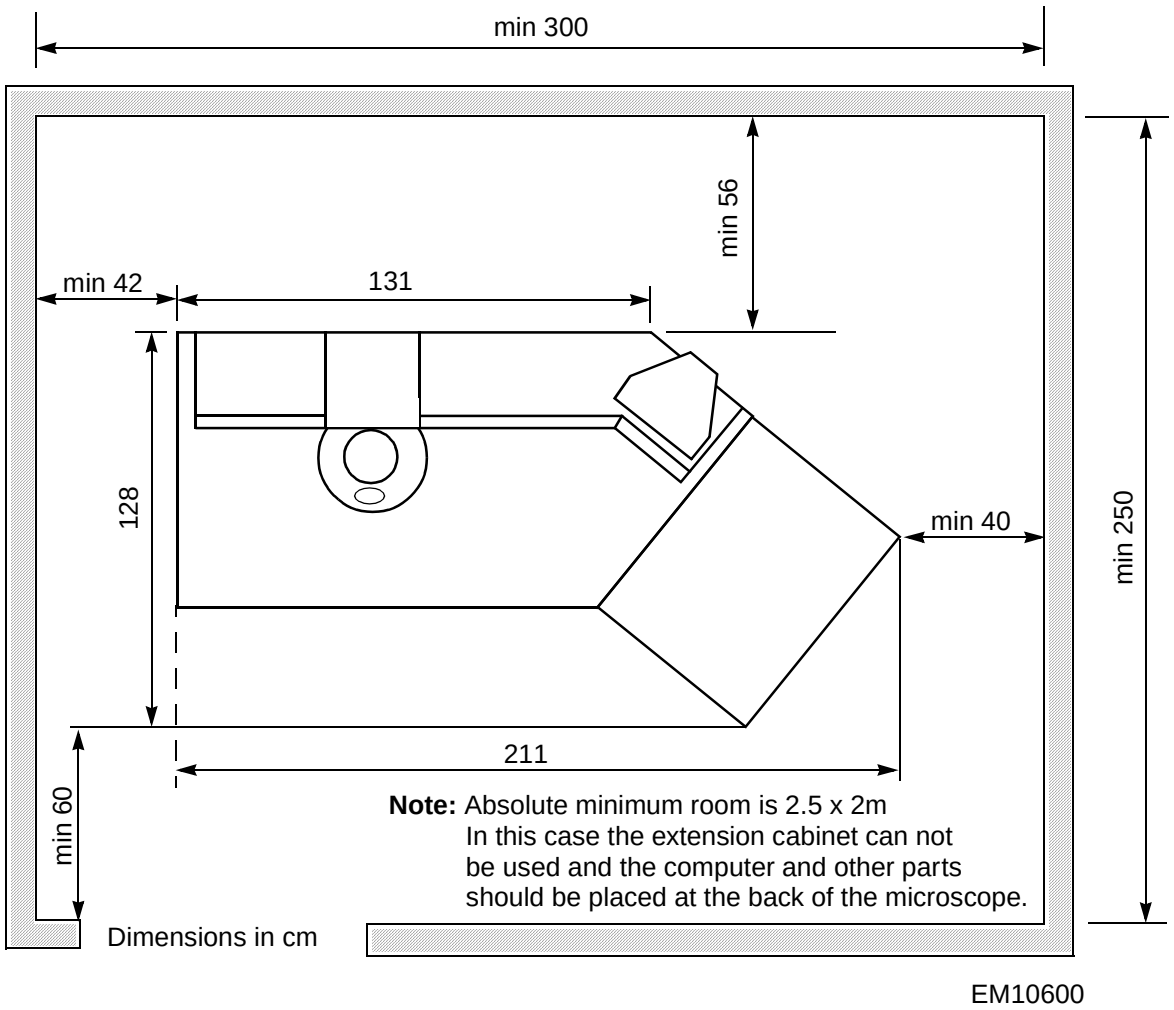


Fig. 1-3 Service clearance

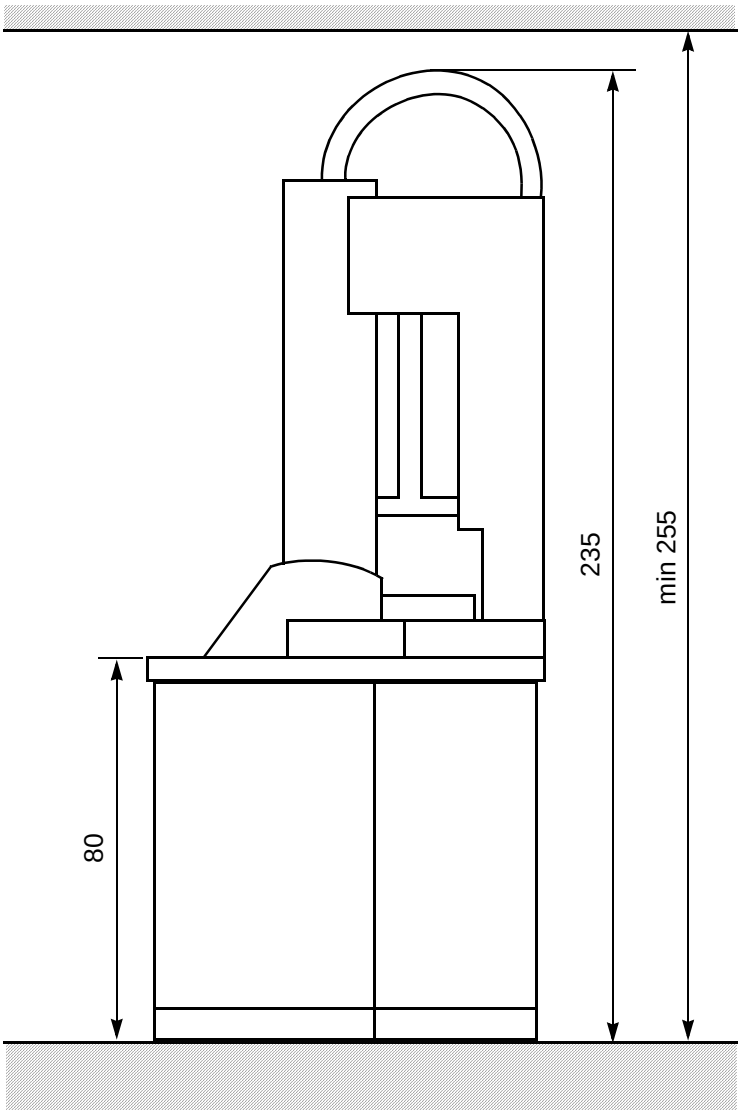


Fig. 1-4 Ceiling height

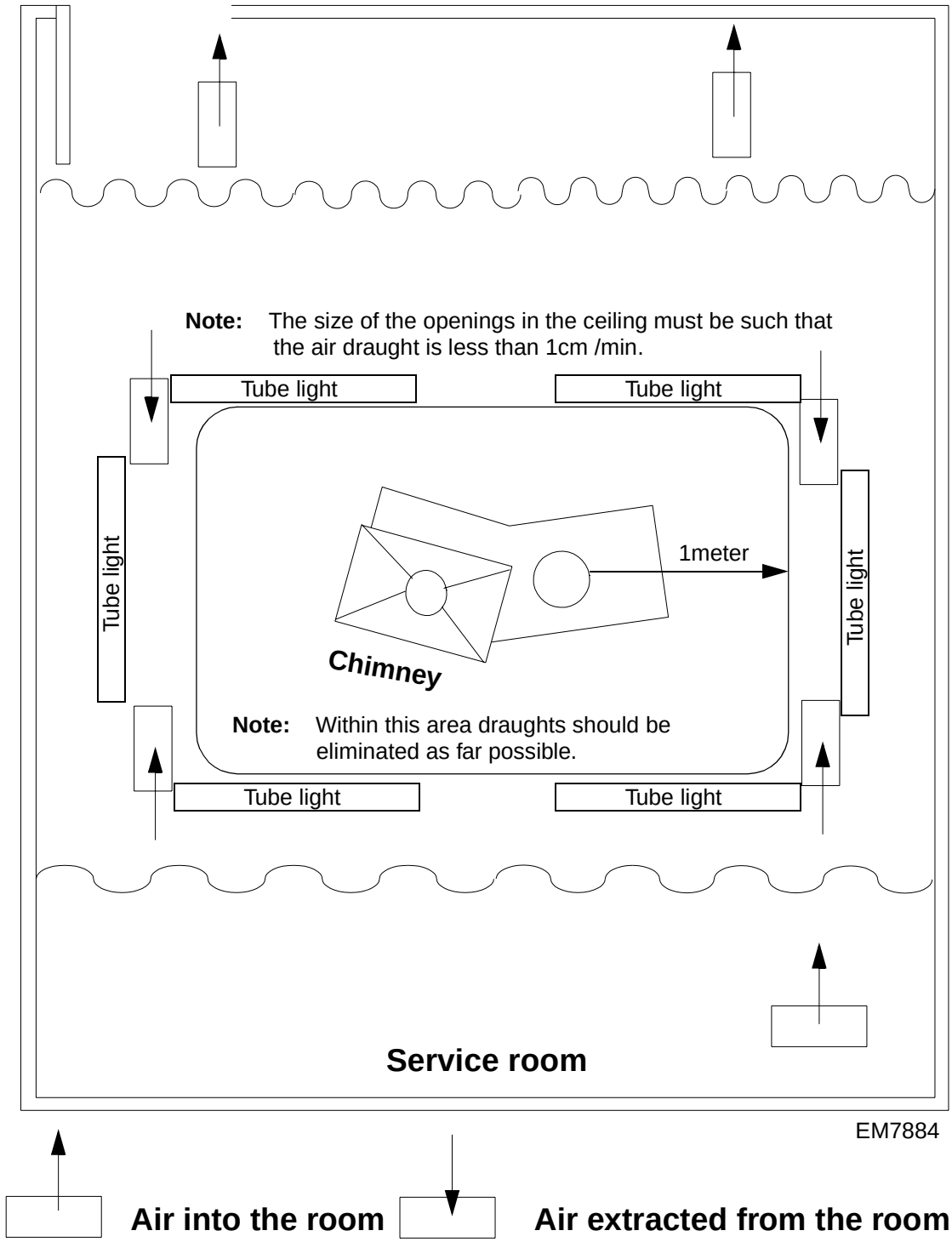


Fig. 1-5 General recommendations for air-conditioning & room light

Cross section of the room

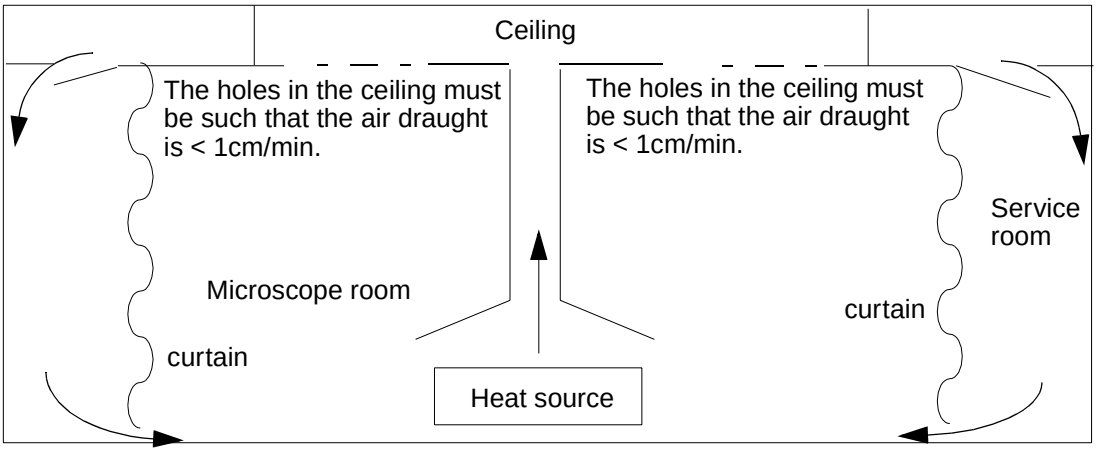


Fig. 6a

Most preferred room air-conditioning

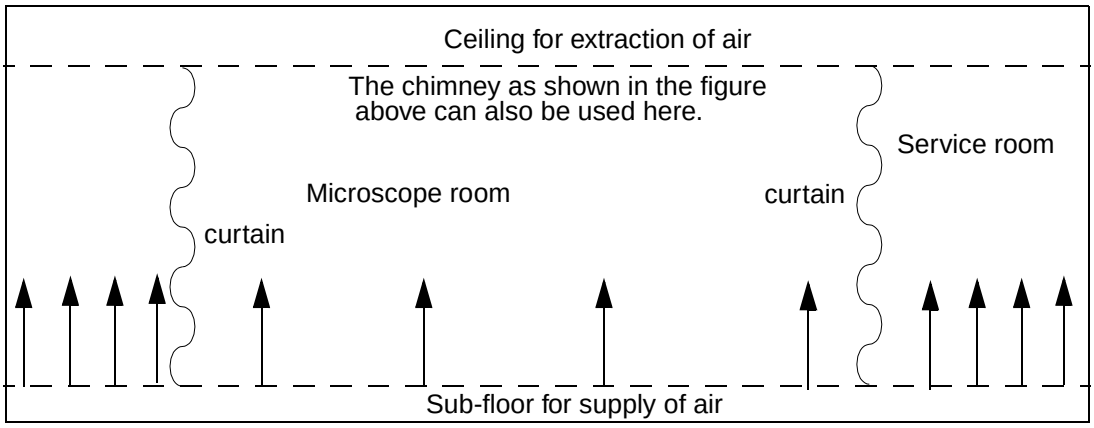


Fig. 6b

EM6917

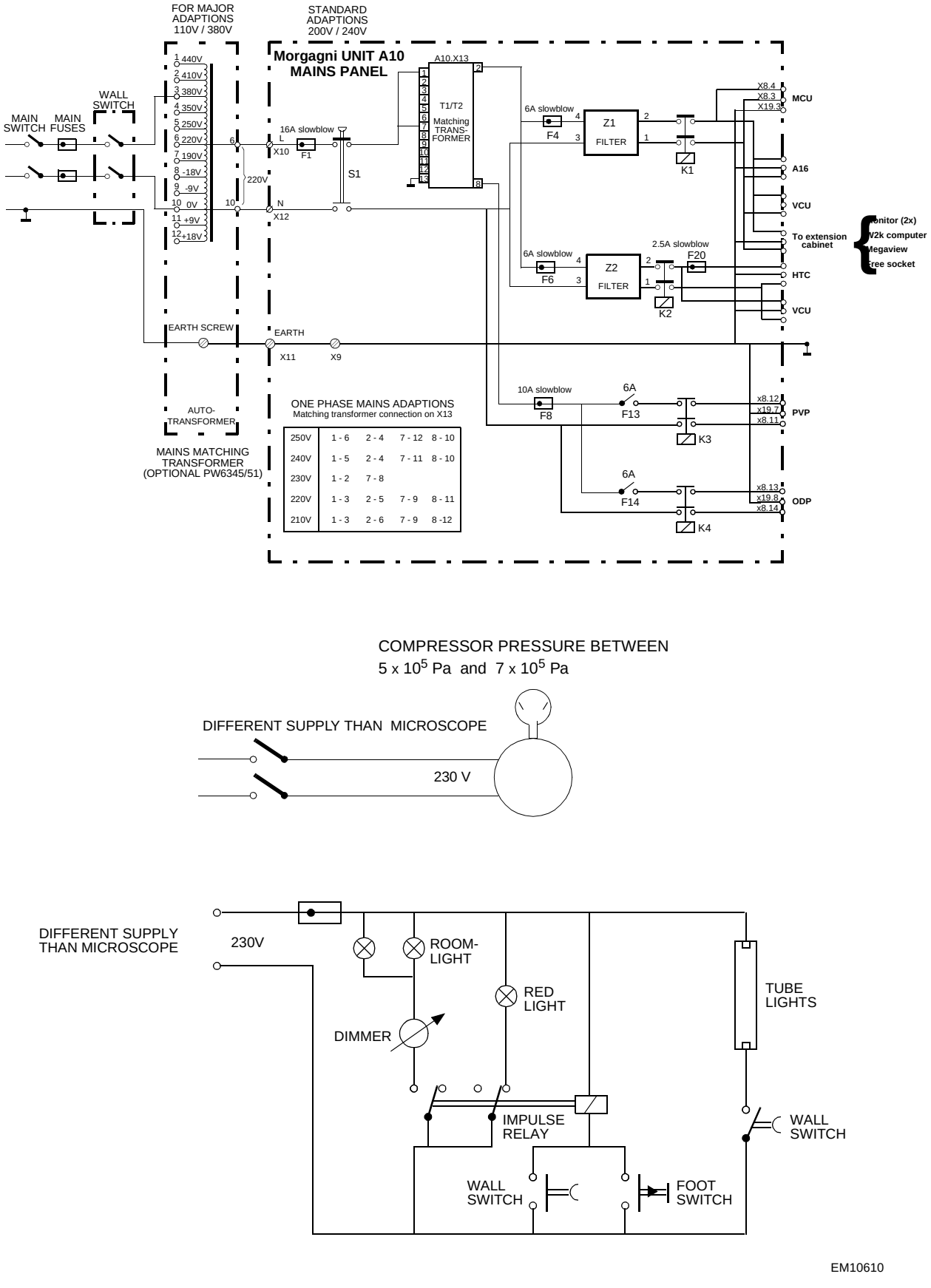
Fig. 1-6 Airflow

Fig :6 a. Preferably no air flow should be present in the microscope room. To prevent this the cold air is blown in via the so-called service room. The curtains will force the air to enter the microscope room via the floor. As the main heat source is now the electronics cabinet, a chimney can be made over the electronics cabinet to drain the local heat by convection (see also Fig. 6a). As a result the other drain openings can be made smaller.

Fig :6 b. Ideally the cold air is blown in from underneath the floor, see Fig. 6b, so that the air rises by natural convection.

Air conditioning .The air-conditioning temperature must be adjustable between 19 °C and 25 °C.

The air-conditioning temperature regulation system must not be an on off (i.e. switched) system but must be a proportional system.



EM10610

Fig. 1-7 Electrical connections

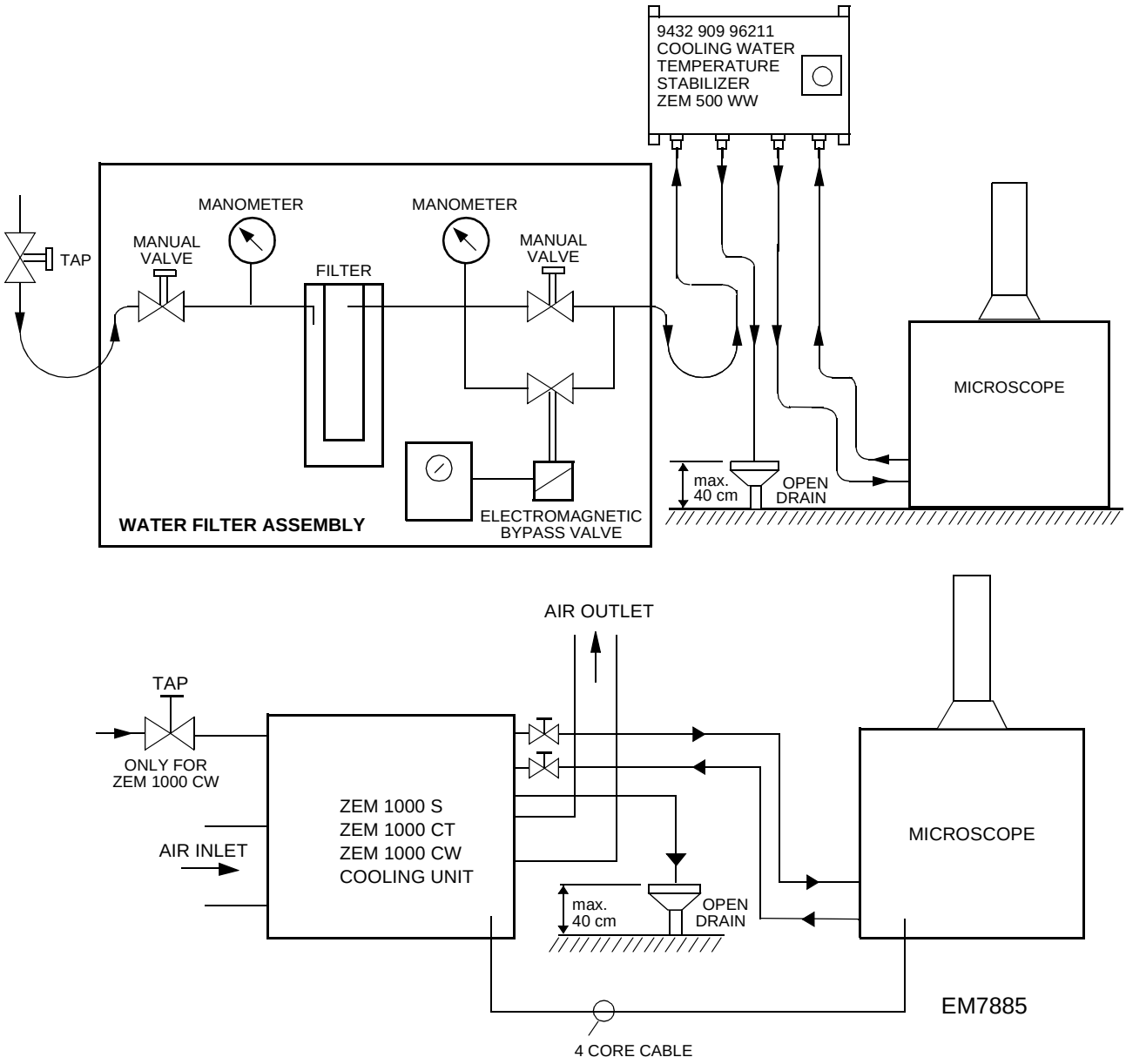


Fig. 1-8 Water connections

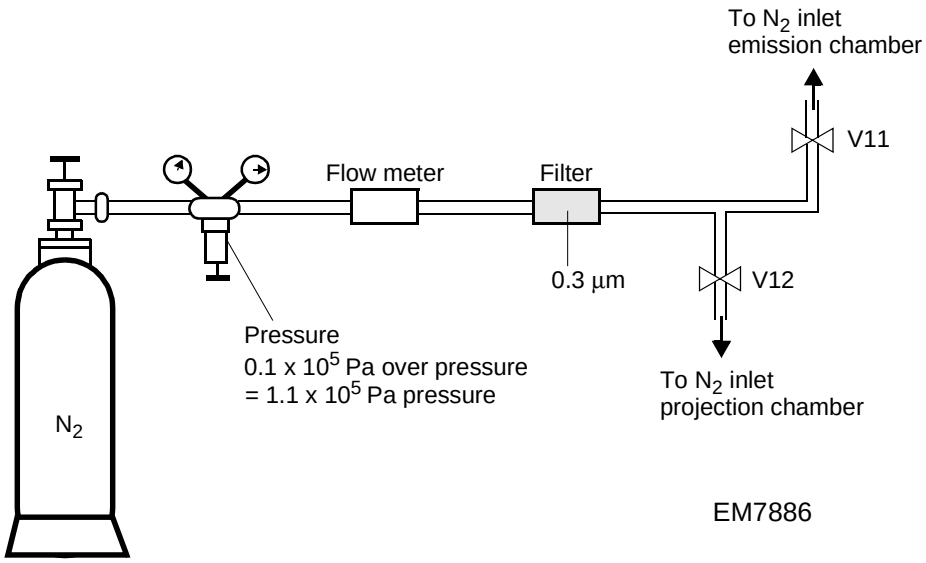


Fig. 1-9 Nitrogen connections

Appendix A
Conversion tables

Length

1 mm	= 0.0393 in
1 cm	= 0.3937 in
1 m	= 3.2808 ft
1 m	= 1.0936 yd
1 in	= 0.0254 m = 25.4 mm
1 in	= 2.54 cm
1 ft	= 0.3048 m
1 yd	= 0.9144 m

Moment (Torque)

1 newton meter	= 1 Nm = 0.102 kgfm
1 Nm	= 0.7375 lbft
1 lbft	= 1.356 Nm
1 kgfm	= 9.8 Nm

Mass

1 g	= 0.0353 oz
1 kg	= 2.205 lb
1 oz	= 28.35 g
1 lb	= 0.4536 kg

Temperature

0 °C	= 32 °F
°C	= 5/9.(°F - 32)
°F	= 9/5.(°C) + 32

Volume

1 cm^3	= 0.061 in^3 = 1ml
1 m^3	= 1.308 $yard^3$
1 litre	= 0.035 ft
1 litre	= 1.761 UK pints
1 litre	= 0.22 UK gallon
1 litre	= 2.113 US pints
1 litre	= 1.057 US quarts
1 litre	= 0.2642 US gallon
1in^3	= 16.387 cm^3
1 $yard^3$	= 0.7646 m^3
1 ft^3	= 28.32 litre =1 UK fl/oz
	= 28.41 cm^3
1 UK pint	= 0.57 litre
1 UK gallon	= 4.5461 litre
1 US pint	= 0.4732 litre

Volume (cont'd)

1 US quart	= 0.9463 litre
1 US fl/oz	= 29.57 cm^3
1 US gallon	= 3.785 litre

Energy

1 Joule	= 1 J = 1 Wsec = 0.2388 cal
1 kilo-Joule	= 1 kJ =1000 J = 0.9478 BTU
1 cal	= 1 frigory = 4.186 J
1 kcal	= 4.1865 kJ
1 BTU	= 1.055 kJ

Frequency

1 Hertz	= 1 Hz = 1 cycle/sec
	= 60 cycles/min(cpm)
1000 cpm	= 1000/60 Hz = 16.67 Hz

Force

1 newton	= 1 N = 0.2248 lbf
1 dyne	= 0.01 N
1 kgf	= 9.806 N
1 lbf	= 4.448 N

Flow

1 litre/min	= 5.886 x 10^{-4} ft^3/sec
1 litre/min	= 4.403 x 10^{-3} US gall/sec
1 litre/min	= 0.0037 x 10^{-3} UK gall/sec
1 ft^3/min	= 0.472 litre/sec
1 US gall/min	= 0.0631 litre/sec
1 UK gall/min	= 0.076 litre/sec

Power

1 watt	= 1 W = 1 J/sec = 0.2388 cal/sec
1 kilowatt	= 1 kW = 1000 W = 860 kcal/h
	= 1.36 pk = 1.34 hp
1 cal/sec	= 4.186 W
1 kcal/h	= 1.163 W
1000 frig/h	= 1.163 W
1 Brit ton of refr.	= 3.89 kW
1 US ton of refr.	= 200 BTU/min=3.51 kW
1 kWh	= 3600000 J = 3.6 MJ
1 pk	= 0.735 kW
1 hp	= 0.7457 kW

Pressure

1 Bar	= 1000 mBar = 10^5 Pa
	= 1.02 kgf/cm^2
	= 0.988 atm = 14.5 lb/in^2
1 mBar	= 0.1 kPa
1 kPa	= 1 kN/m^2 = 10 mBar
1 Pascal	= 1 Pa =1 N/m^2 = 0.01 mBar
1 lbf/in^2	= 0.07 kg/cm^2 = 0.068 atm
	= 6.894 kPa = 68.94 mBar
	= 0.069 Bar
1 kgf/cm^2	= 1 atm = 98.066 kPa
	= 0.9806 Bar
1 atm	= 101.325 kPa =1.0132 Bar
1 mm Hg	= 1 Torr= 0.1333 kPa
	= 1.333 mBar
1 mm H_2O	= 9.804 Pa = 98.066 mBar

Magnetism

Magnetic field strength:

$$H_{\text{p-p}} = \frac{2.76 \times V_{\text{p-p}}}{f} = Oersted$$

$$H_{\text{p-p}} = \frac{220 \times V_{\text{p-p}}}{f} = A_{\text{p-p}}/m$$

$$H = A/m \quad (H = \pm 0.0125 \text{ Oersted})$$

Magnetic induction:

B = μ x H	B = Tesla = 10^4 Gauss
	$\mu = \mu_0 \times \mu_r$
	μ_r = 1 in vacuum and air
	$\mu_0 = 4\pi \times 10^{-7}$ Vsec/A.m
Oersted	= $10^3/4\pi$ A/m = 79.6 A/m

Light

Color temperatures	K
Candlelight	= 1930
Tungsten lamp, home use	= 2800
Quartz halogen lamp	= 3200
Fluo. lamp, warm white	= 3500
Fluo. lamp, white	= 4500
Fluo. lamp, daylight	= 6500
Clear sky	= 10 000
Luminance	Lux
Clear, mid-day sky	=100 000
Cloudy, mid-day sky	= 32 000
Office, under fluo. light	= 500
Candle light, distance of 20 cm	= 10

Vacuum

Pressure units:

1 atm	= 760 Torr
1000 mBar	= 750 Torr = 10^5 Pa
1 Pa	= 0.01 mBar = 1.10^{-5} Bar
	= 7.5×10^{-3} Torr = 9.87×10^{-6} atm
	= 1.45×10^{-4} lbf/in^2
	= 1.02×10^{-5} kgf/cm^2
	= 2.953×10^{-4} in Hg
	= 7.5×10^{-4} mm Hg
	= 4.015×10^{-3} in H_2O
	= 0.102 mm H_2O
	= 7.5 micron = 99.99+ % vacuum
	= 1 N/m^2
1 atm	= 1.013 10^5 Pa = 101.325 kPa
1 Torr	= 1.333 10^2 Pa = 1 mm Hg
1 mm Hg	= 1.333×10^2 Pa
1 micron	= 1 μm Hg

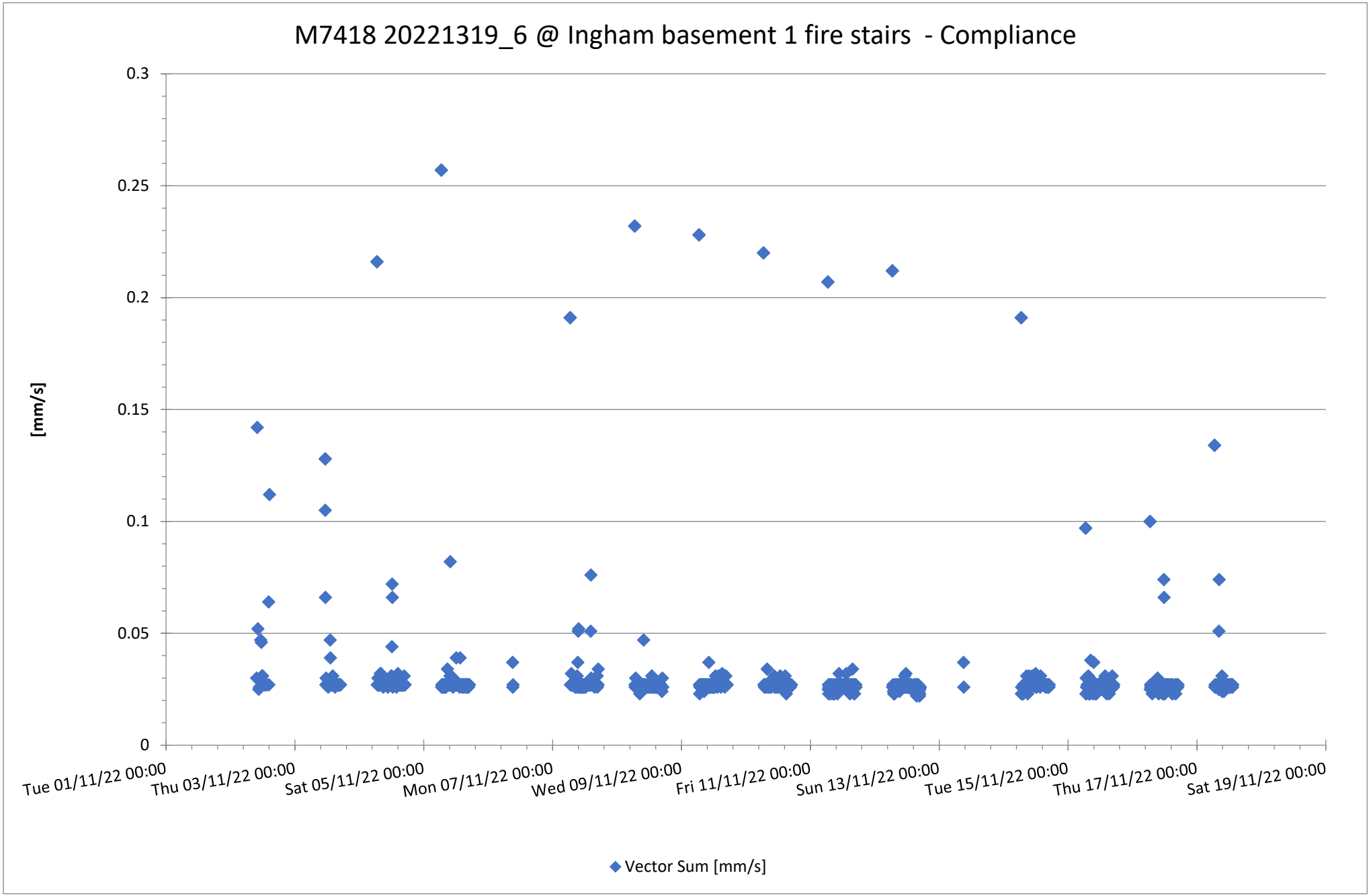
Pumping speed units:

1 l/s	= 60 l/min = 2.12 ft^3/min
	= 3.6 m^3/h
1 ft^3/min	= 0.472 l/s = 28.32 l/min
	= 1.7 m^3/h
1 m^3/h = 0.278 l/s	= 16.67 l/min = 0.589 ft^3/min

Leak rate units:

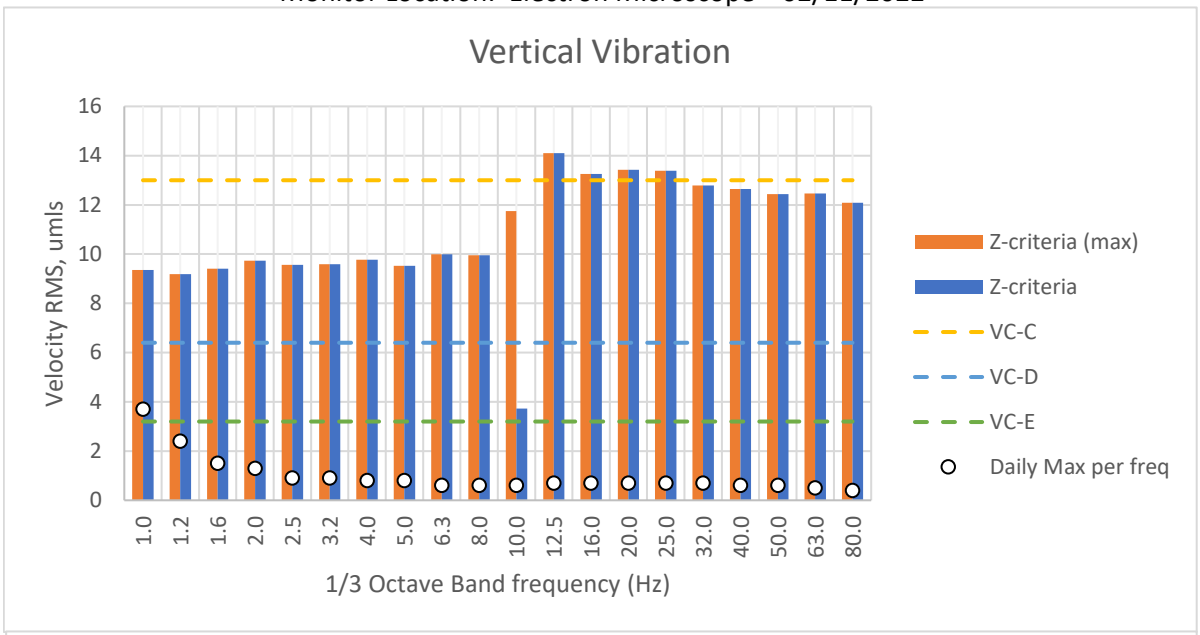
1 Torr l/s	= 1.333 mBarl/sec
	= 1.316 atm cm^3/sec
	= 10^3 lusec
	= 2.795×10^{-3} atm.ft^3/min
	= 2.083×10^5 grammes/year (Freon 12)
	= 5.7×10^{-3} kg/h (air)

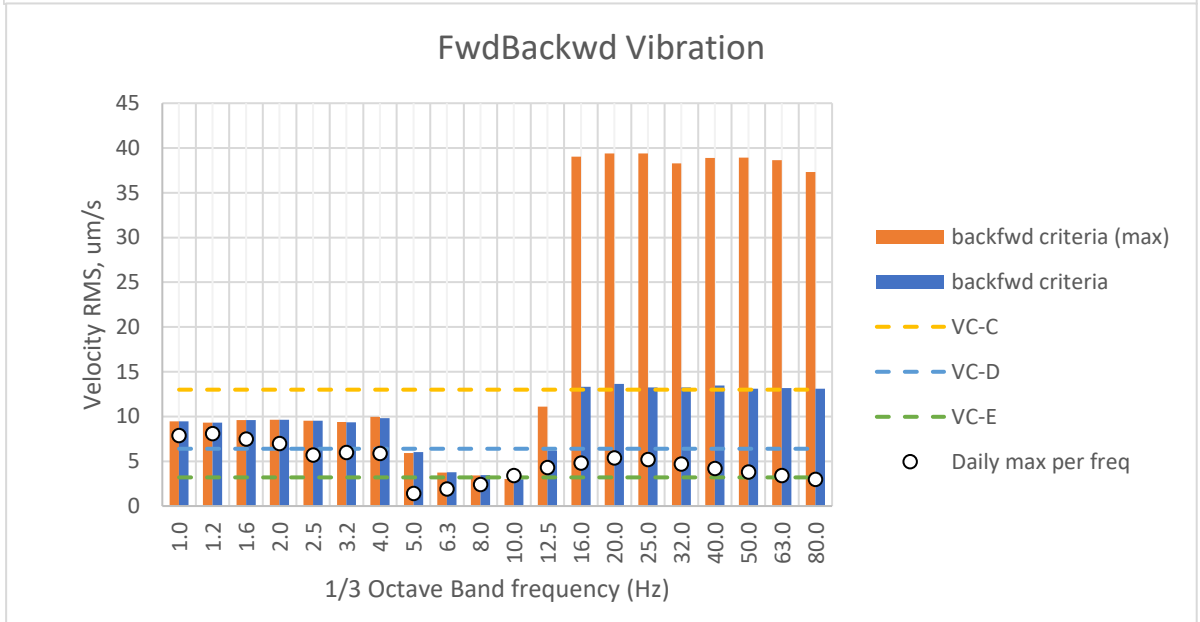
APPENDIX B – VIBRATION MONITORING DATA - FIRE STAIRS (LEVEL 1 BASEMENT)

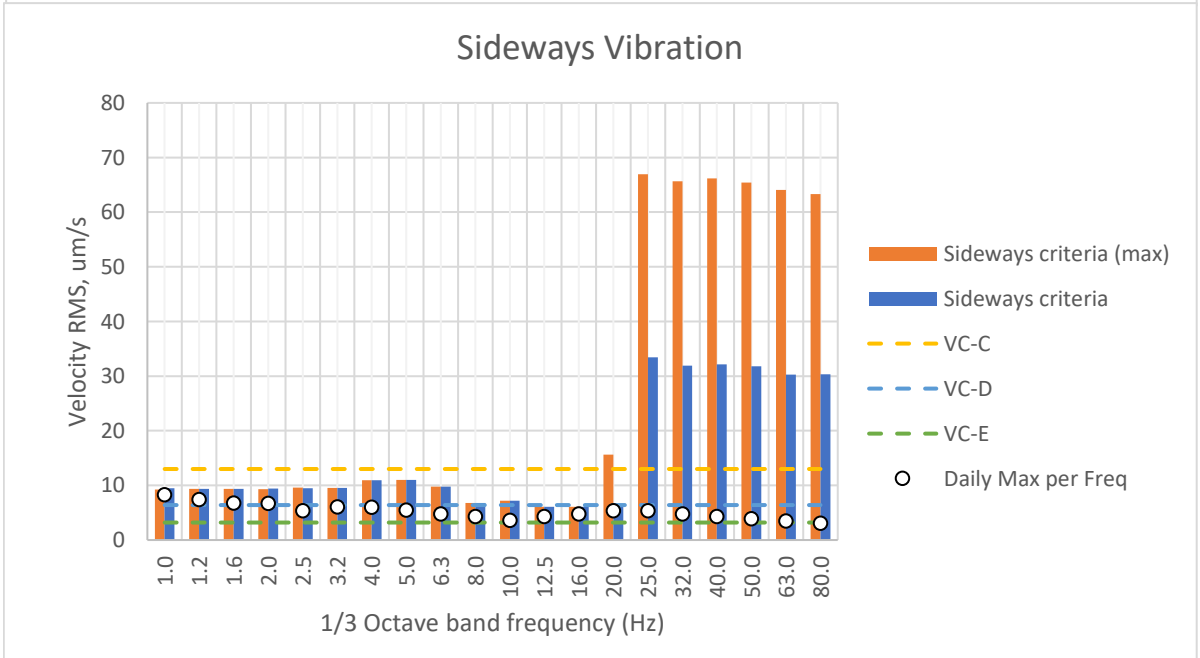

M7418 20221319_6 @ Ingham basement 1 fire stairs - Compliance
[mm/s]
0.3
0.25
0.2
0.15
0.1
0.05
0
Tue 01/11/22 00:00
Thu 03/11/22 00:00
Sat 05/11/22 00:00
Mon 07/11/22 00:00
Wed 09/11/22 00:00
Fri 11/11/22 00:00
Sun 13/11/22 00:00
Tue 15/11/22 00:00
Thu 17/11/22 00:00
Sat 19/11/22 00:00
Vector Sum [mm/s]

APPENDIX C – VIBRATION MONITORING DATA – ELECTRON MICROSCOPE

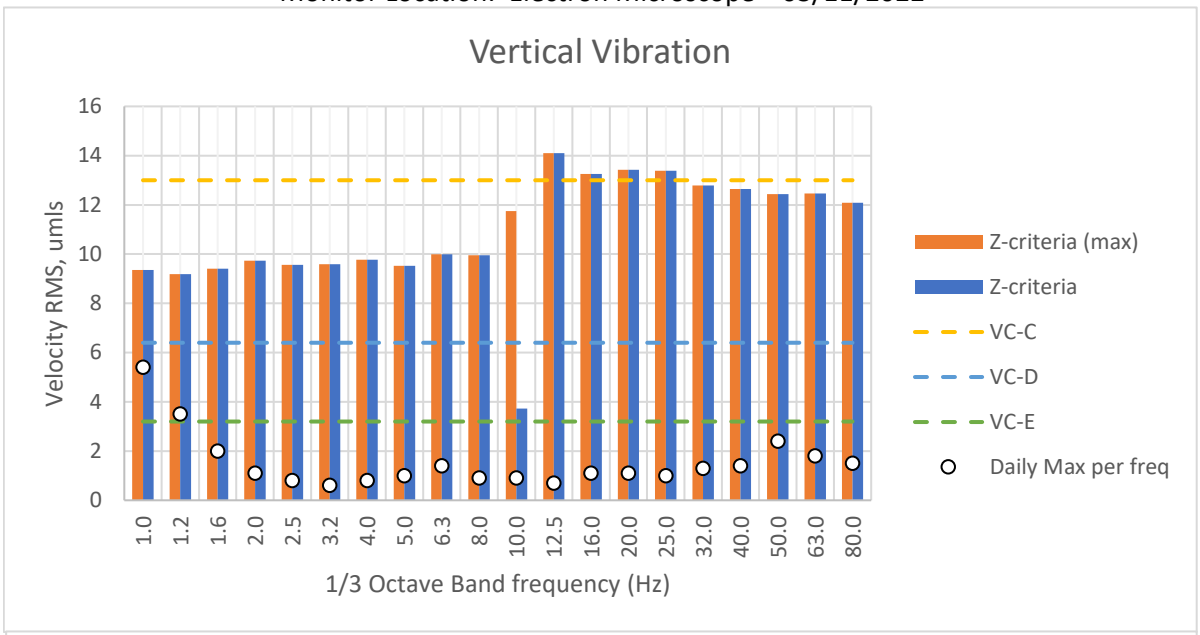
Monitor Location: Electron Microscope 02/11/2022

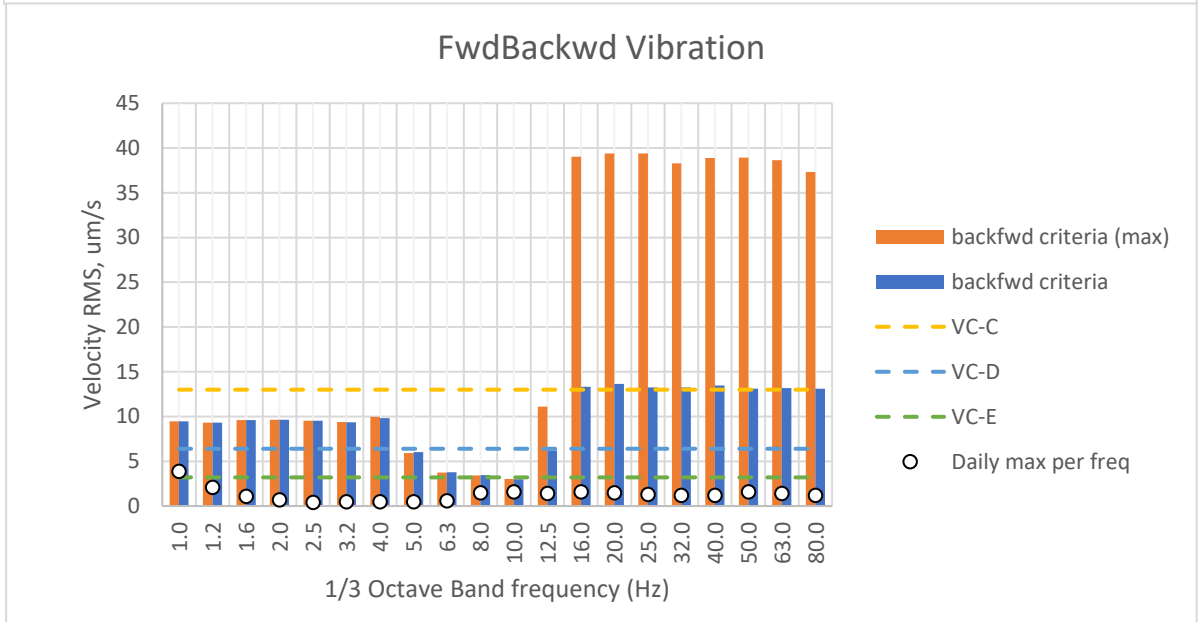


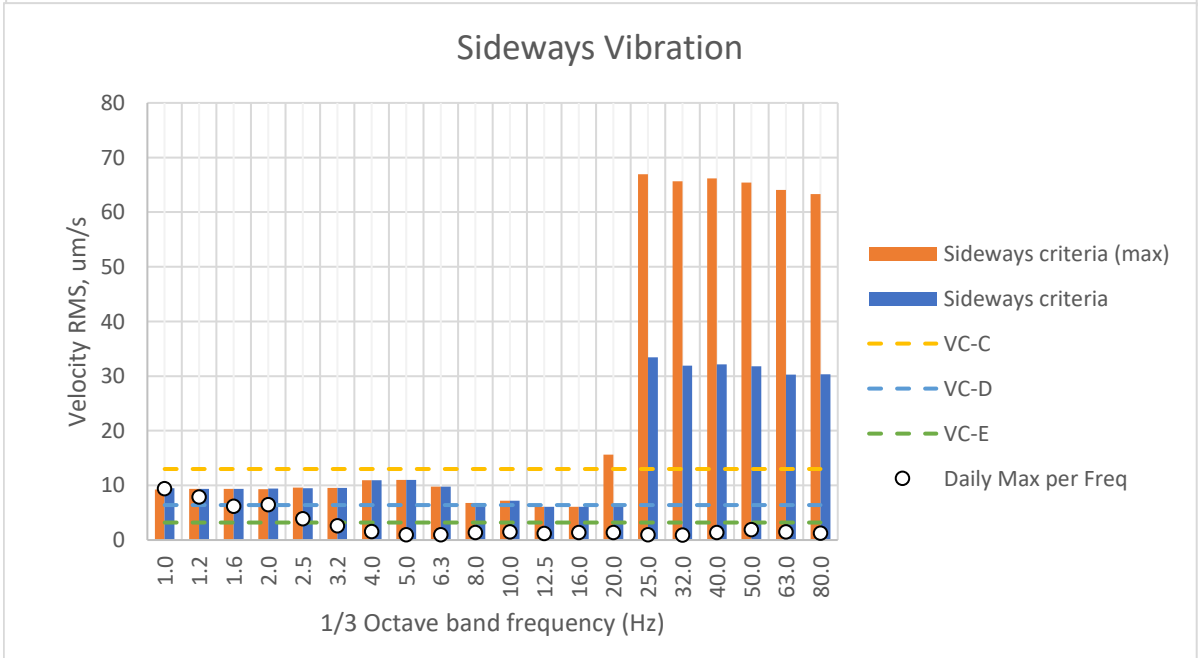




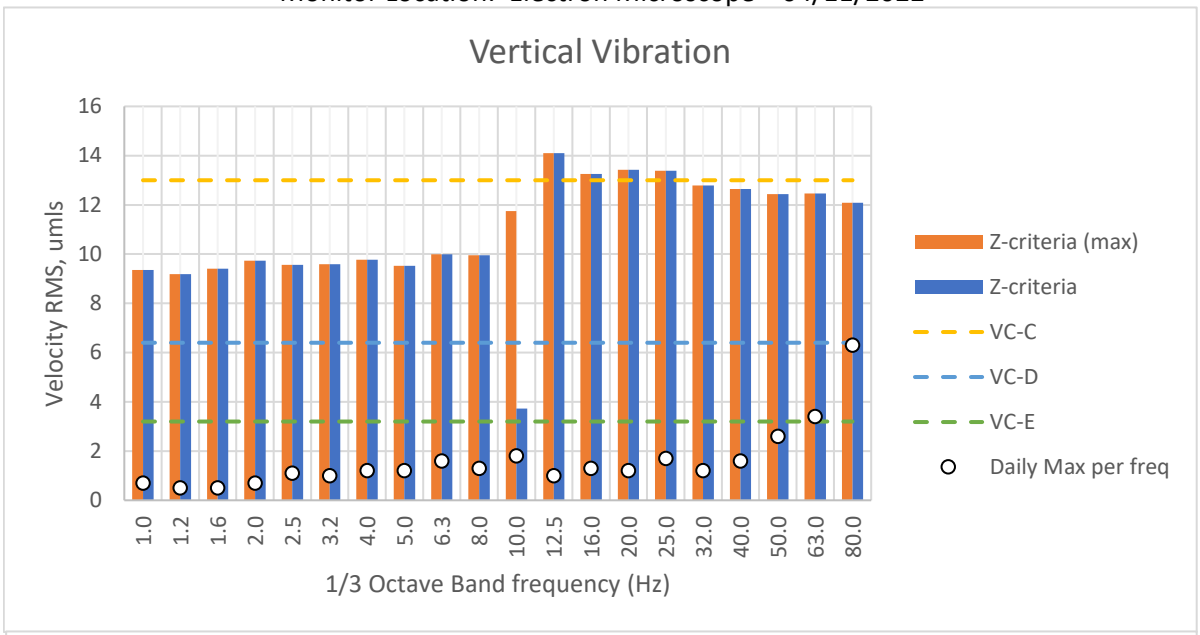
Monitor Location: Electron Microscope 03/11/2022

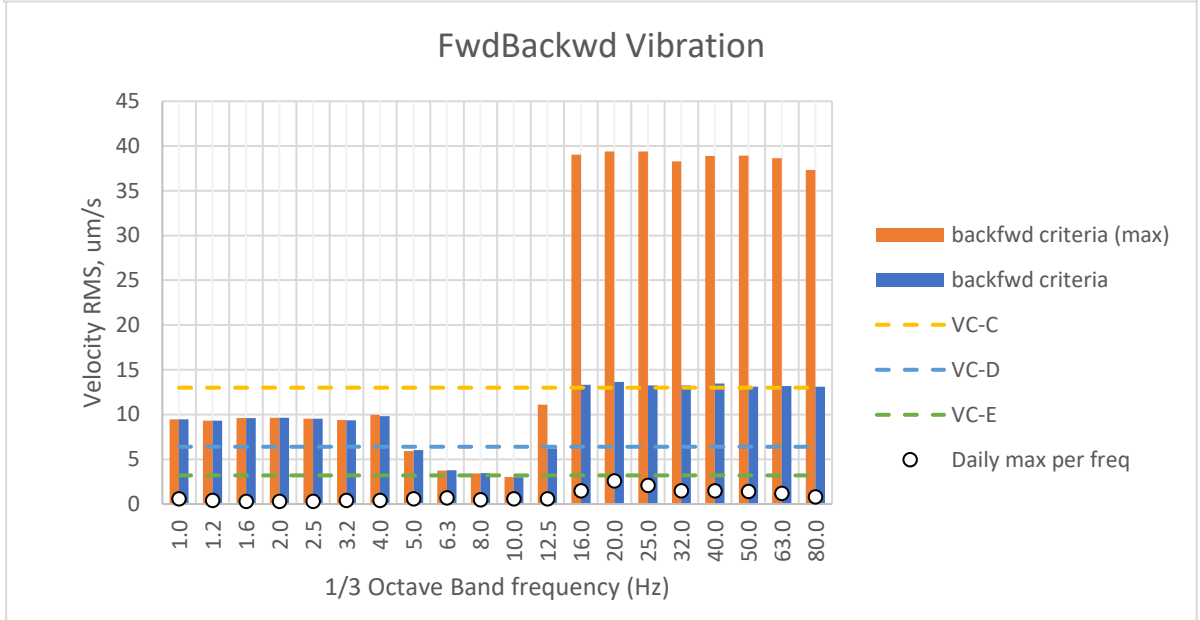


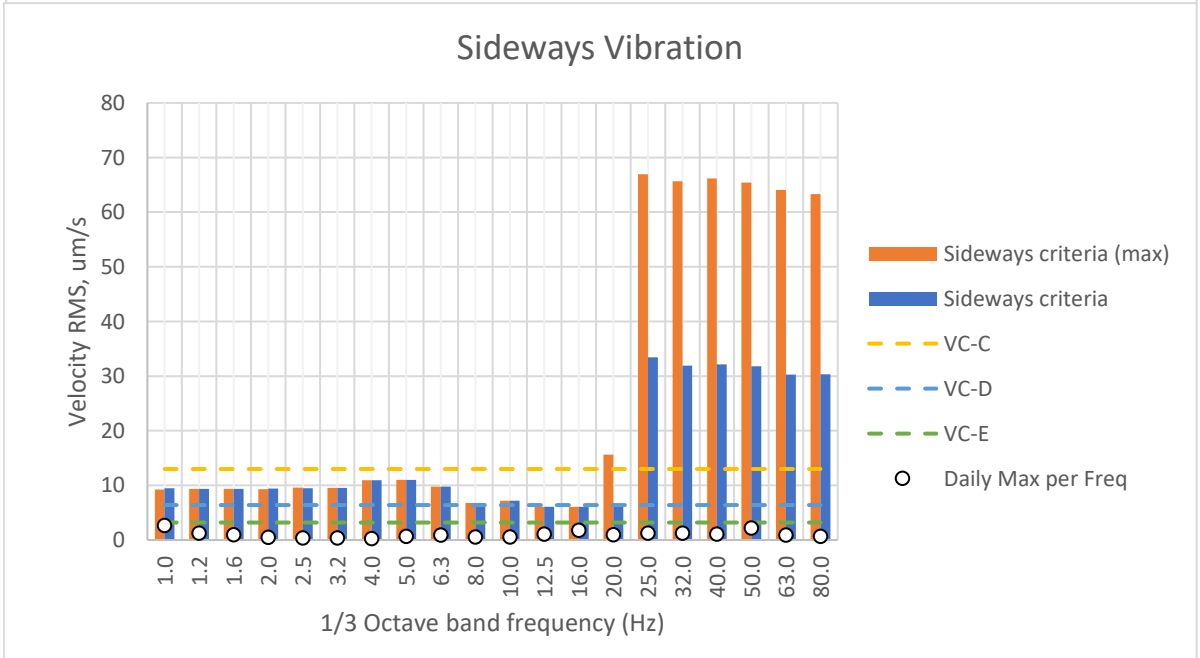




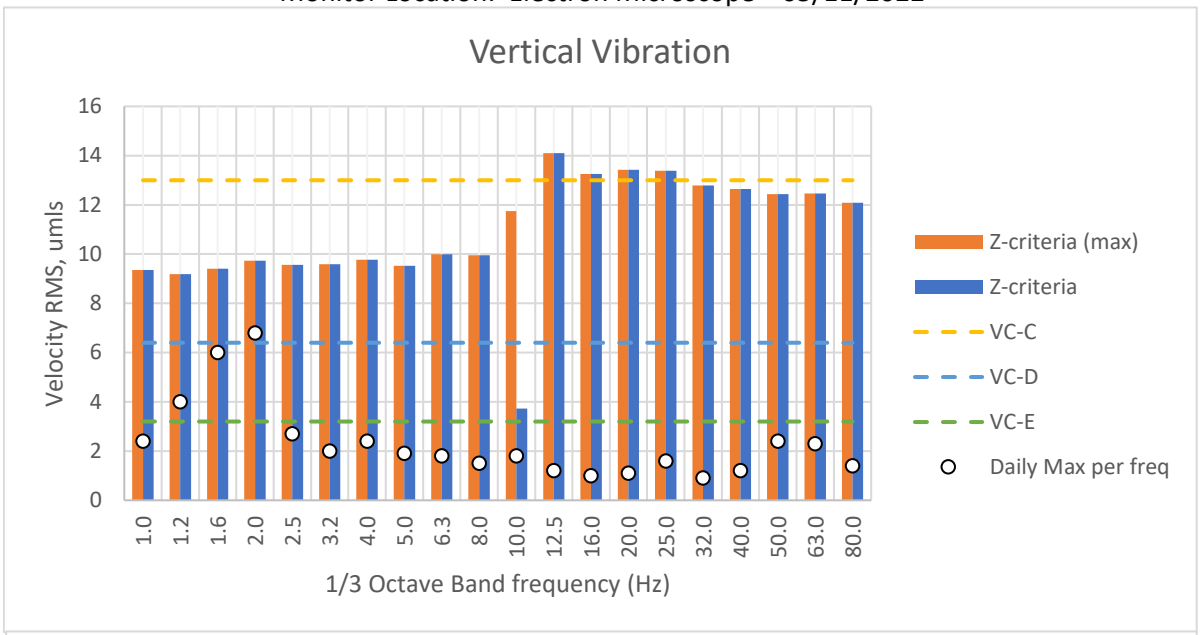
Monitor Location: Electron Microscope 04/11/2022

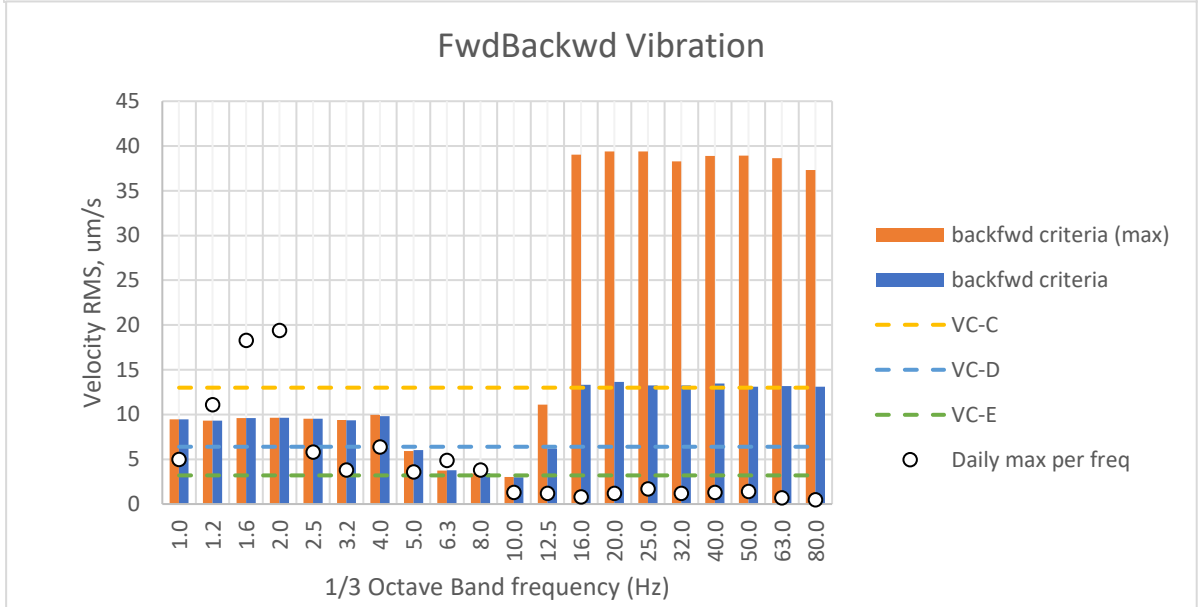


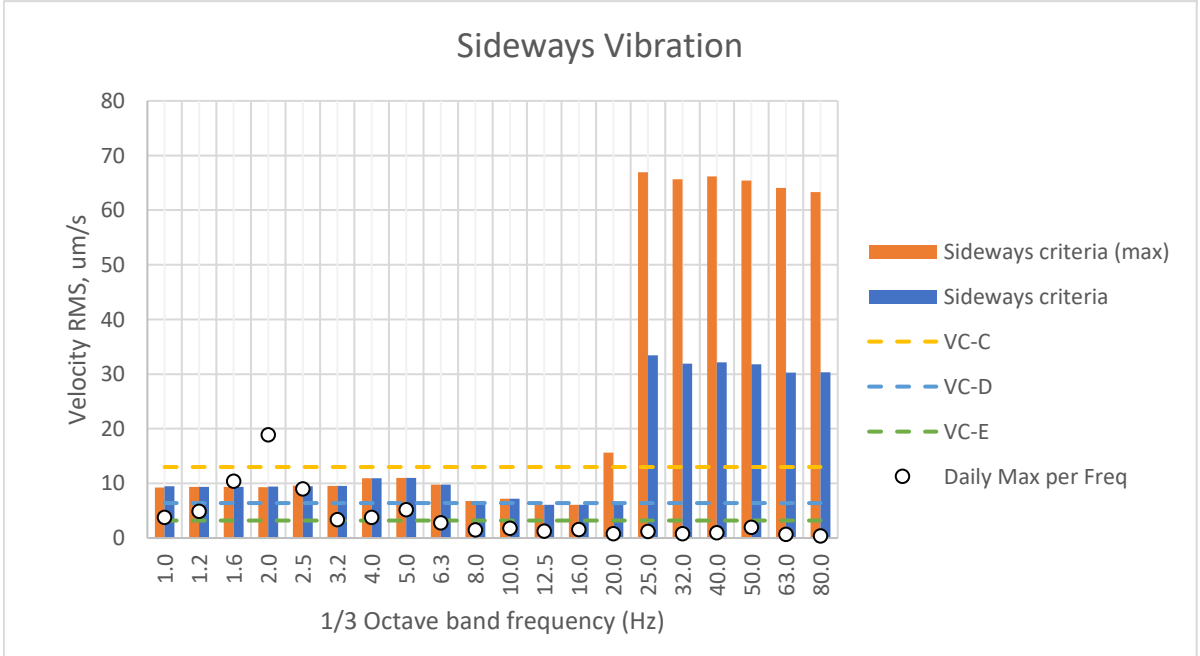




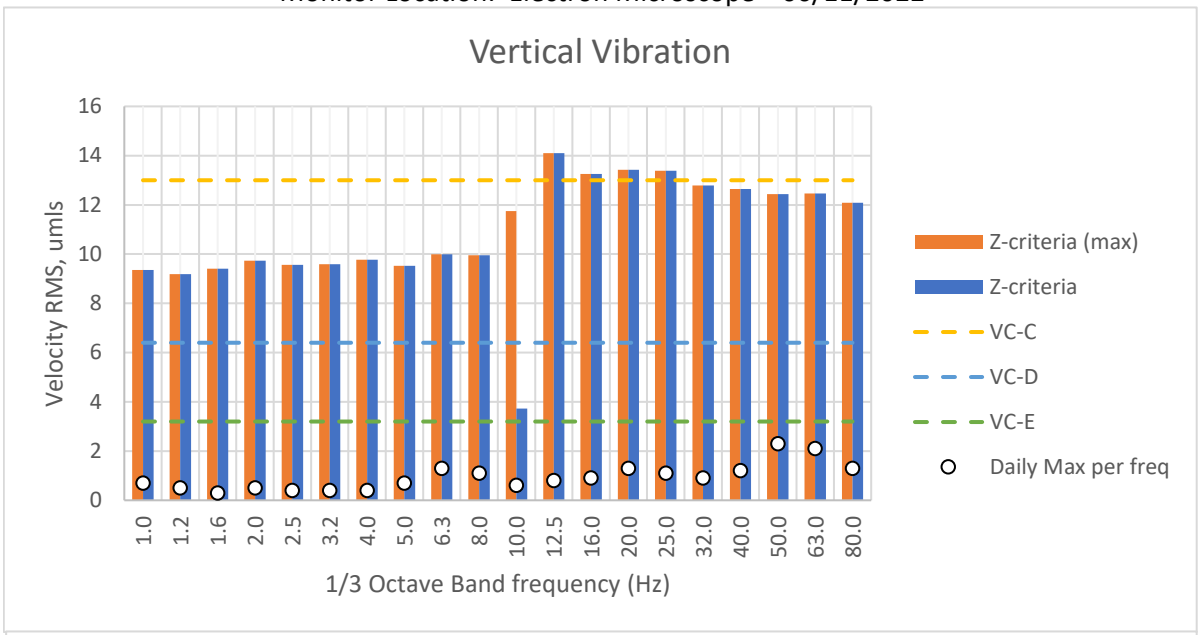
Monitor Location: Electron Microscope 05/11/2022

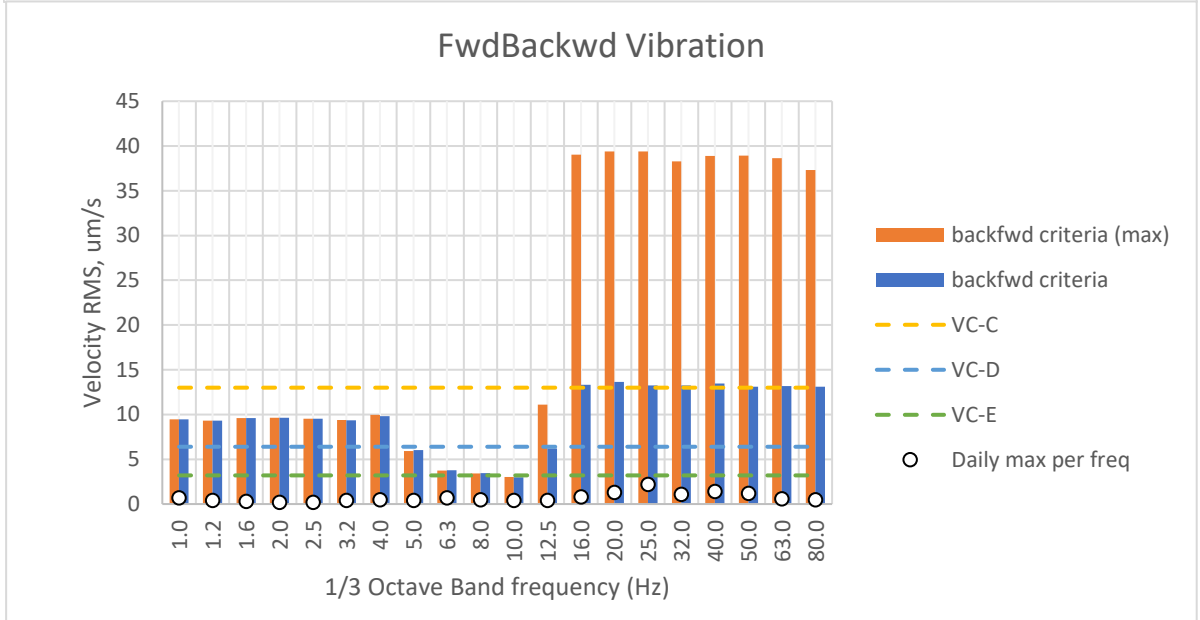


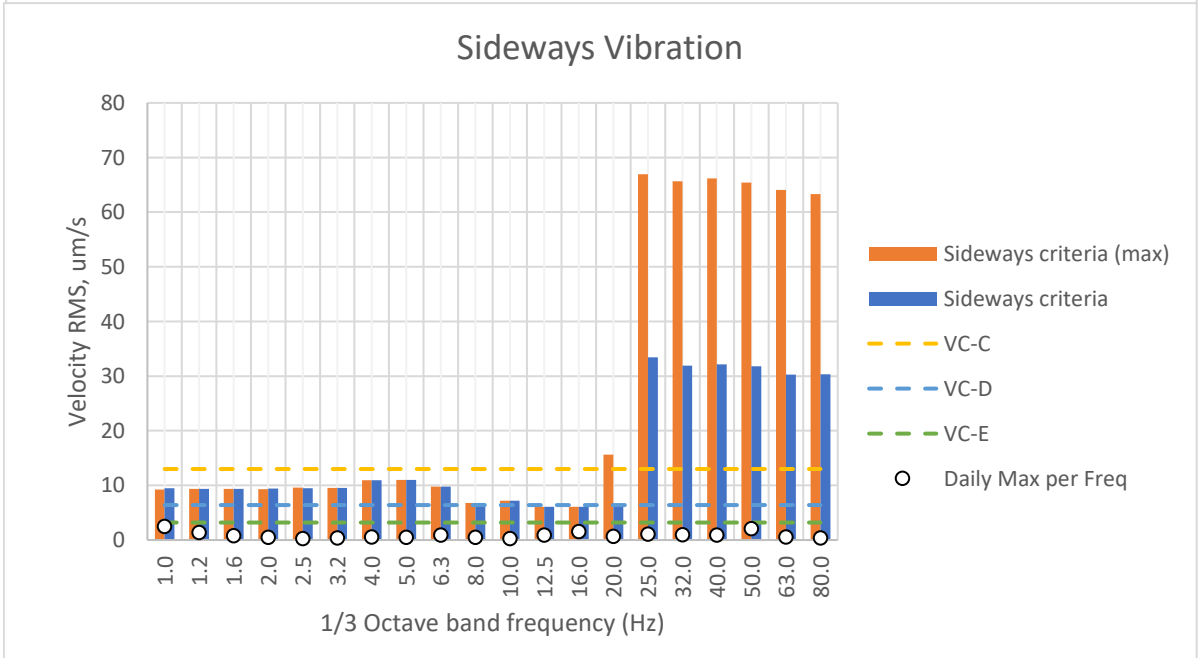




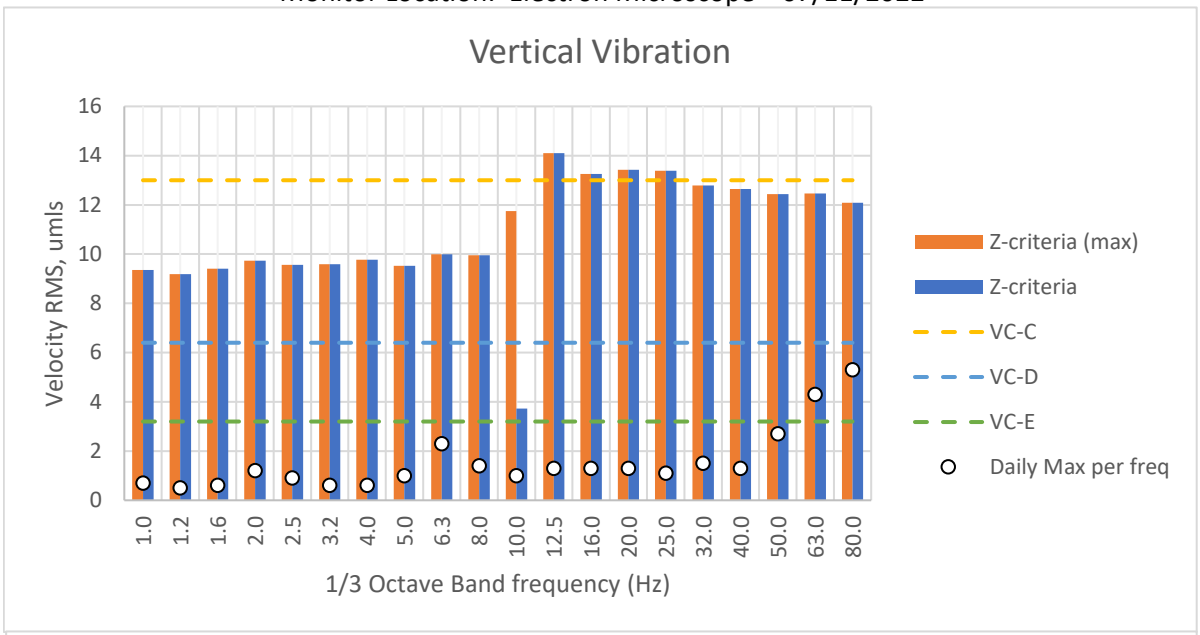
Monitor Location: Electron Microscope 06/11/2022

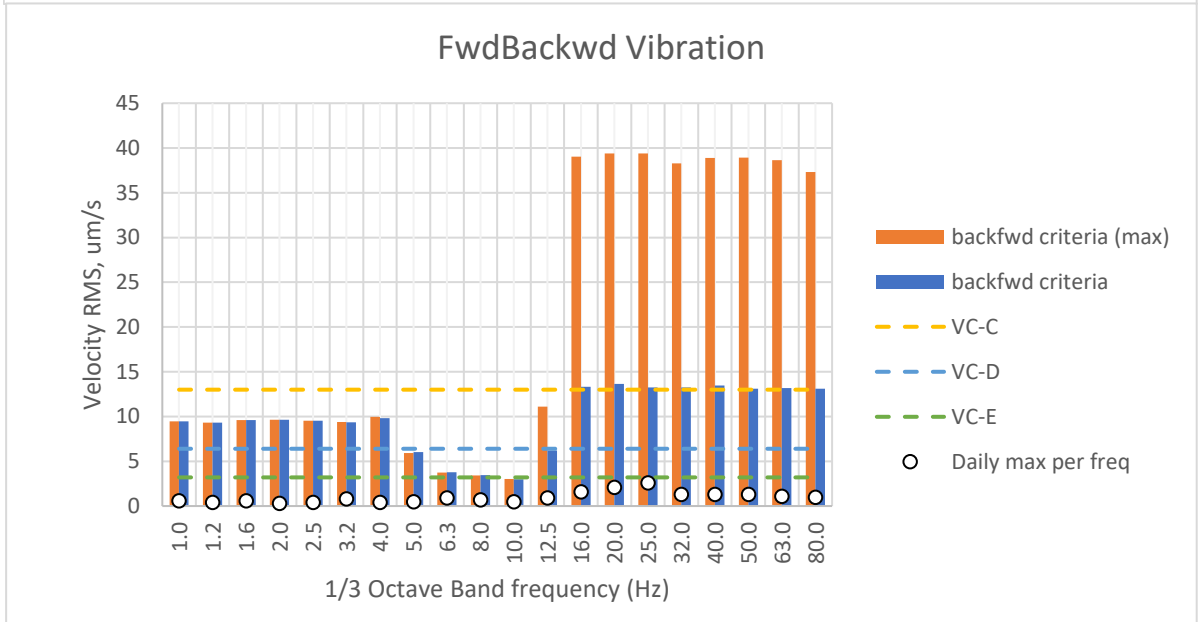


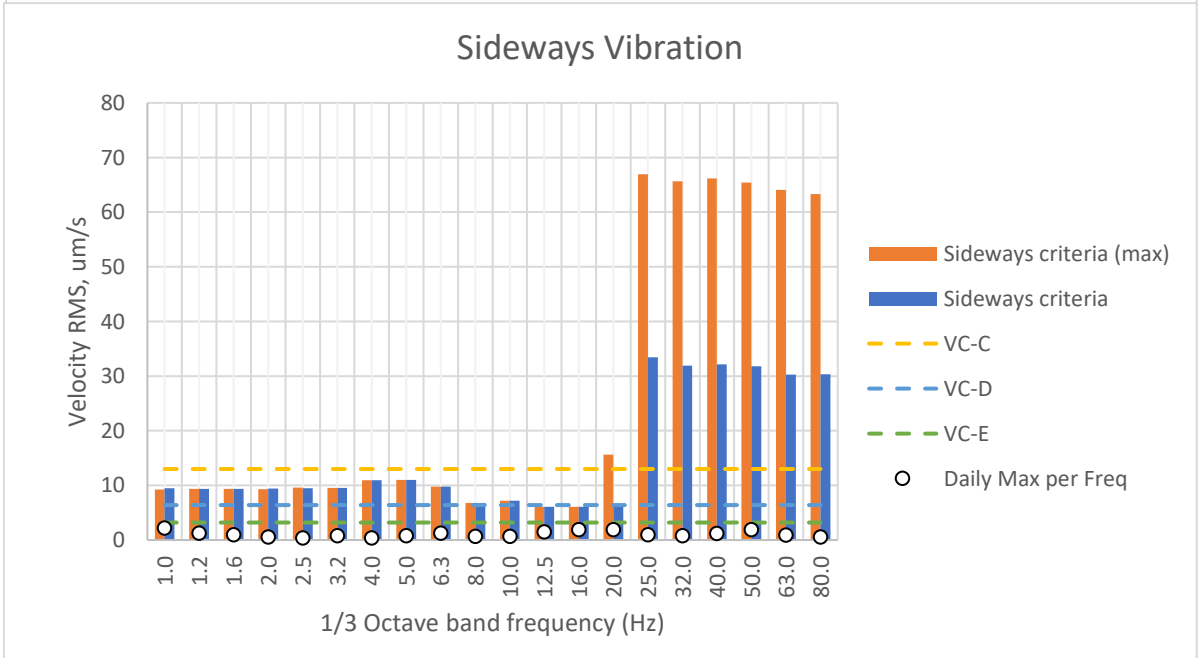




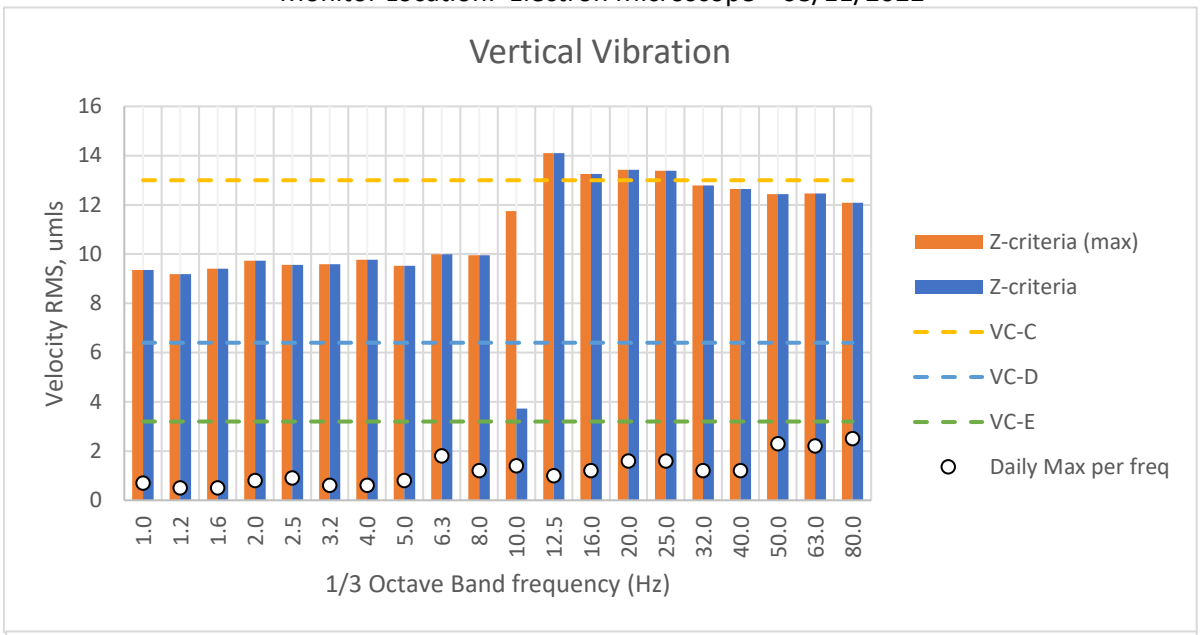
Monitor Location: Electron Microscope 07/11/2022

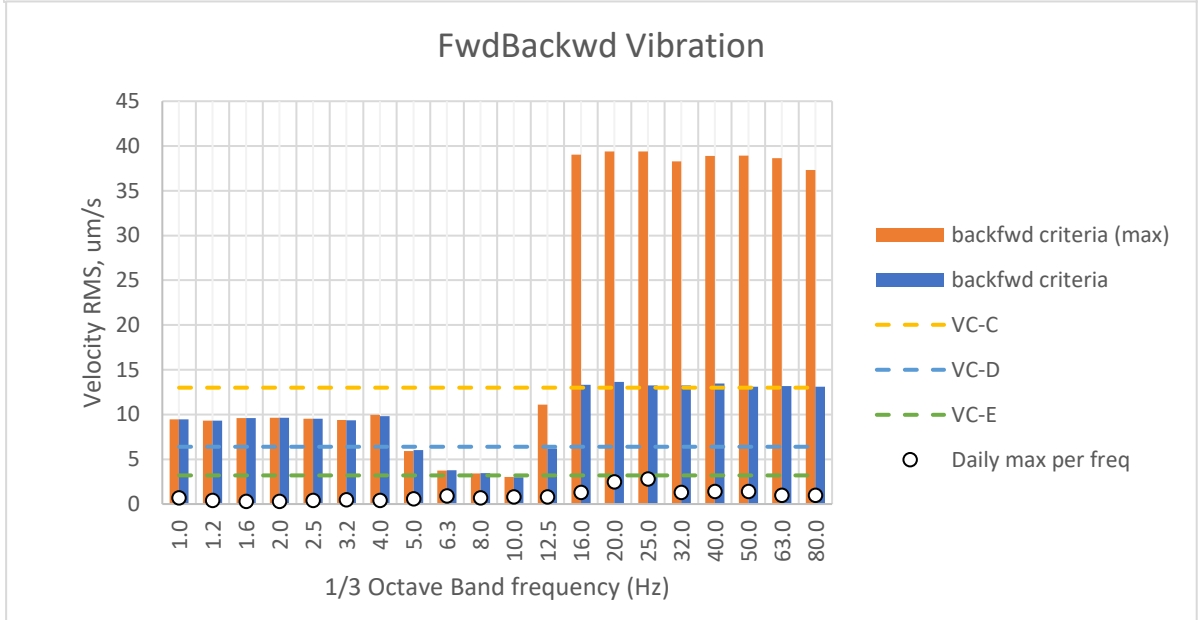


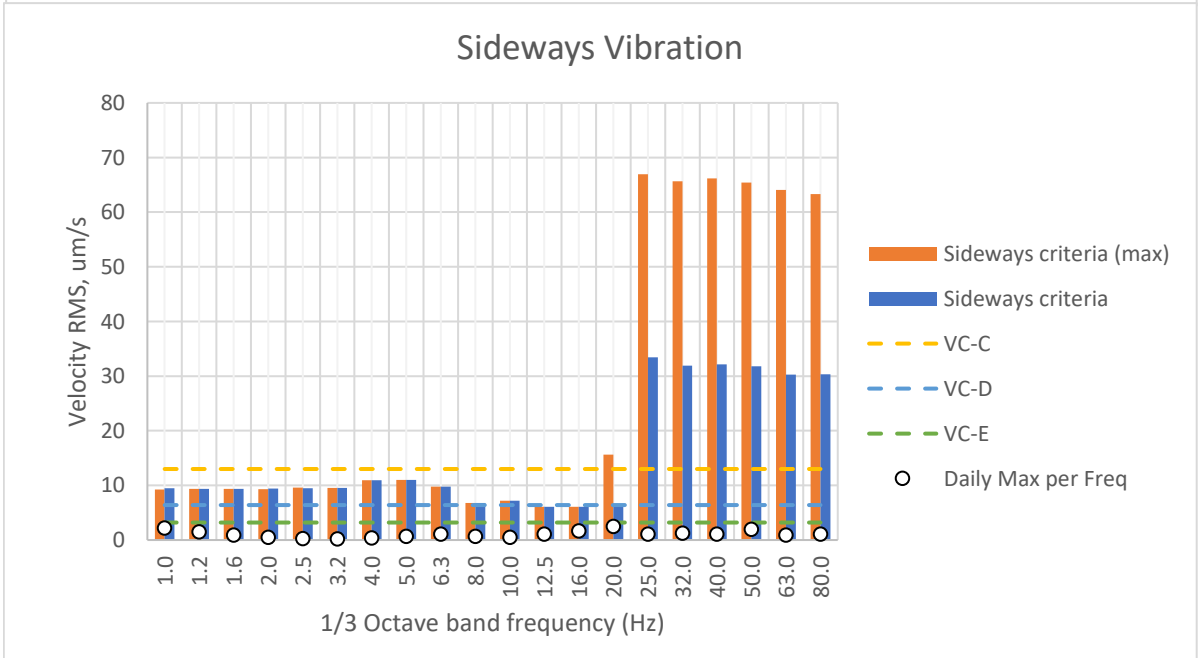




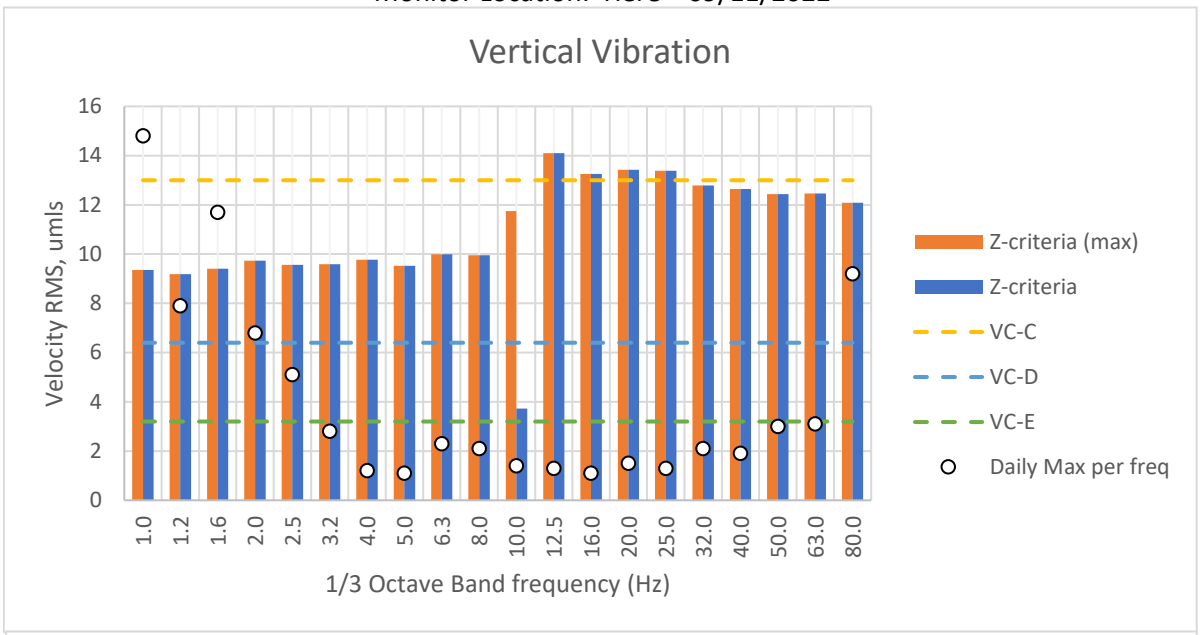
Monitor Location: Electron Microscope 08/11/2022

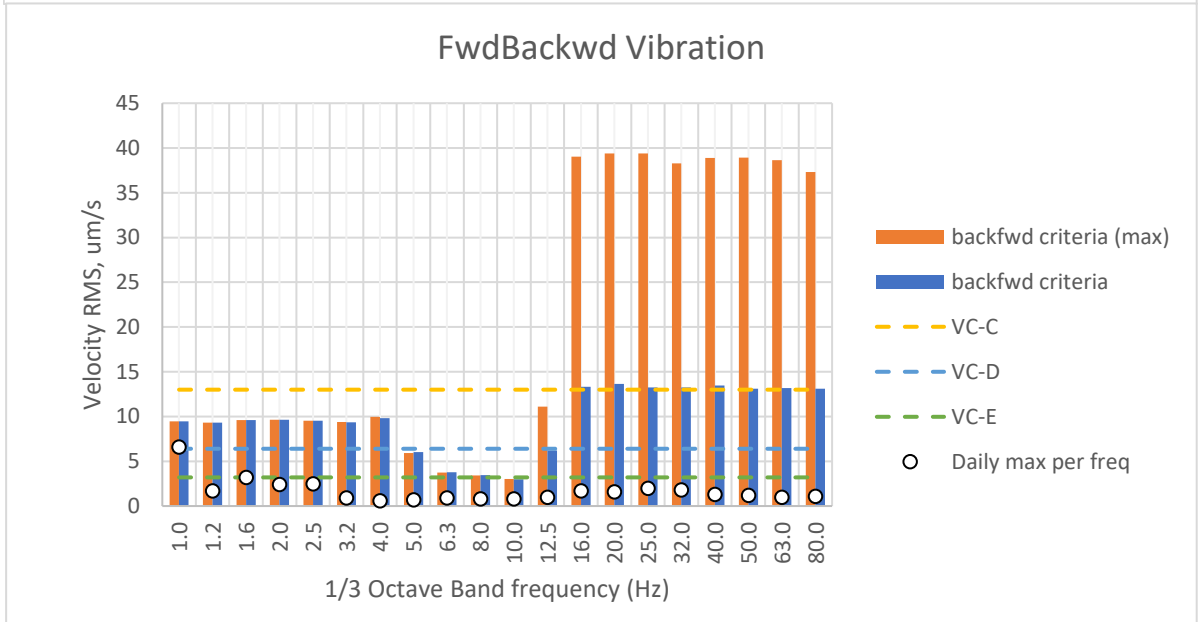


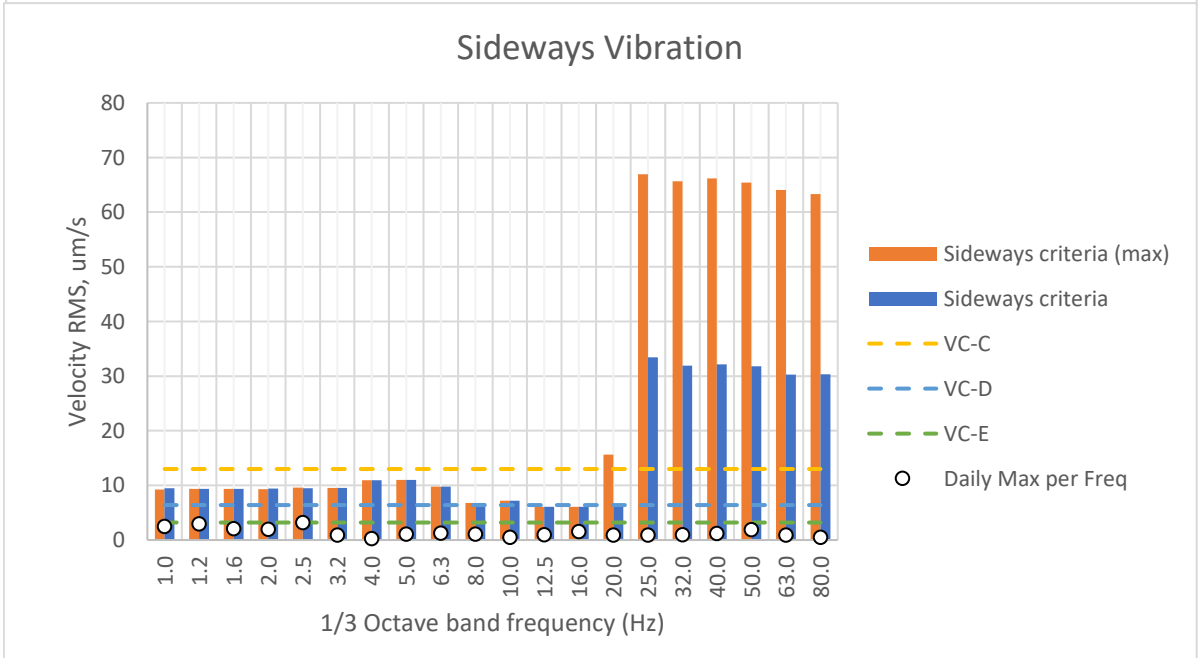




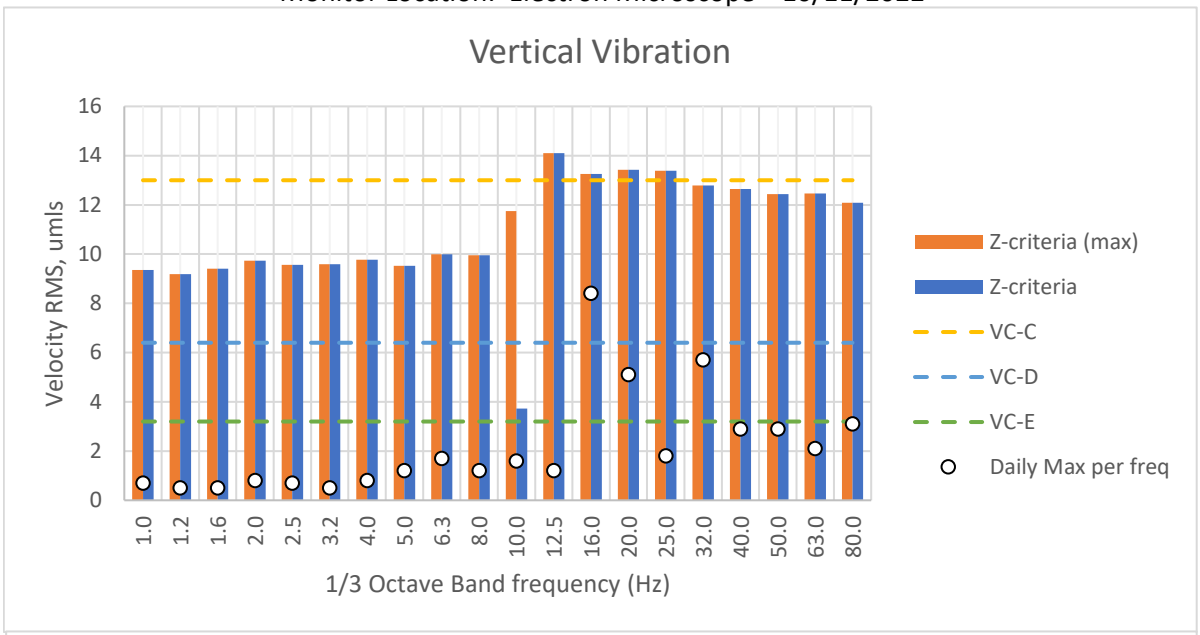
Monitor Location: Here 09/11/2022

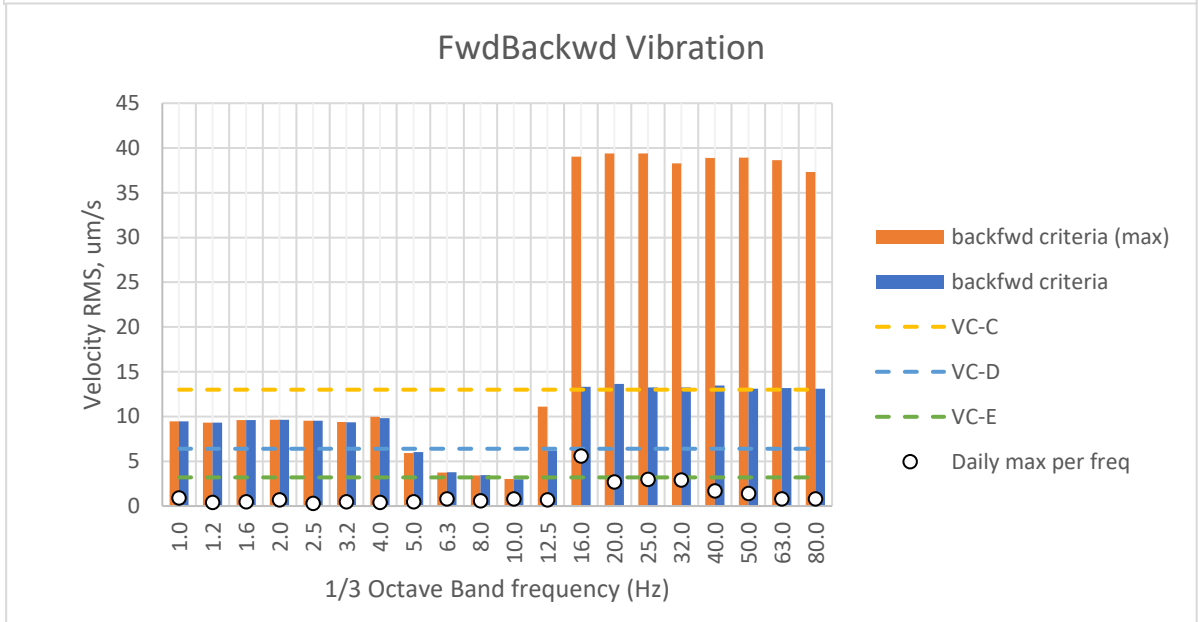


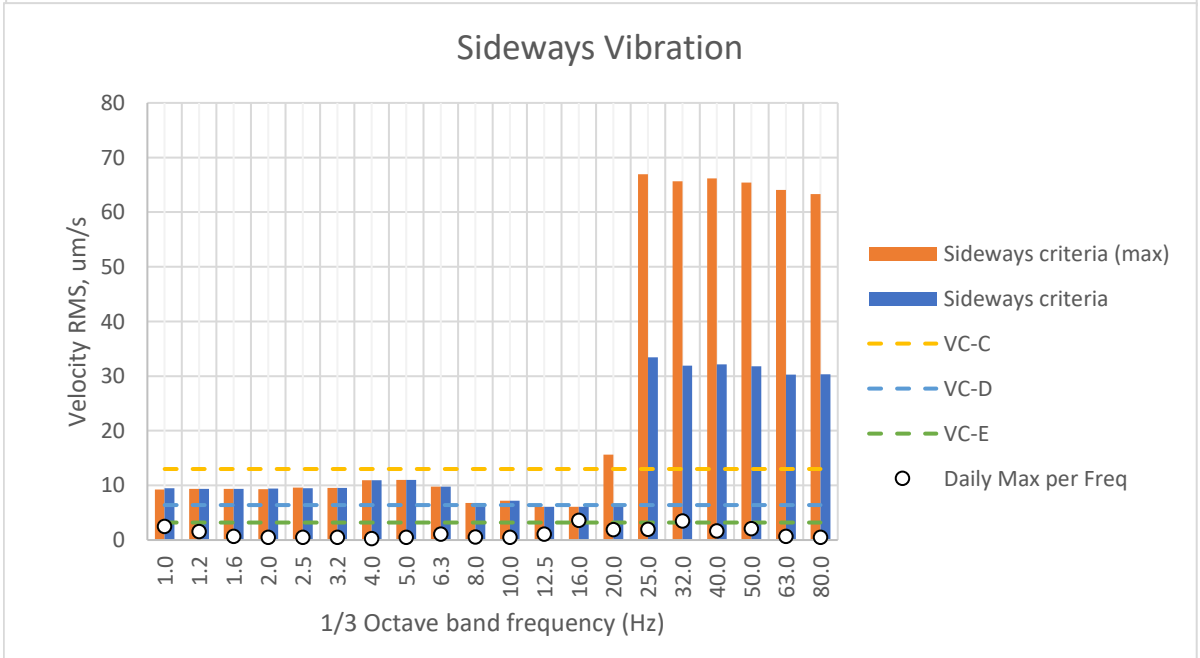




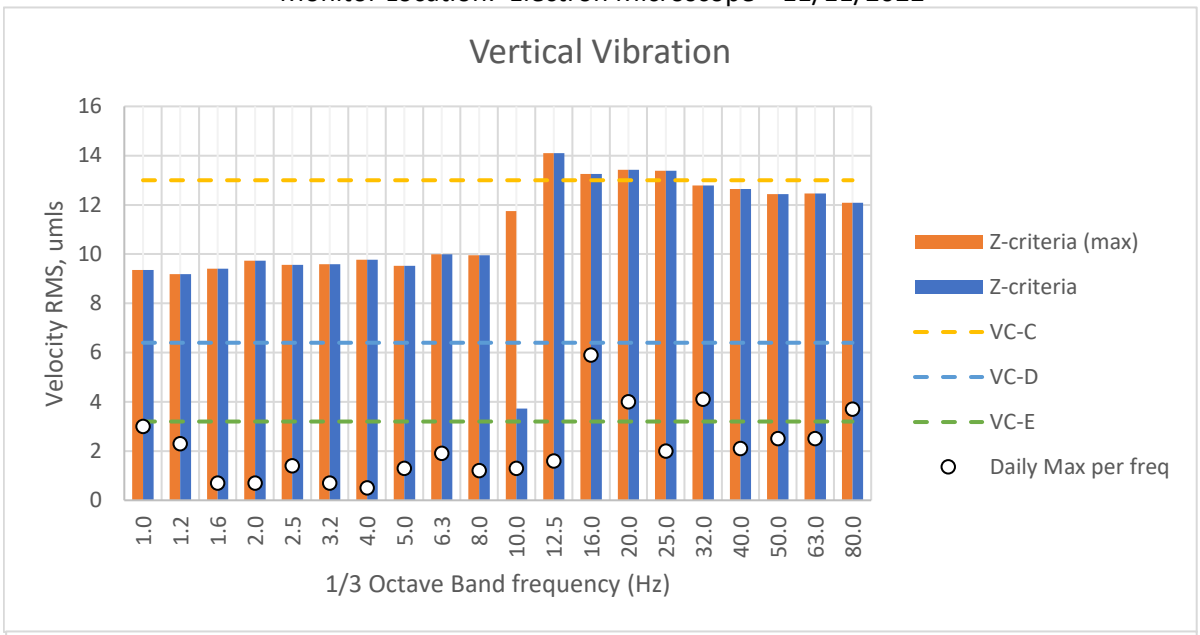
Monitor Location: Electron Microscope 10/11/2022

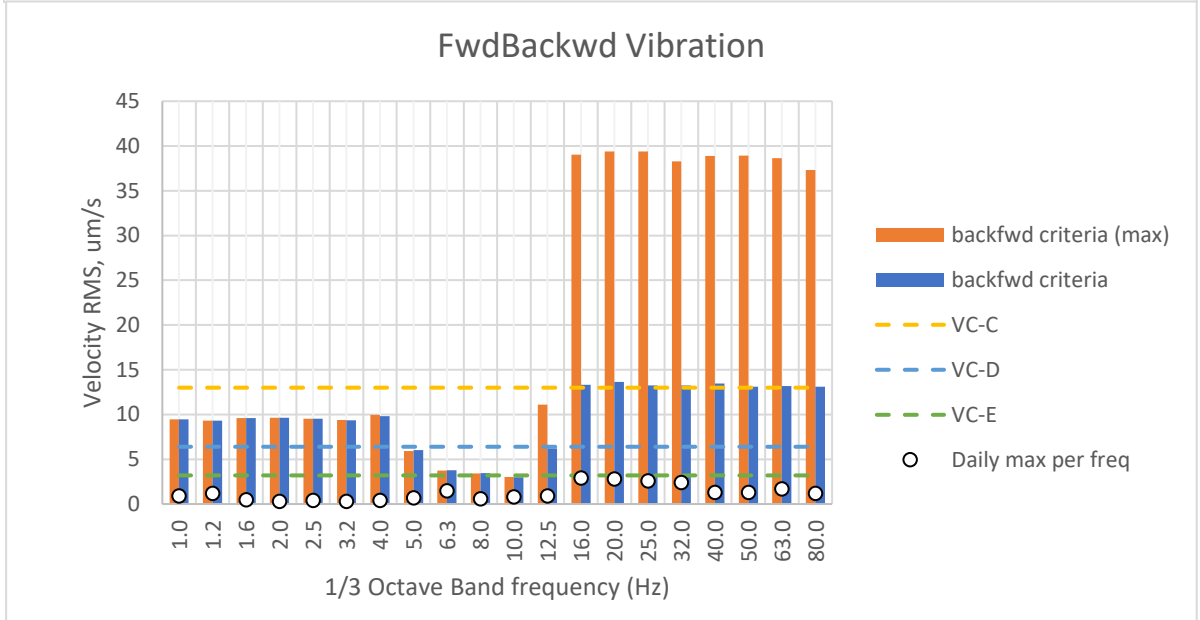


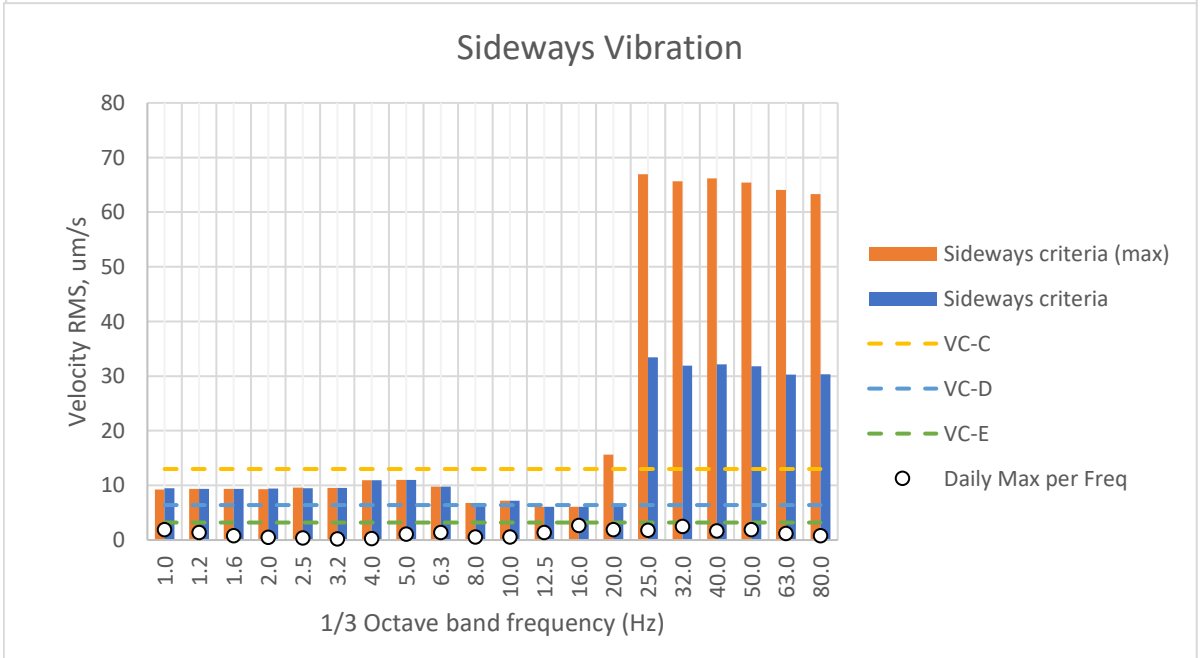




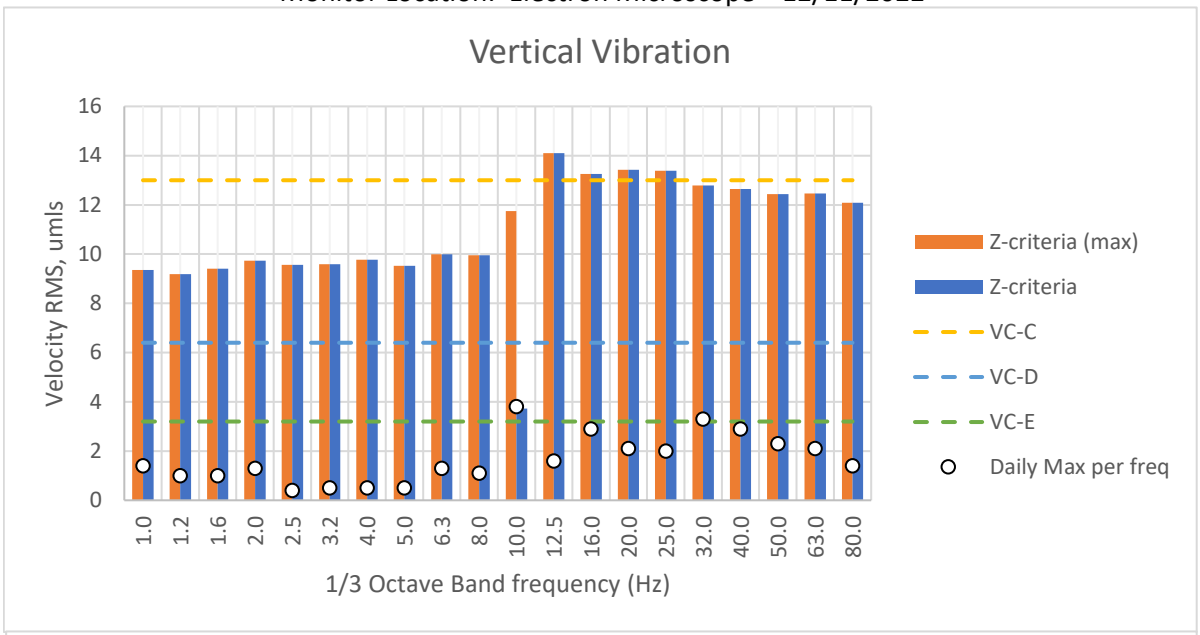
Monitor Location: Electron Microscope 11/11/2022

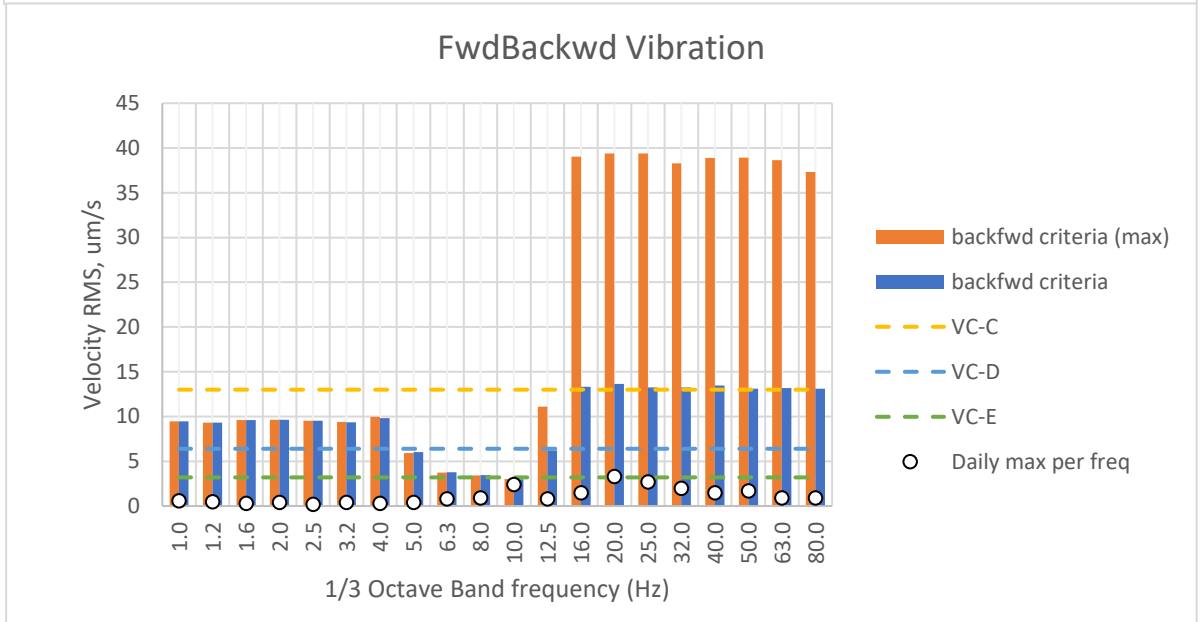


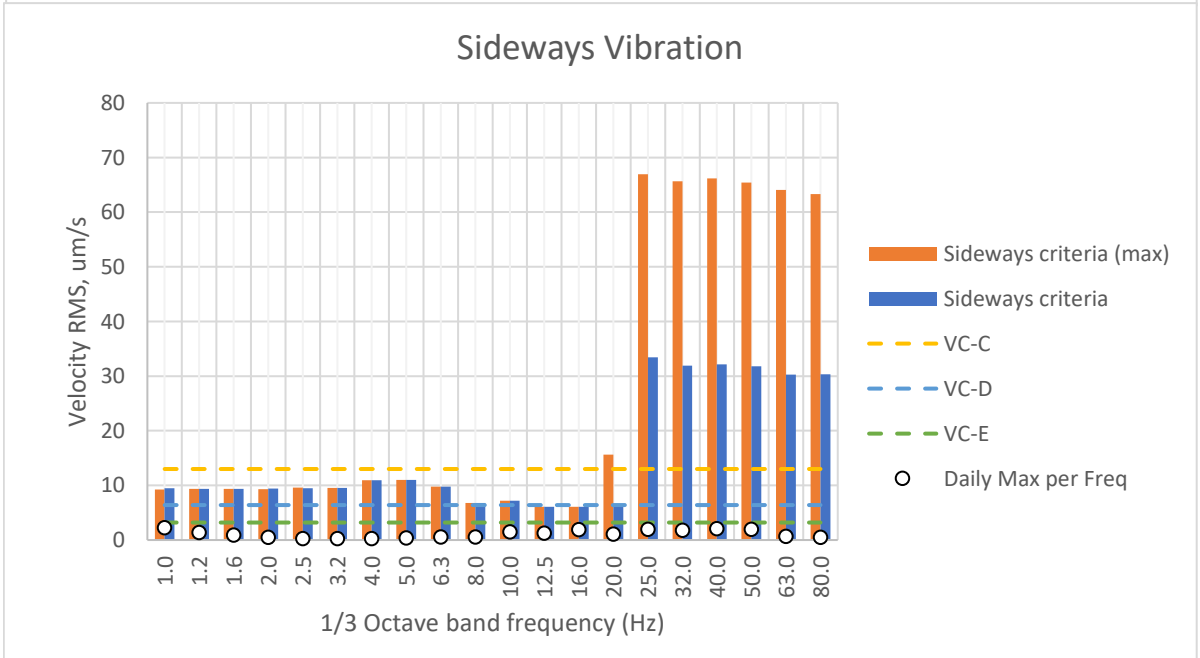




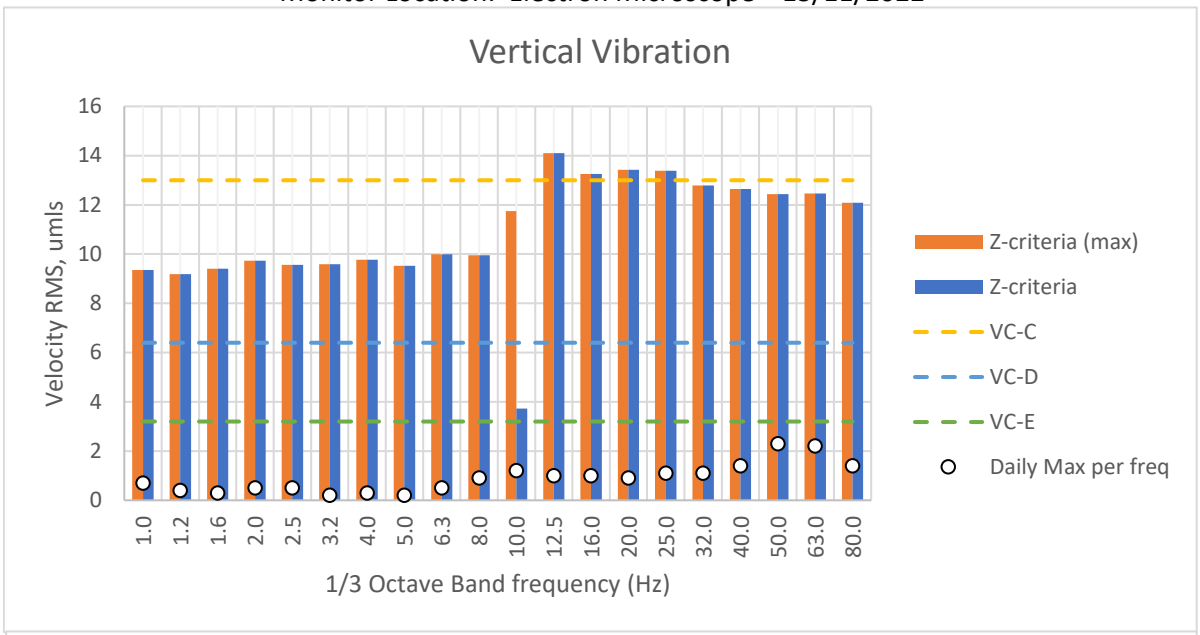
Monitor Location: Electron Microscope 12/11/2022

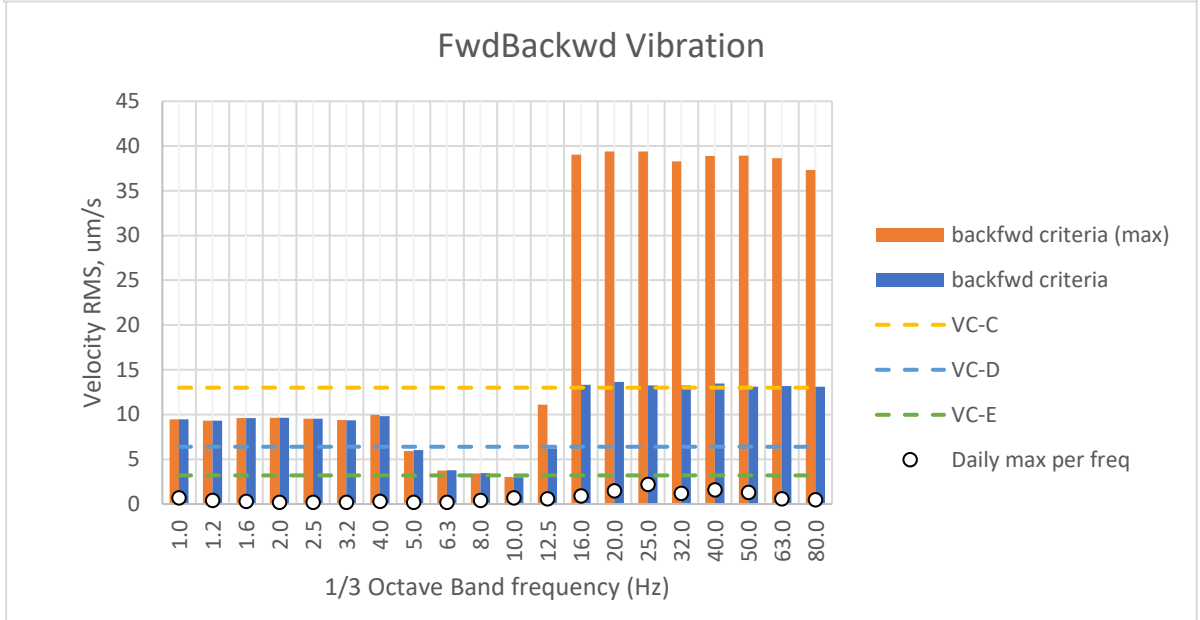


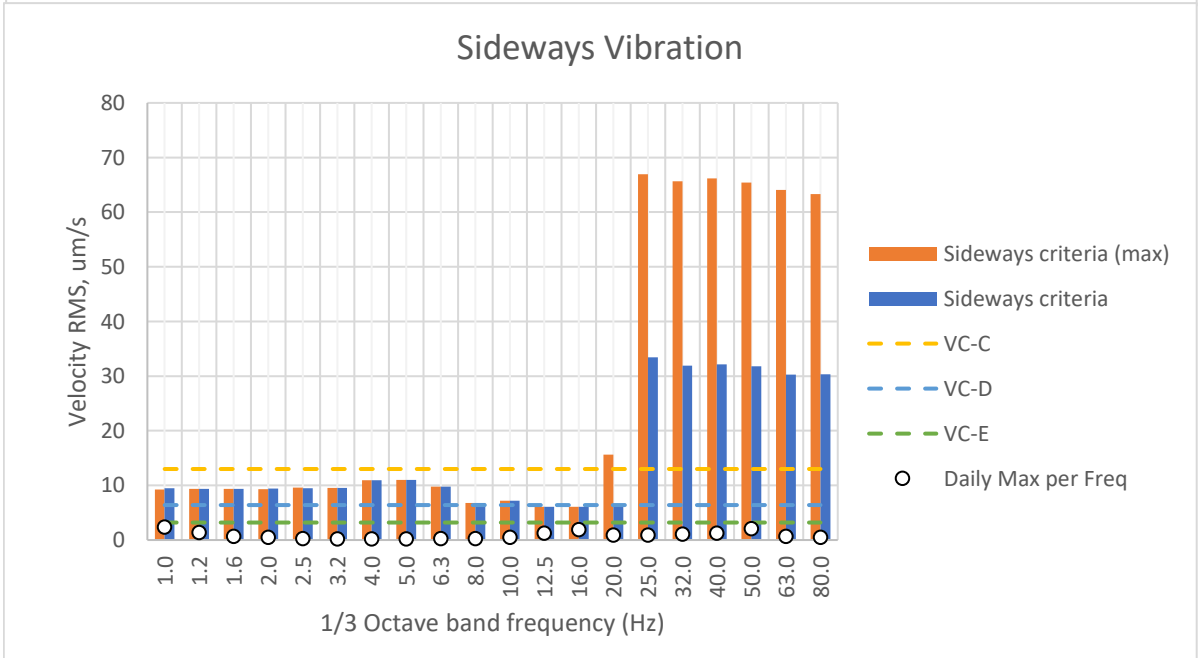




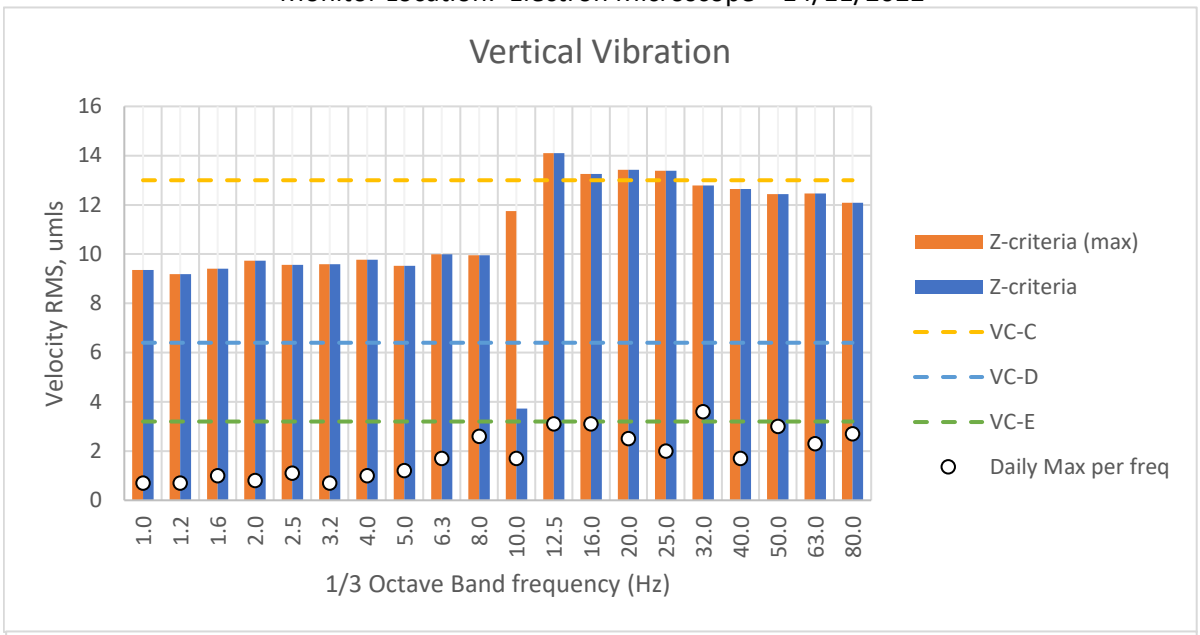
Monitor Location: Electron Microscope 13/11/2022

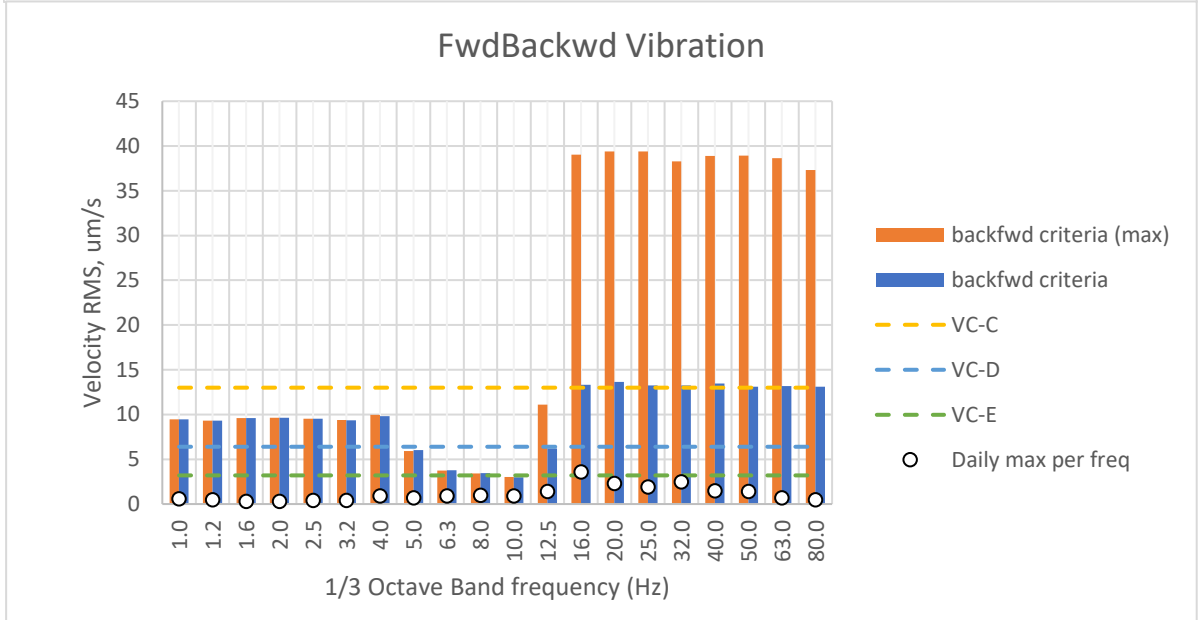


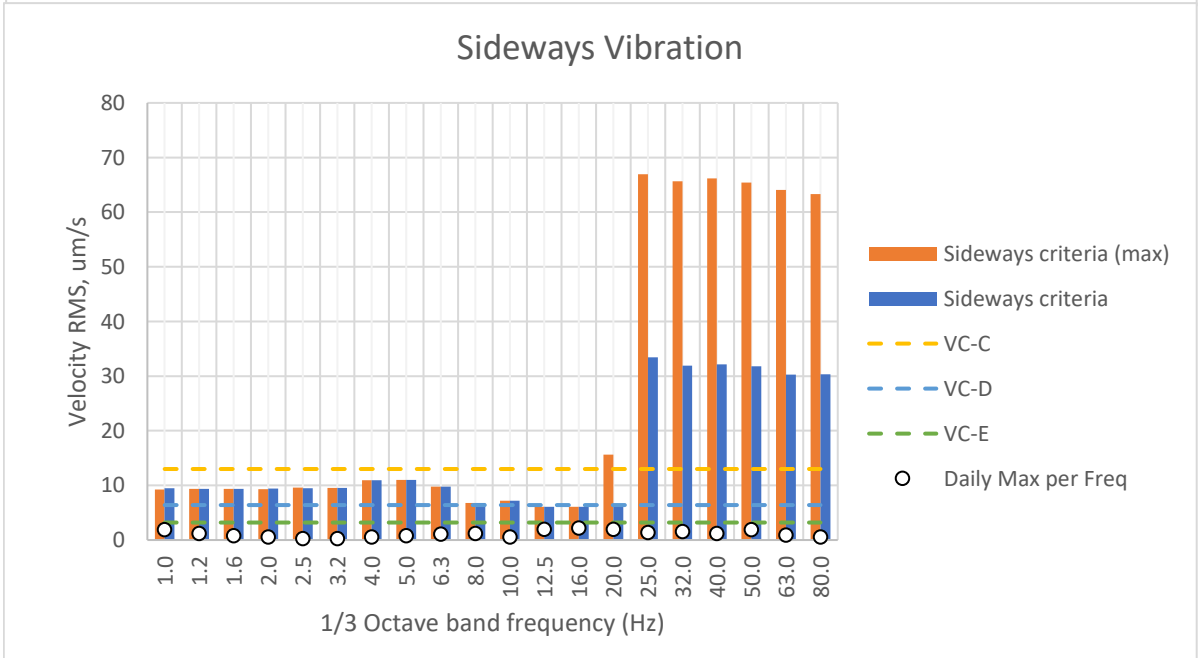




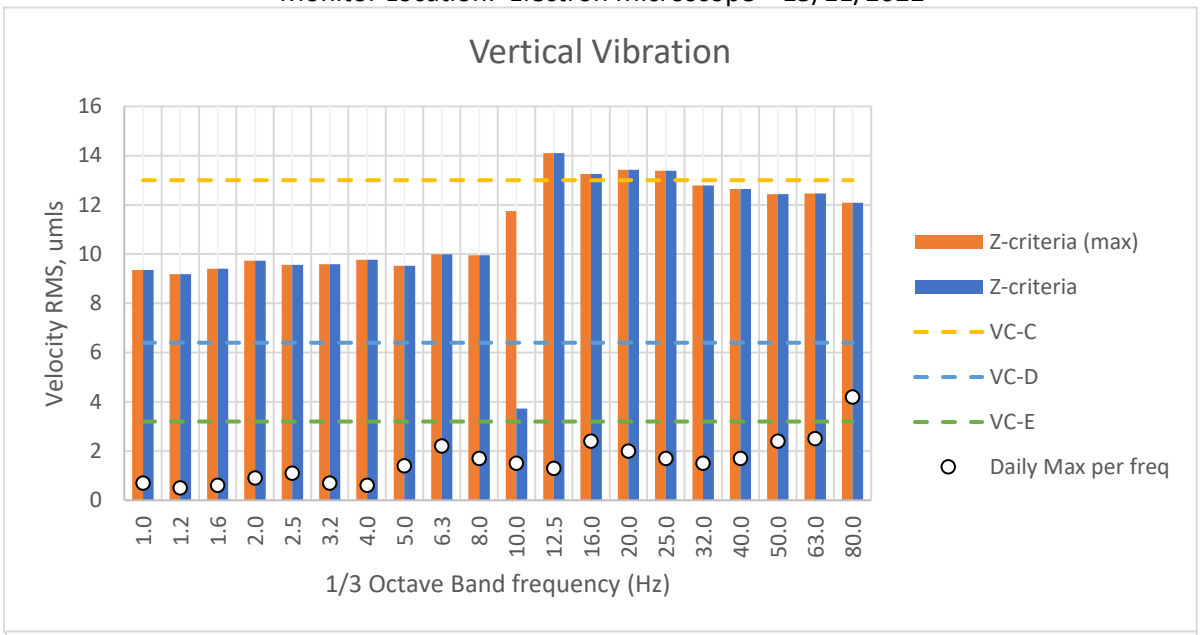
Monitor Location: Electron Microscope 14/11/2022

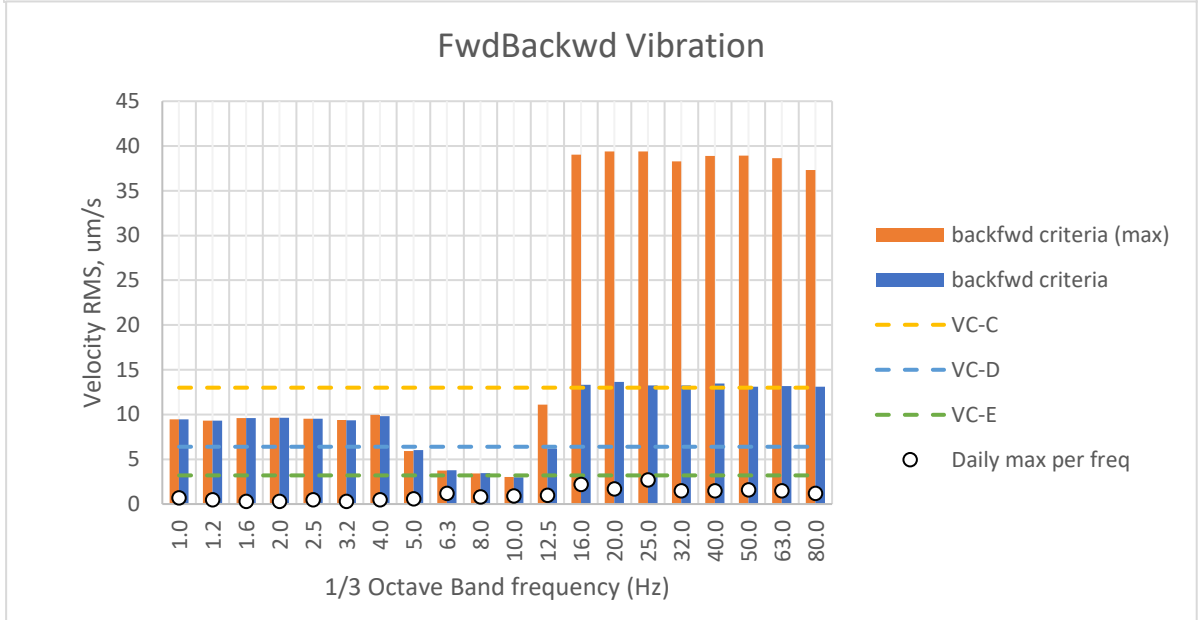


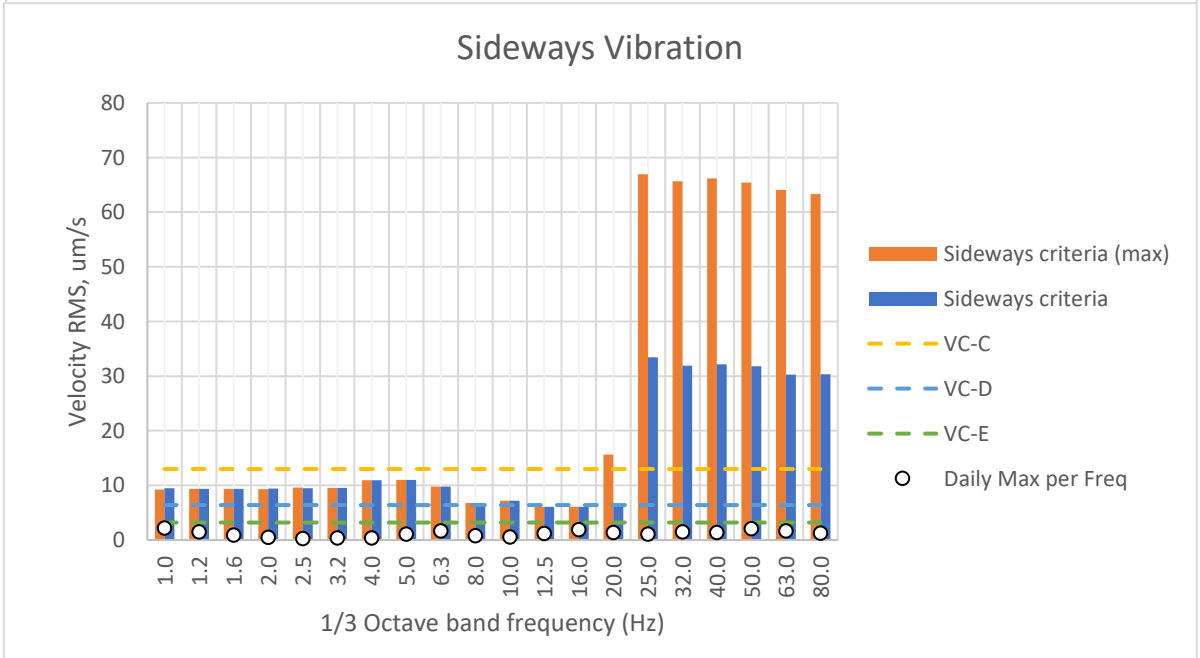




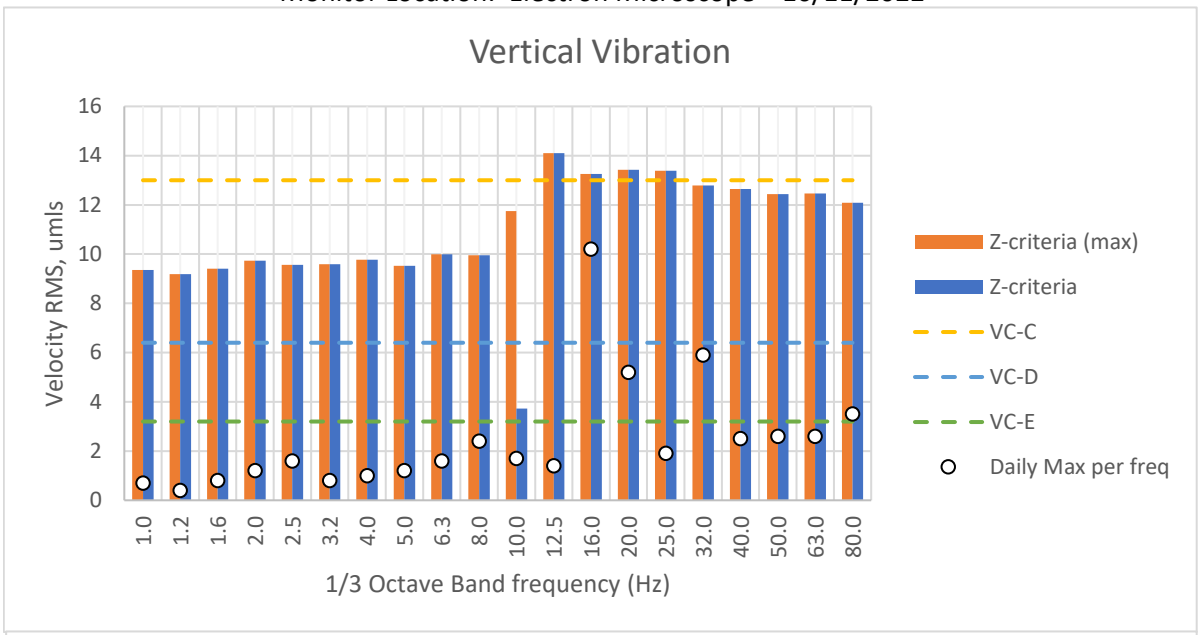
Monitor Location: Electron Microscope 15/11/2022

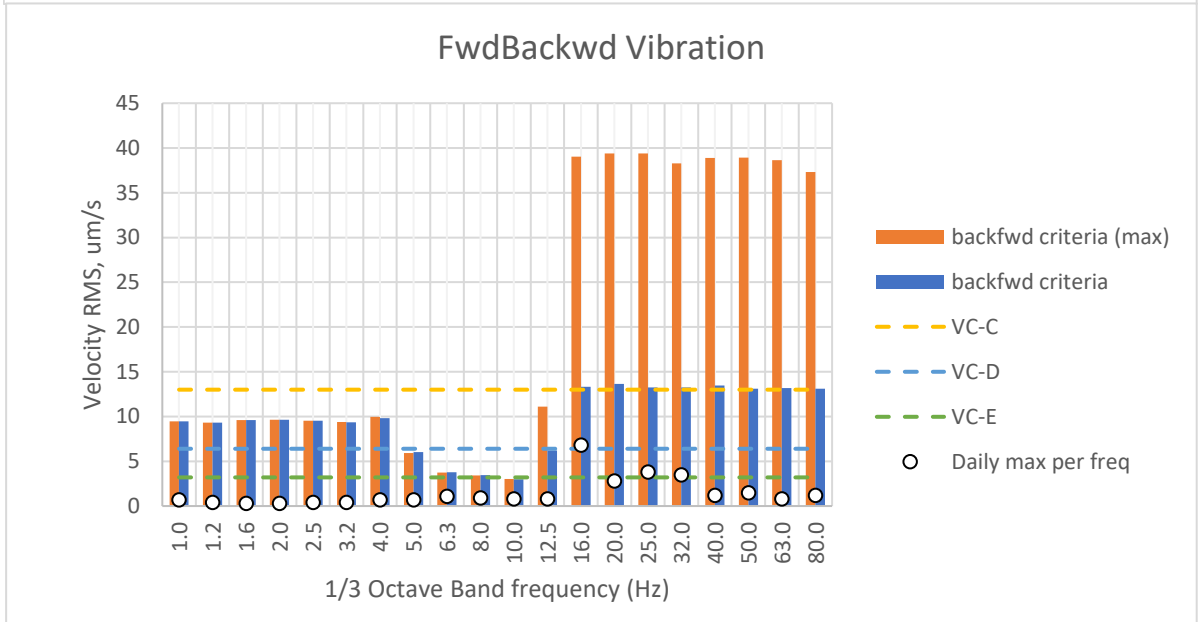


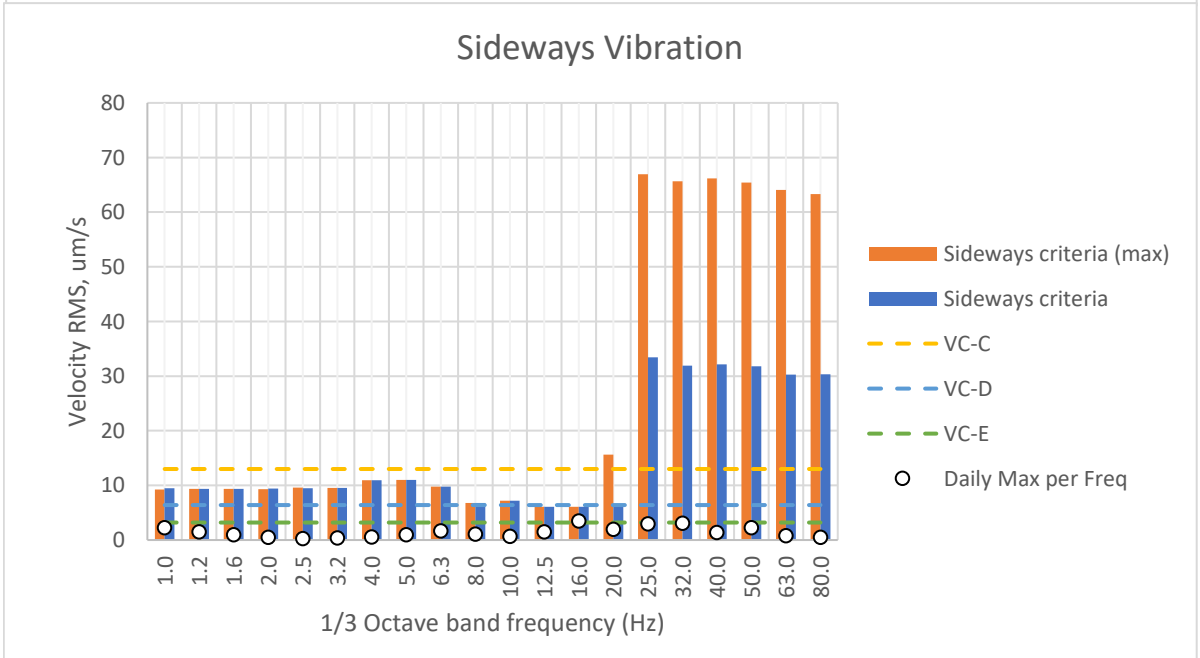




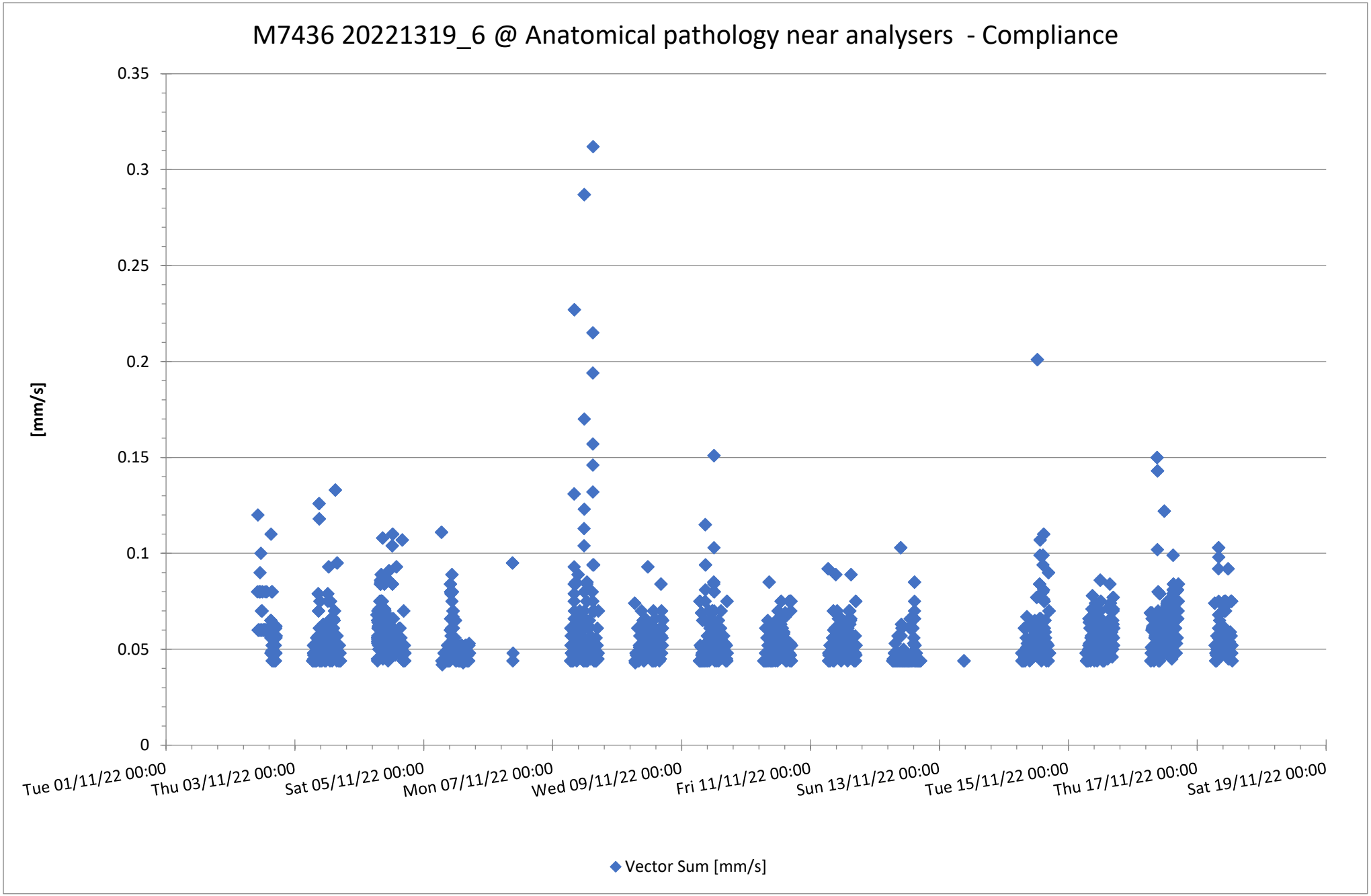
Monitor Location: Electron Microscope 16/11/2022







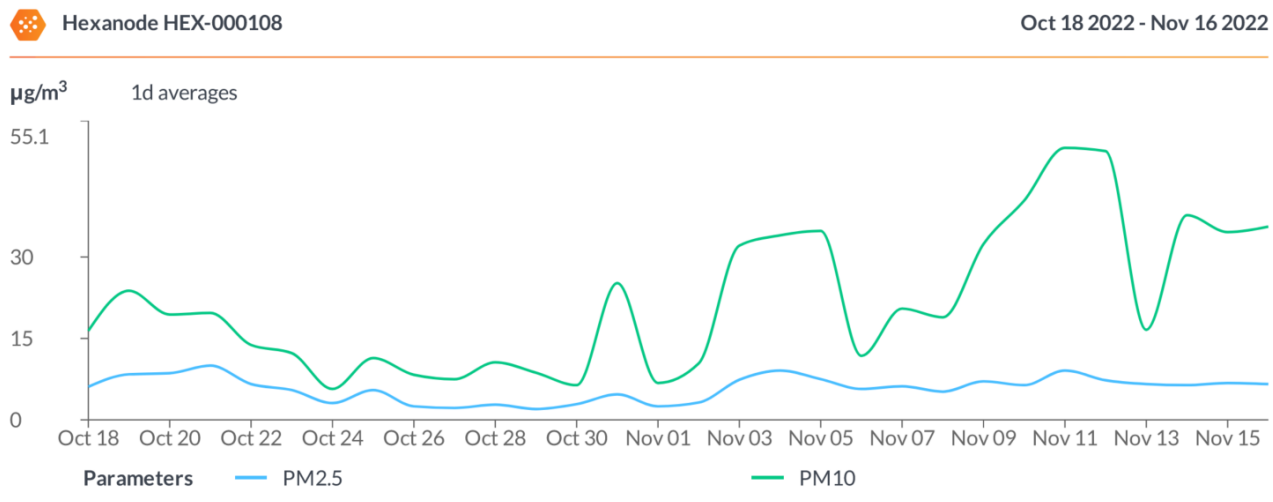
APPENDIX D – VIBRATION MONITORING DATA - ANATOMICAL PATHOLOGY (ANALYSERS)


M7436 20221319_6 @ Anatomical pathology near analysers - Compliance
[mm/s]
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Tue 01/11/22 00:00
Thu 03/11/22 00:00
Sat 05/11/22 00:00
Mon 07/11/22 00:00
Wed 09/11/22 00:00
Fri 11/11/22 00:00
Sun 13/11/22 00:00
Tue 15/11/22 00:00
Thu 17/11/22 00:00
Sat 19/11/22 00:00
Vector Sum [mm/s]

APPENDIX E – DUST MONITORING DATA – LIVERPOOL GIRLS HIGH SCHOOL BOUNDARY

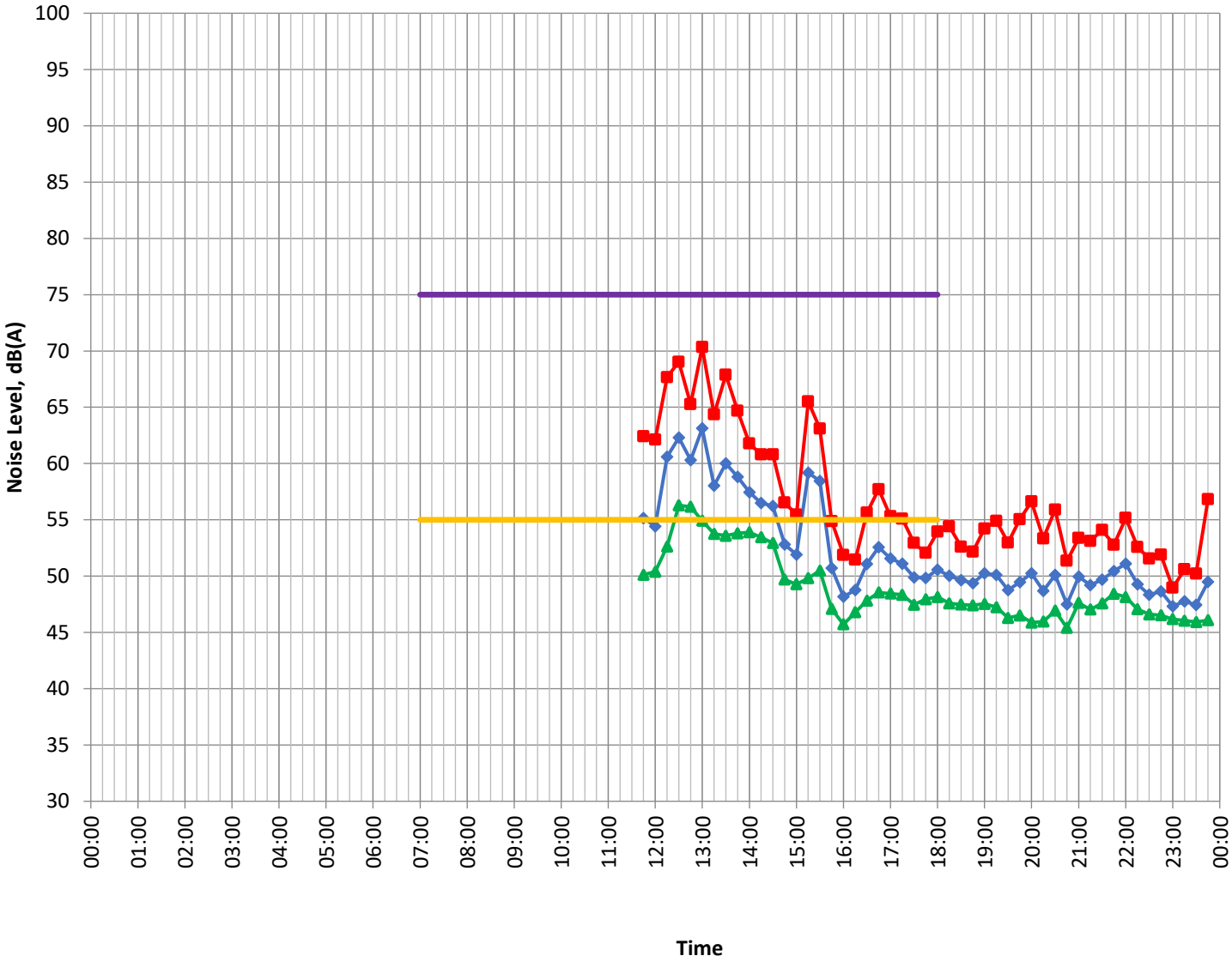
µg/m³	Hexanode HEX-000108	
Daily Averages	PM2.5	PM10
Oct 18 2022	6	16
Oct 19 2022	8	24
Oct 20 2022	9	19
Oct 21 2022	10	20
Oct 22 2022	7	14
Oct 23 2022	6	12
Oct 24 2022	3	6
Oct 25 2022	5	11
Oct 26 2022	2	8
Oct 27 2022	2	8
Oct 28 2022	3	11
Oct 29 2022	2	9
Oct 30 2022	3	6
Oct 31 2022	5	25
Nov 1 2022	3	7
Nov 2 2022	3	10
Nov 3 2022	7	32
Nov 4 2022	9	34
Nov 5 2022	7	35
Nov 6 2022	6	12
Nov 7 2022	6	20
Nov 8 2022	5	19
Nov 9 2022	7	32
Nov 10 2022	6	40
Nov 11 2022	9	50
Nov 12 2022	7	49
Nov 13 2022	7	17
Nov 14 2022	6	38
Nov 15 2022	7	35
Nov 16 2022	7	36

Dust Monitoring Graphs

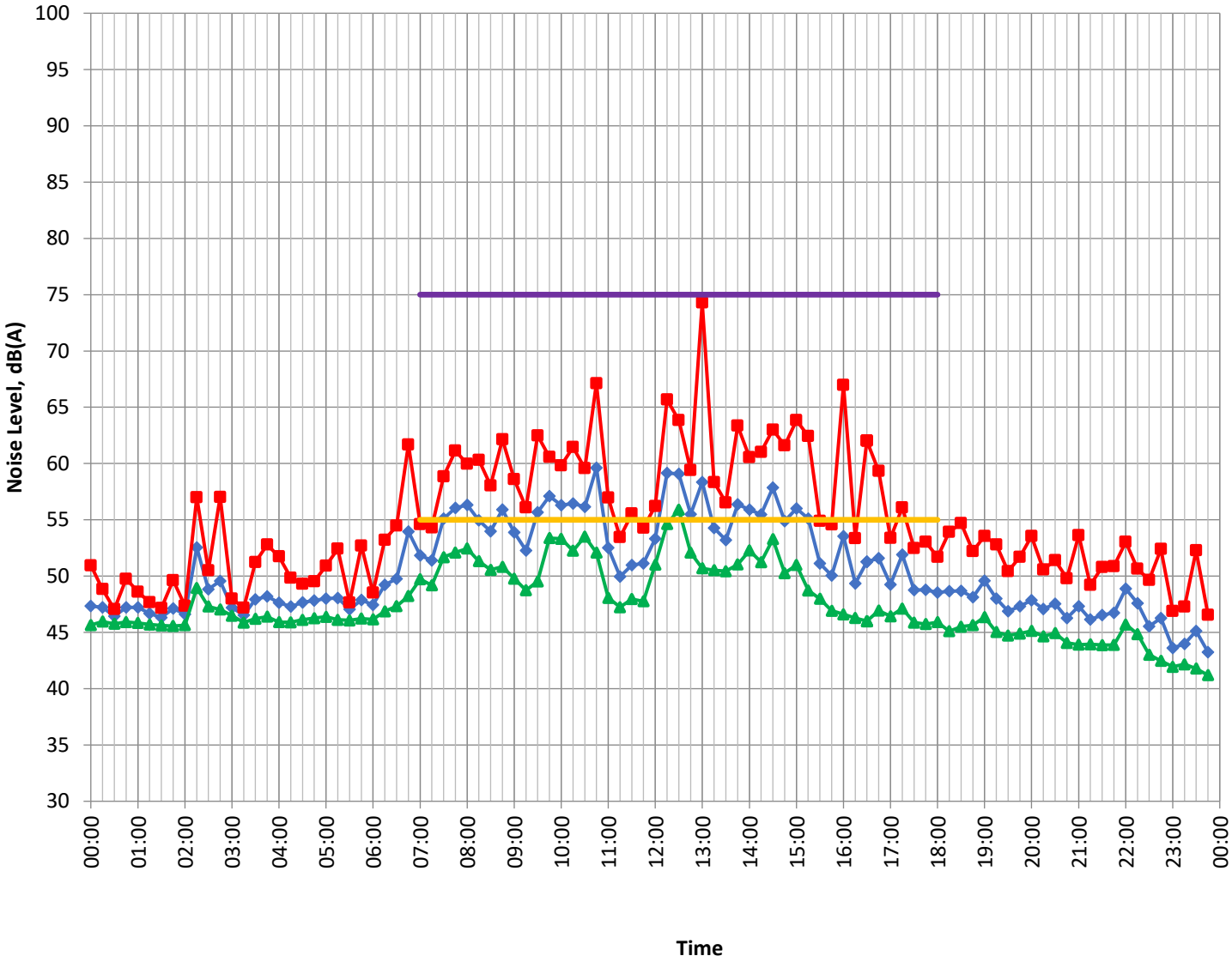


APPENDIX F – NOISE MONITORING DATA - LIVERPOOL GIRLS BOUNDARY

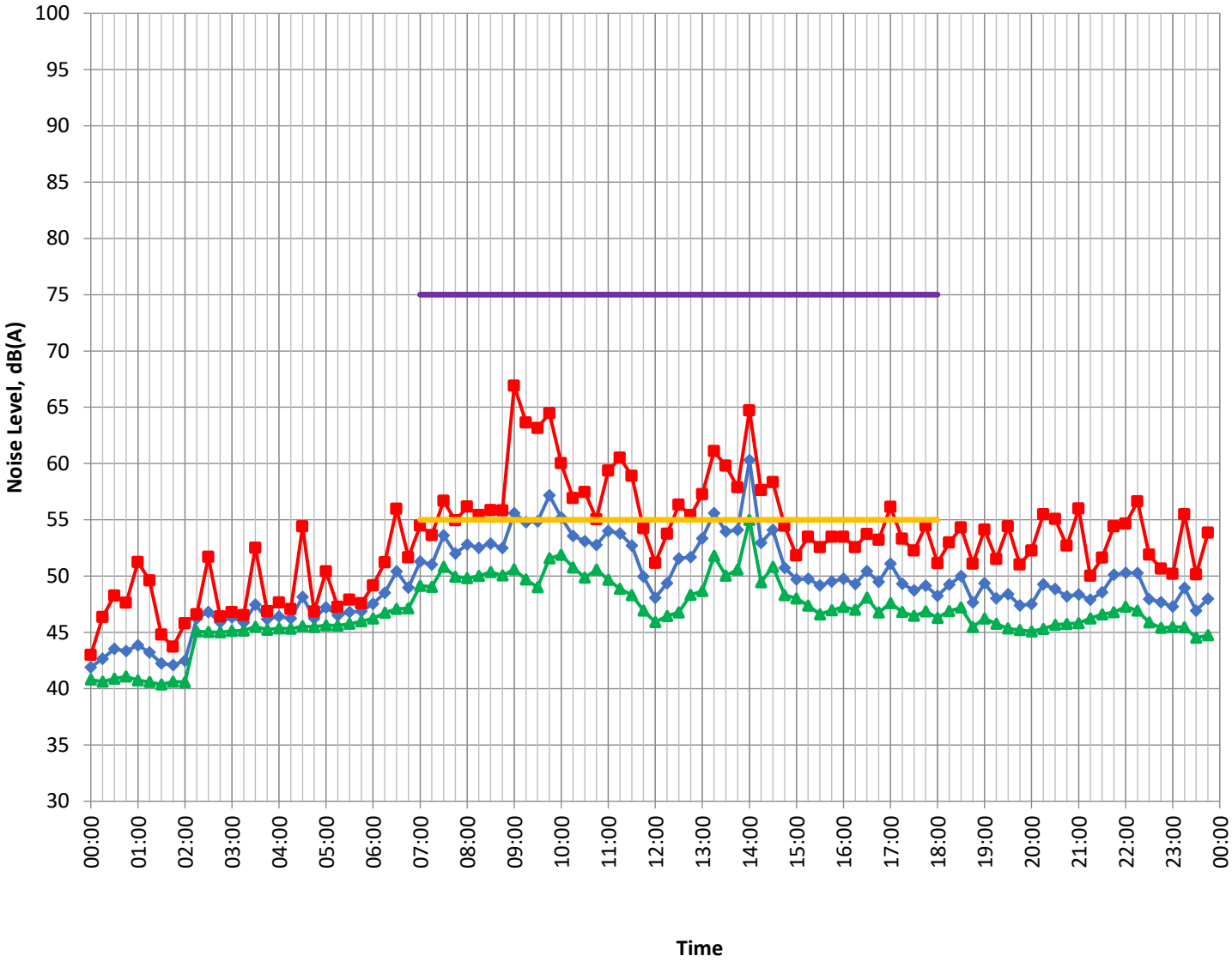
Liverpool Girls Boundary : Tue : 18/10/2022



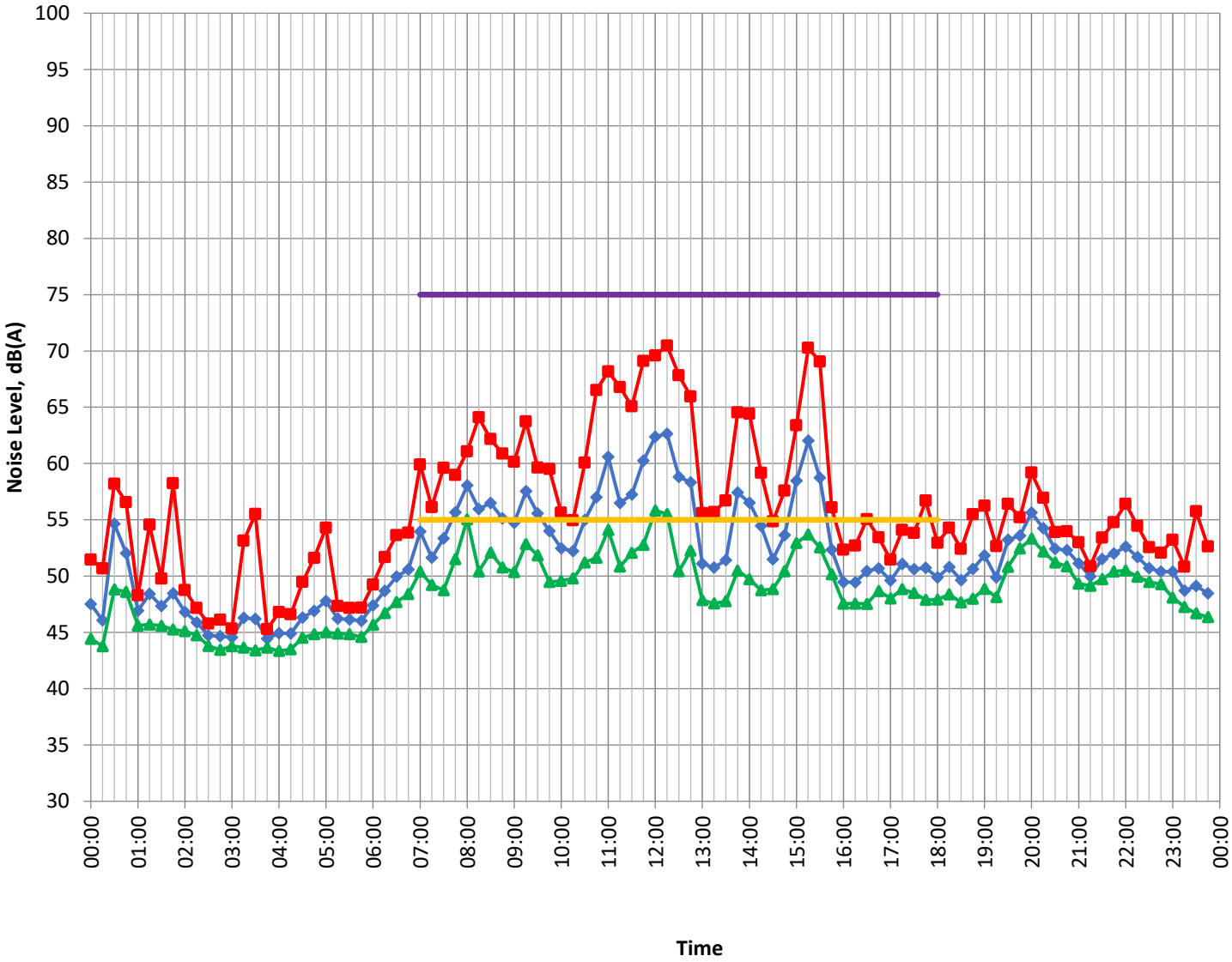
Liverpool Girls Boundary : Wed : 19/10/2022



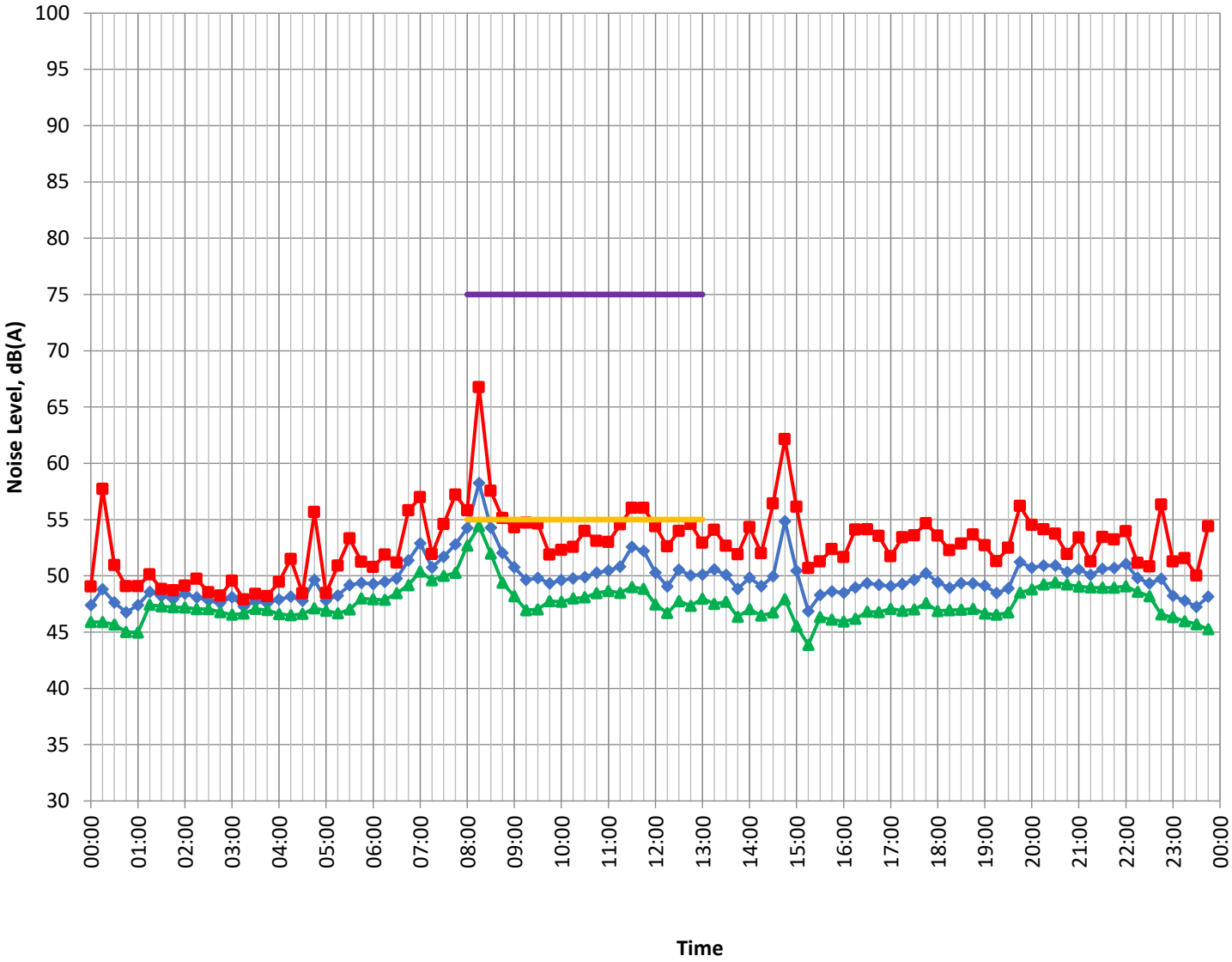
Liverpool Girls Boundary : Thu : 20/10/2022



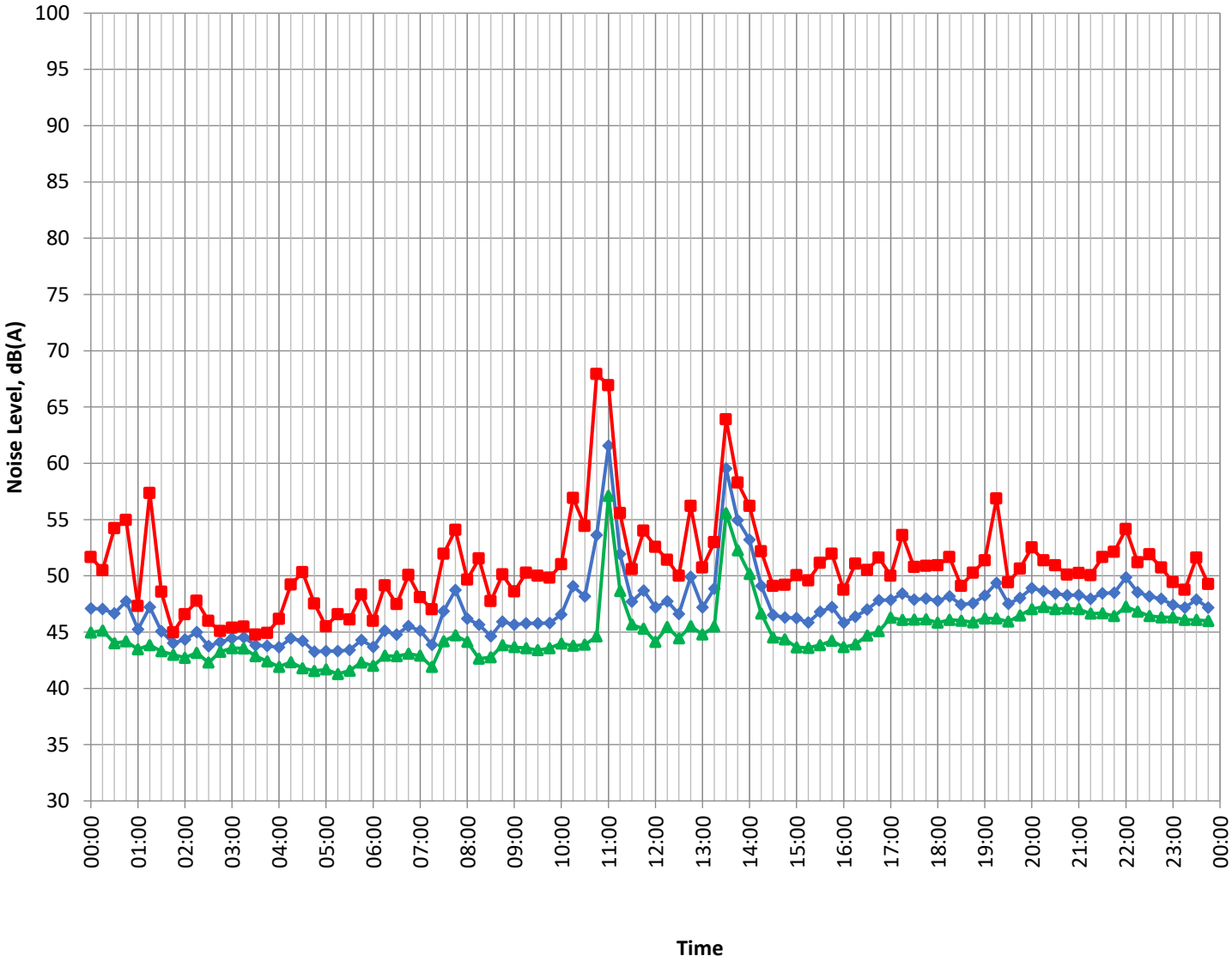
Liverpool Girls Boundary : Fri : 21/10/2022



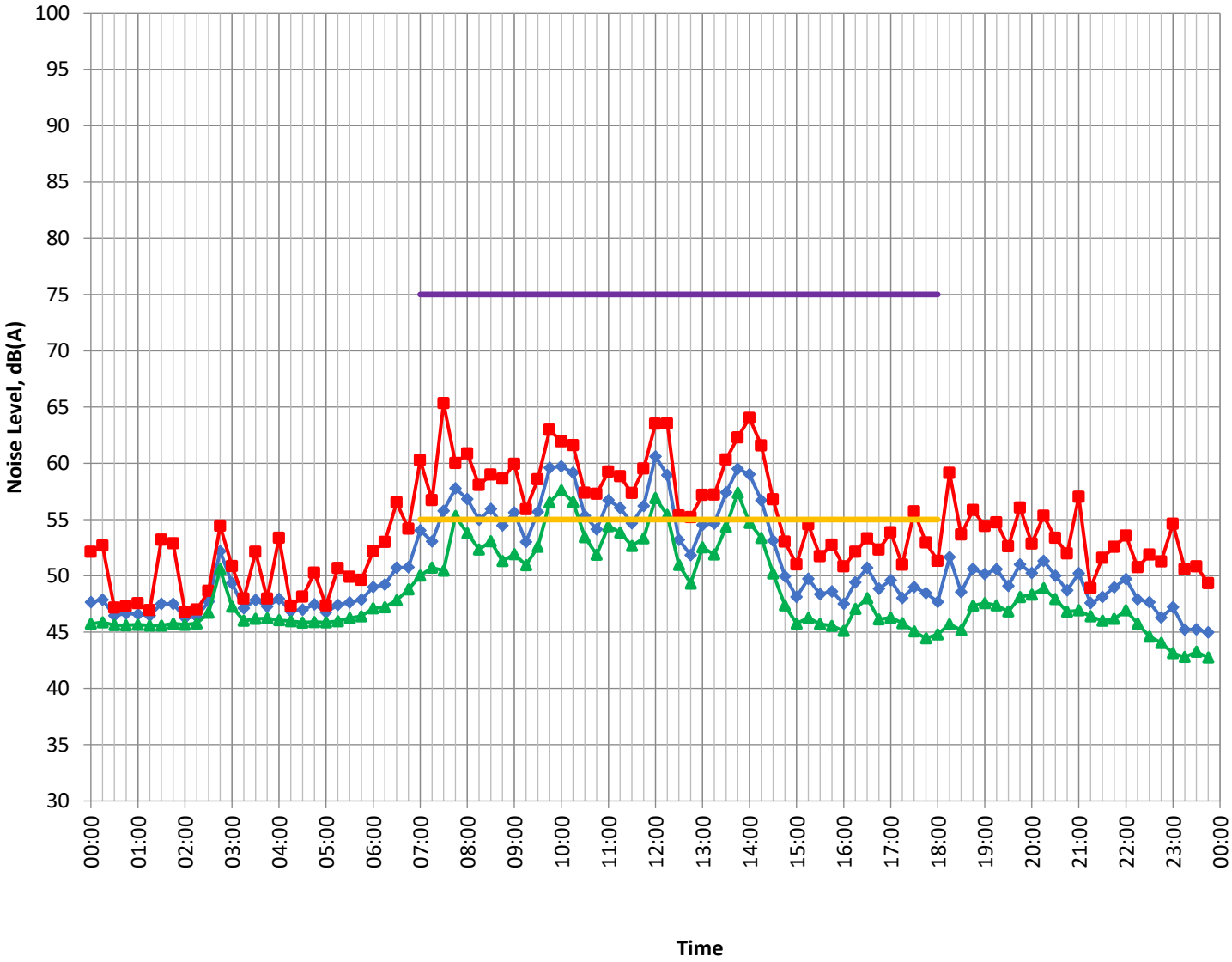
Liverpool Girls Boundary : Sat : 22/10/2022



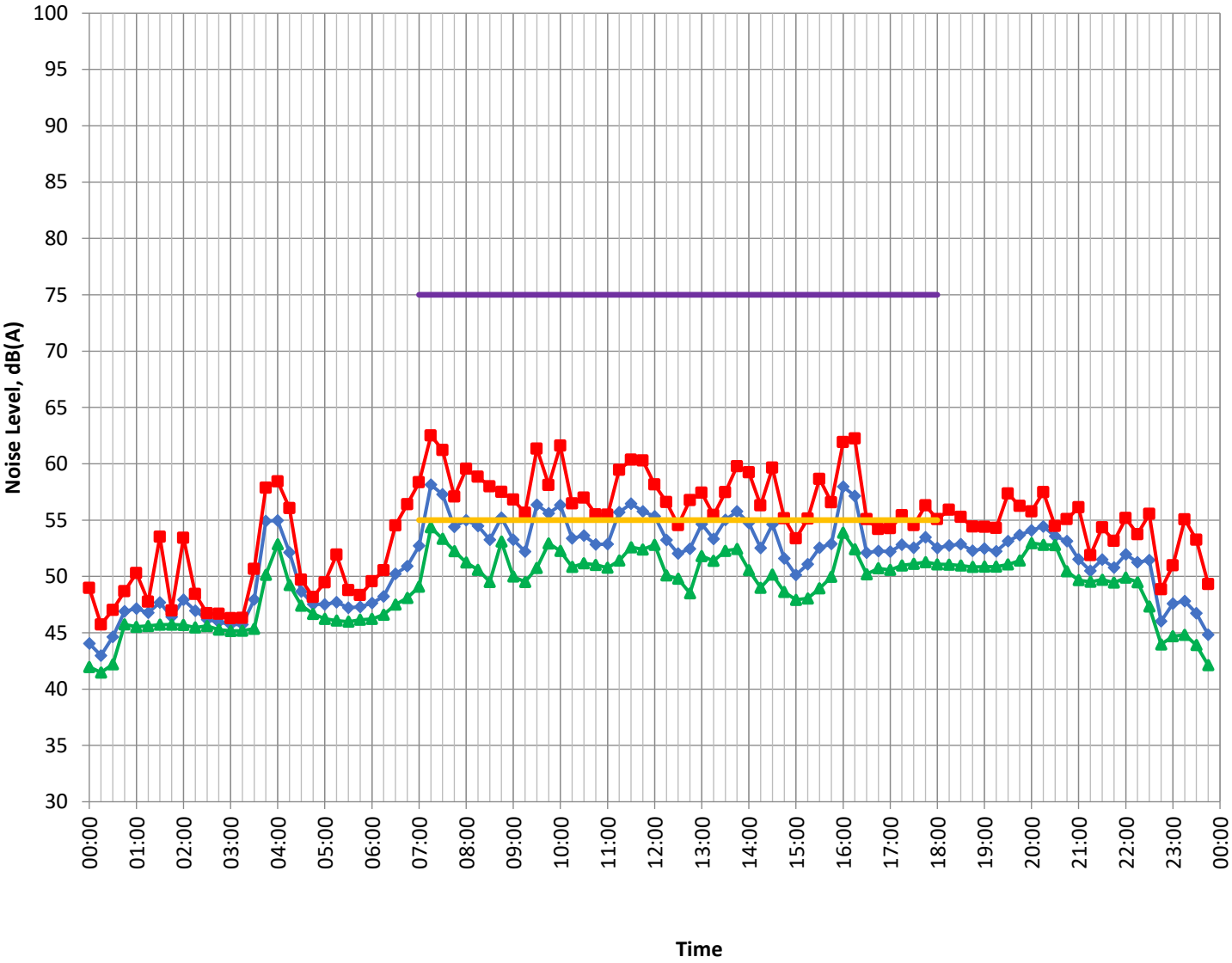
Liverpool Girls Boundary : Sun : 23/10/2022



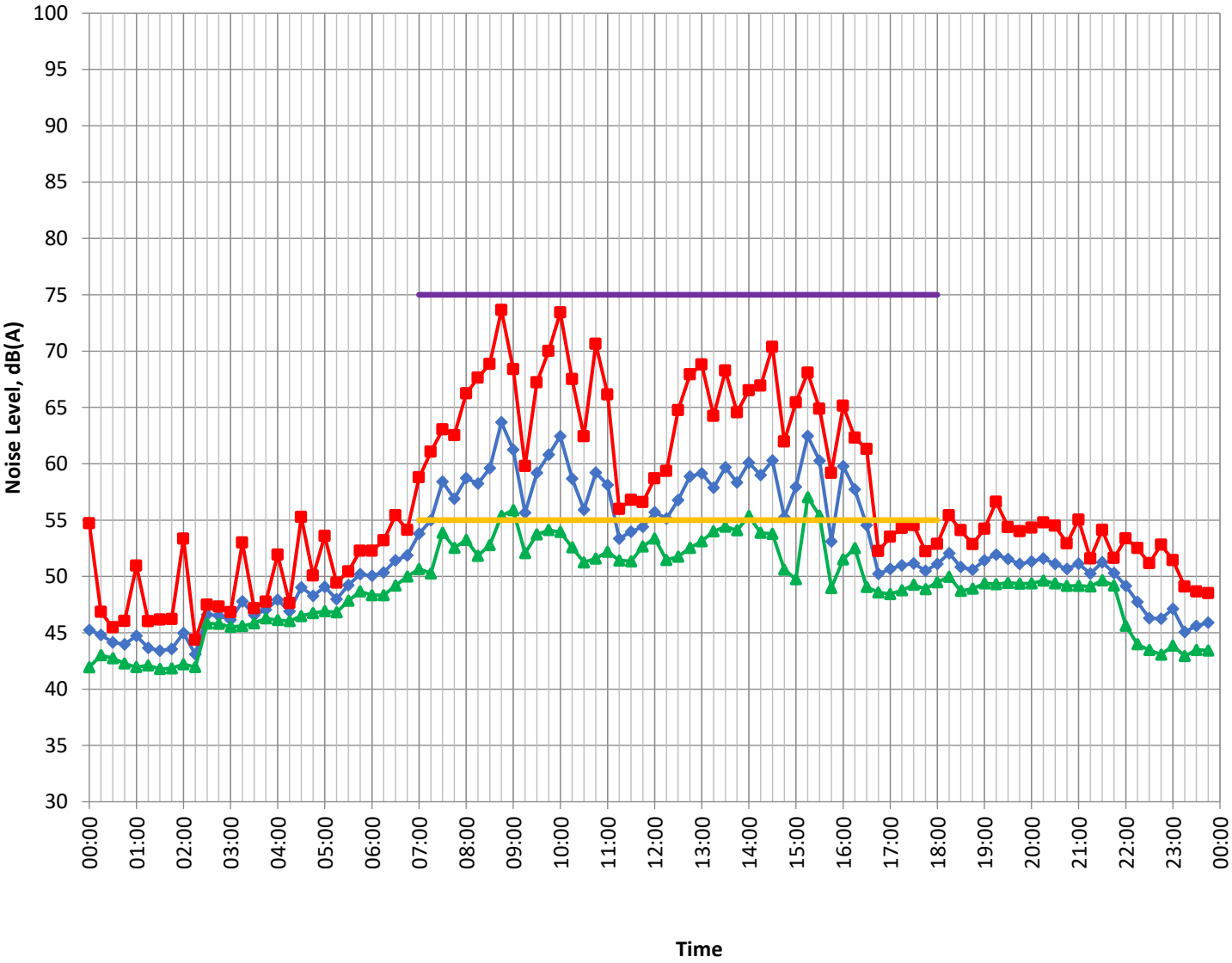
Liverpool Girls Boundary : Mon : 24/10/2022



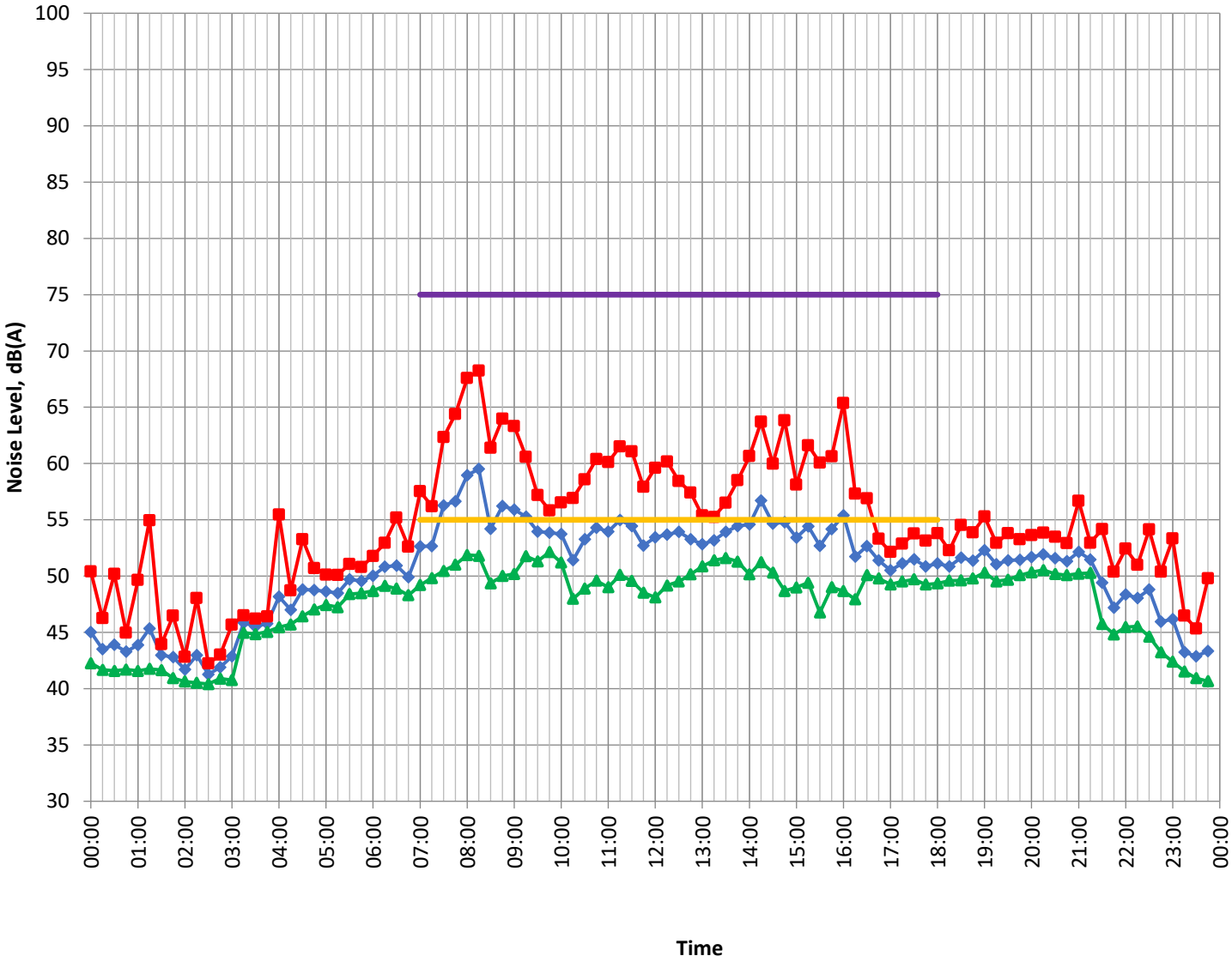
Liverpool Girls Boundary : Tue : 25/10/2022



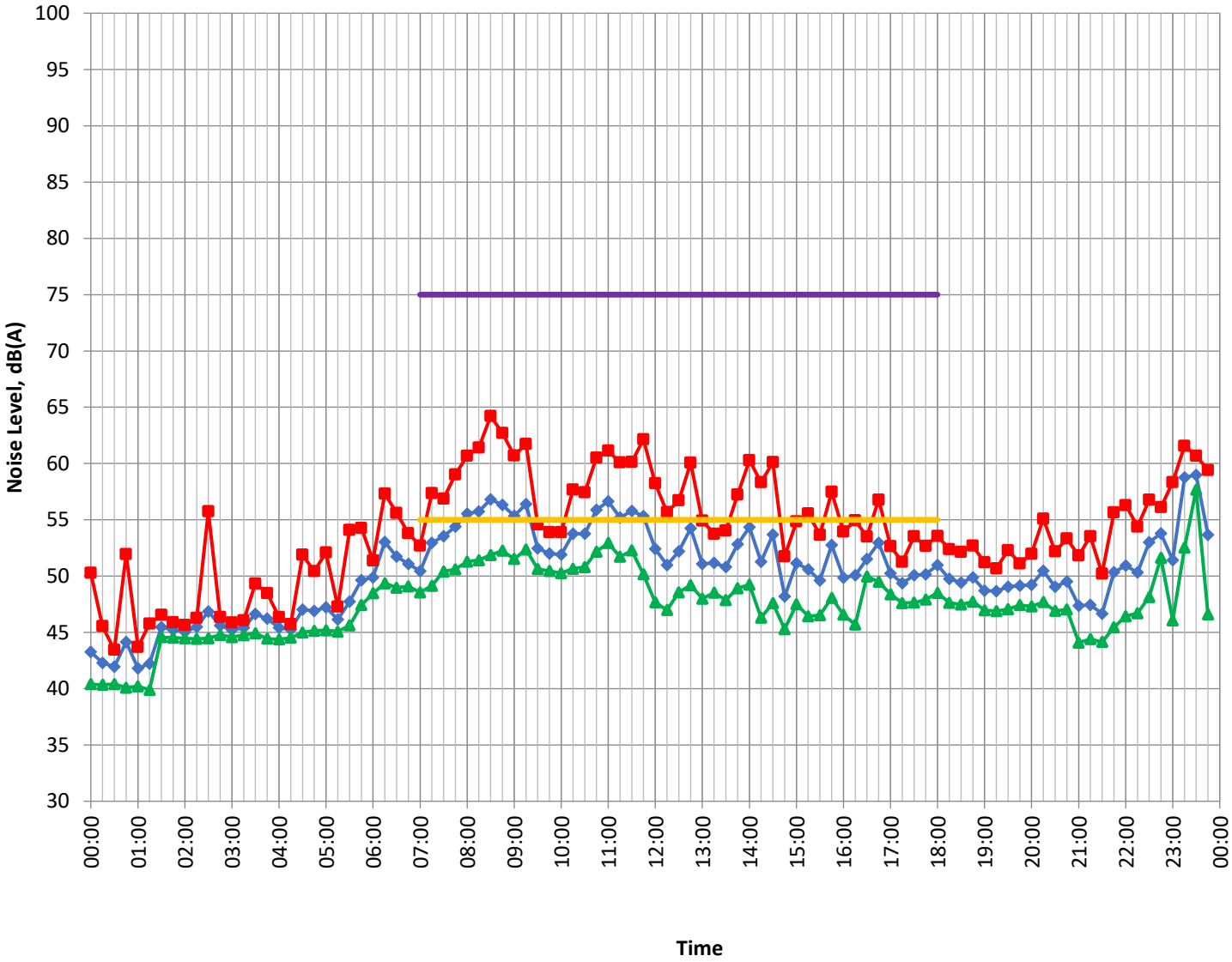
Liverpool Girls Boundary : Wed : 26/10/2022



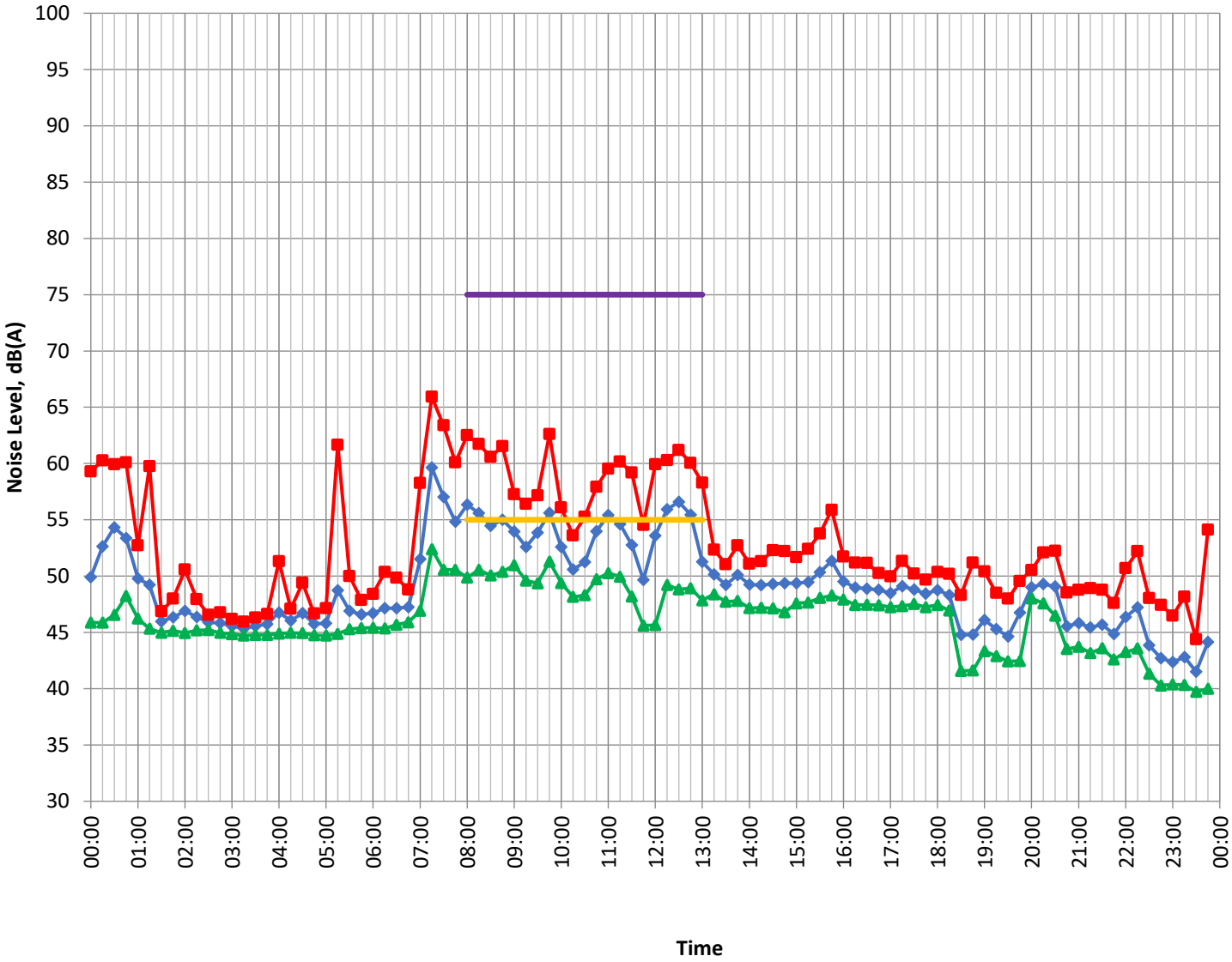
Liverpool Girls Boundary : Thu : 27/10/2022



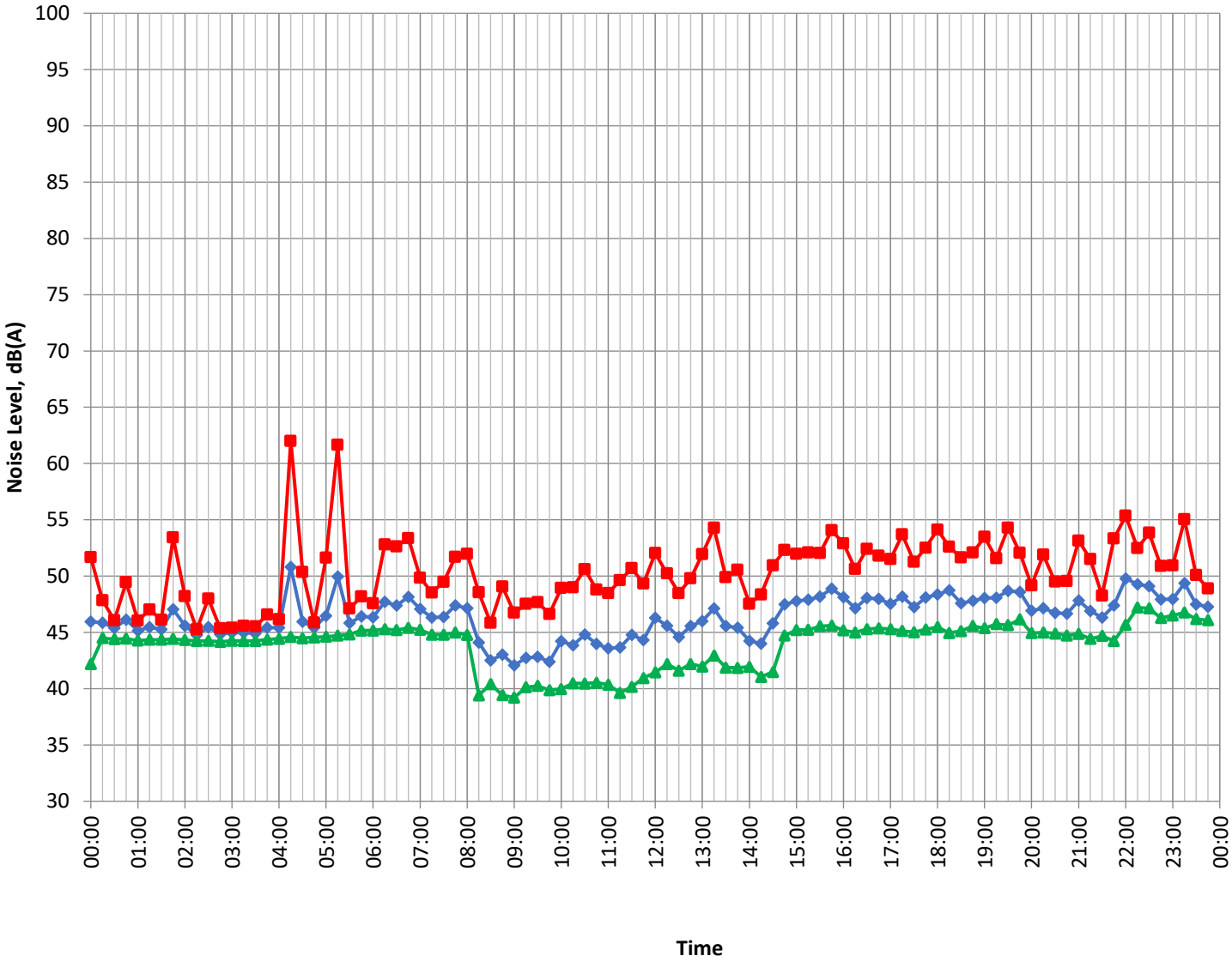
Liverpool Girls Boundary : Fri : 28/10/2022



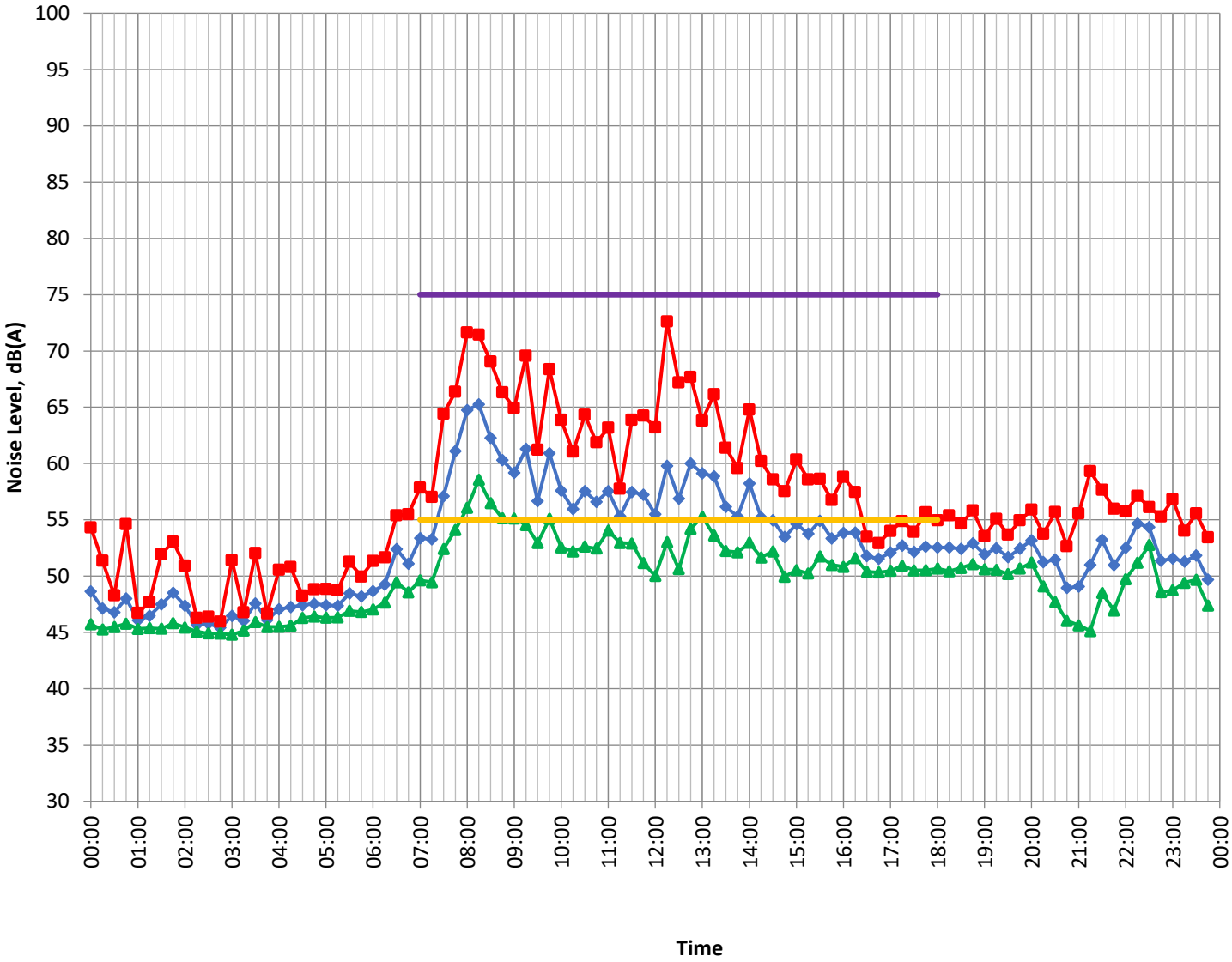
Liverpool Girls Boundary : Sat : 29/10/2022



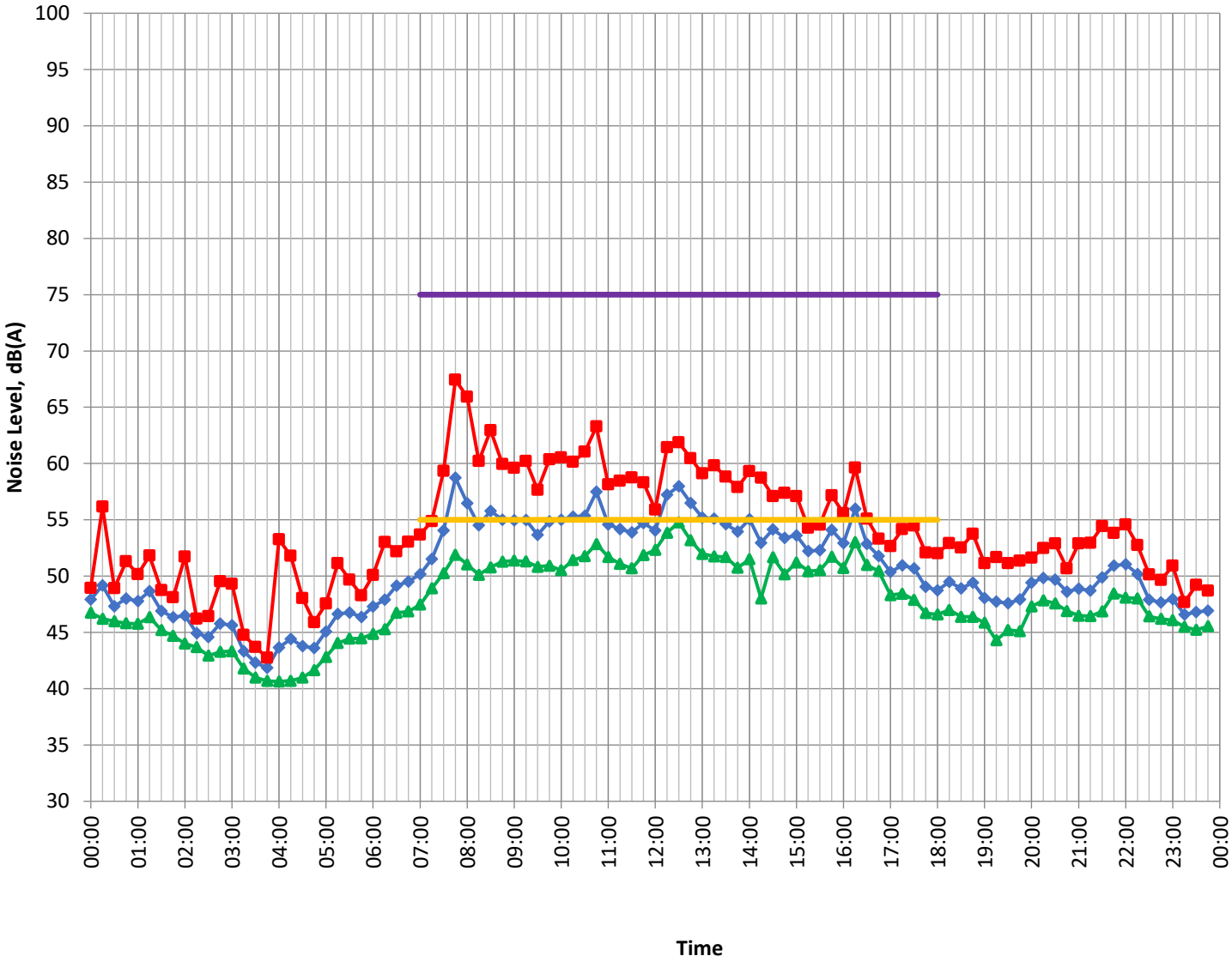
Liverpool Girls Boundary : Sun : 30/10/2022



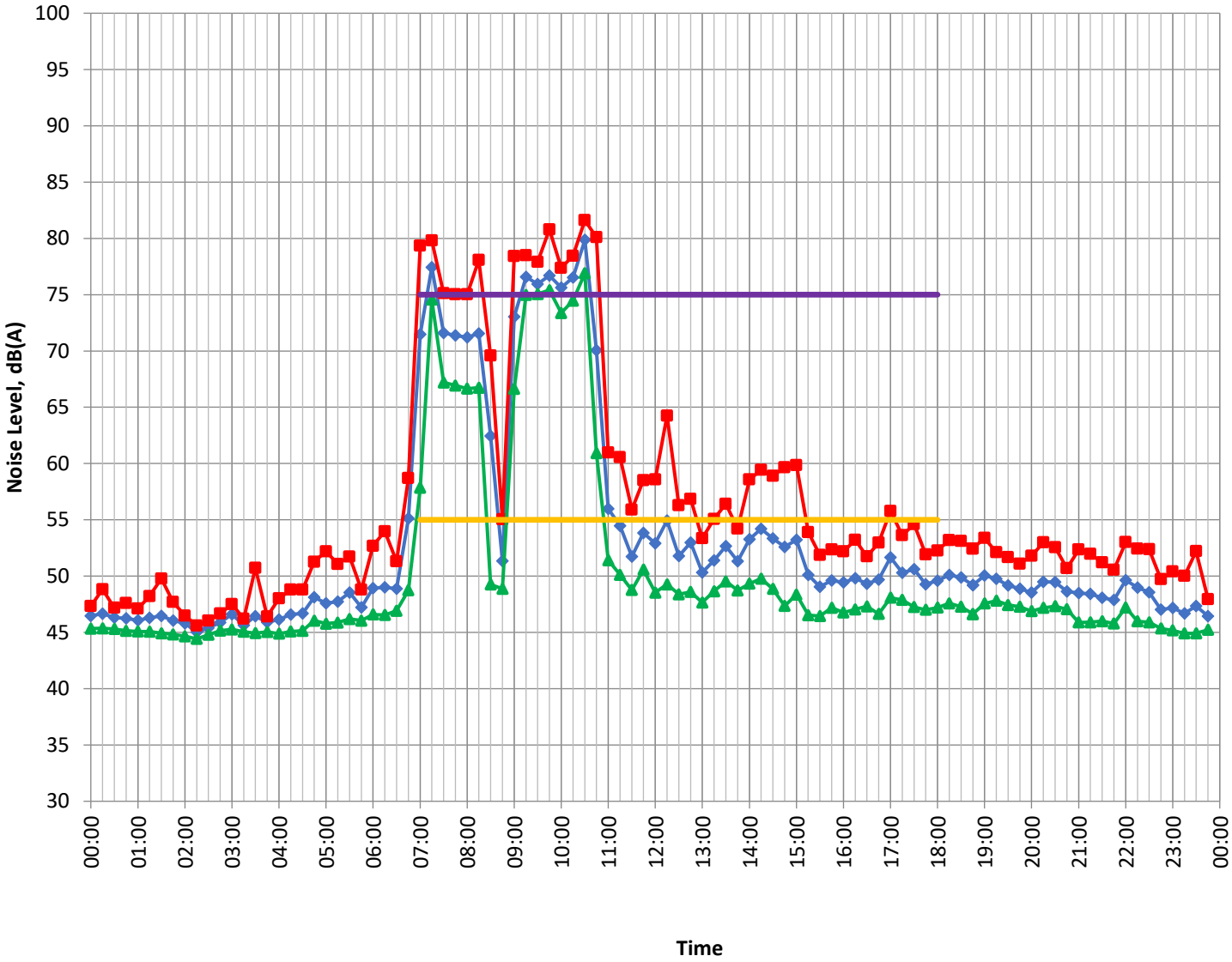
Liverpool Girls Boundary : Mon : 31/10/2022



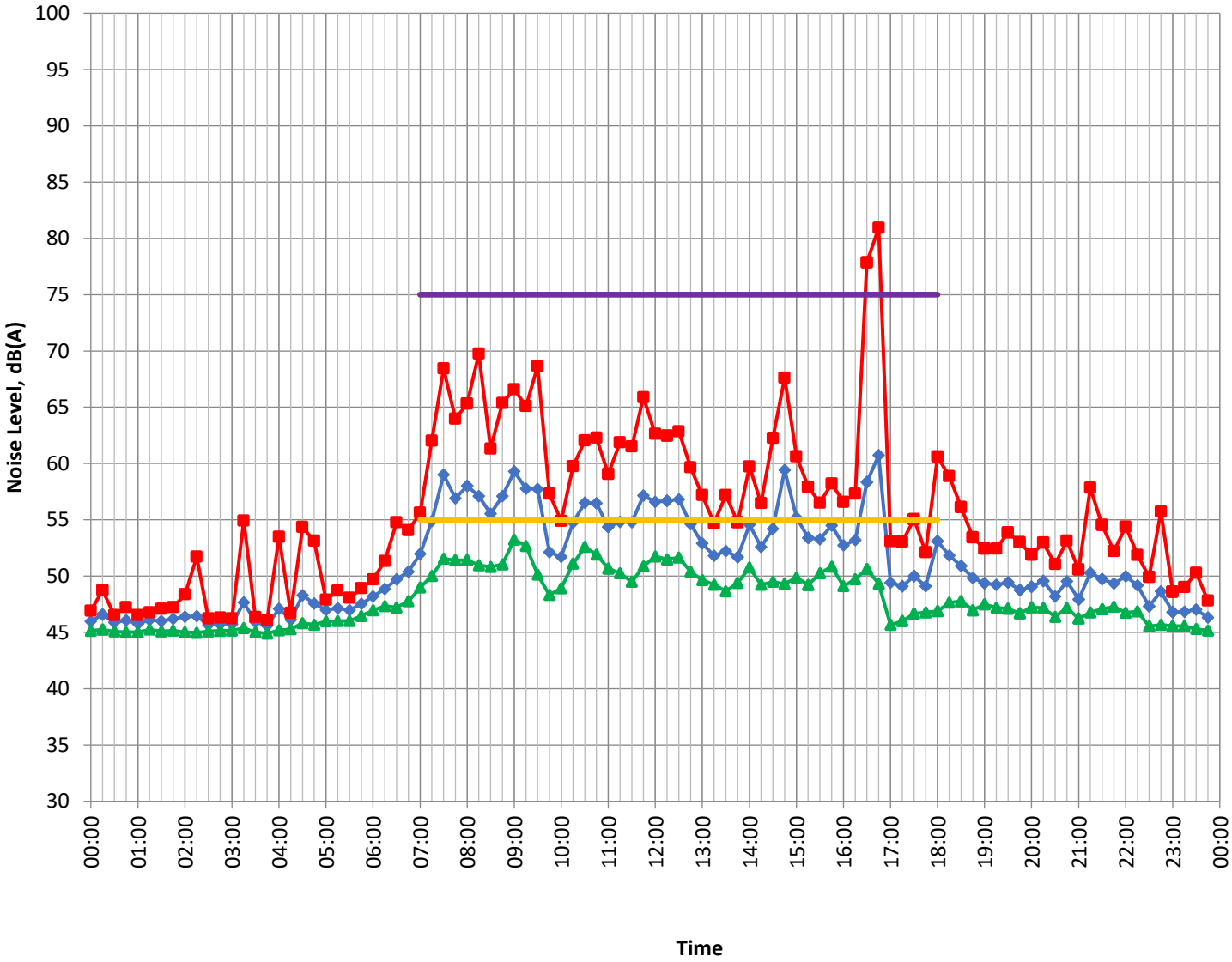
Liverpool Girls Boundary : Tue : 1/11/2022



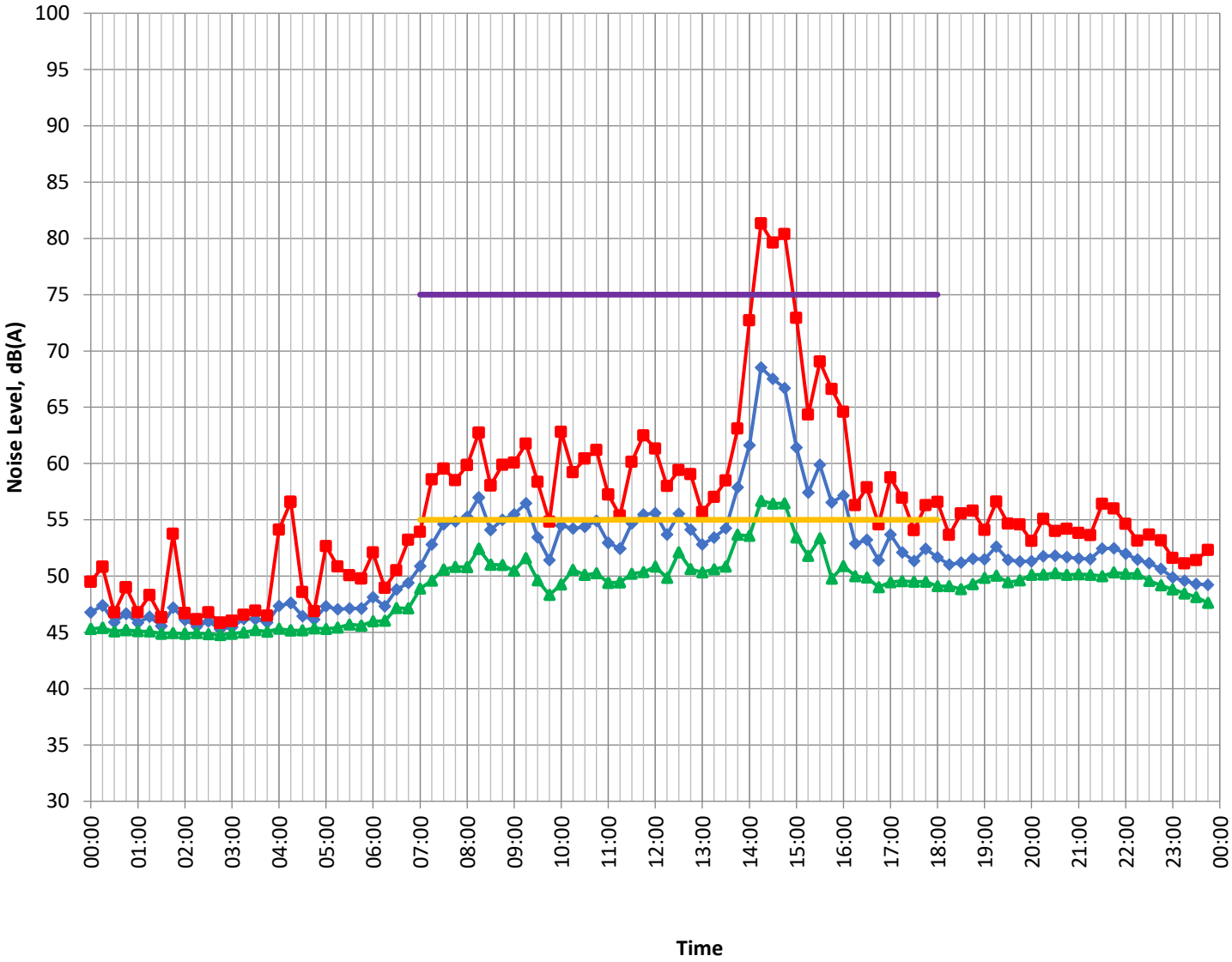
Liverpool Girls Boundary : Wed : 2/11/2022



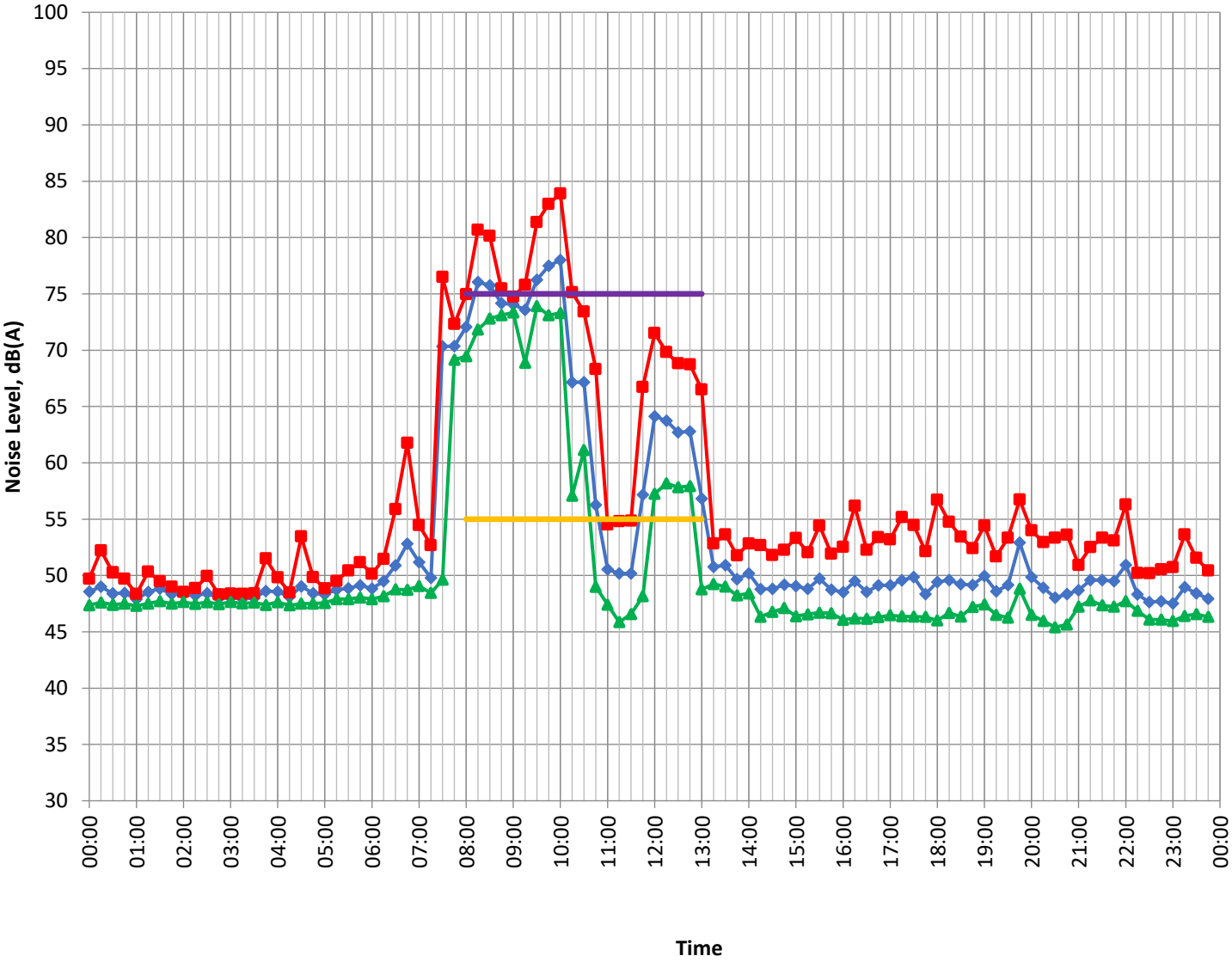
Liverpool Girls Boundary : Thu : 3/11/2022



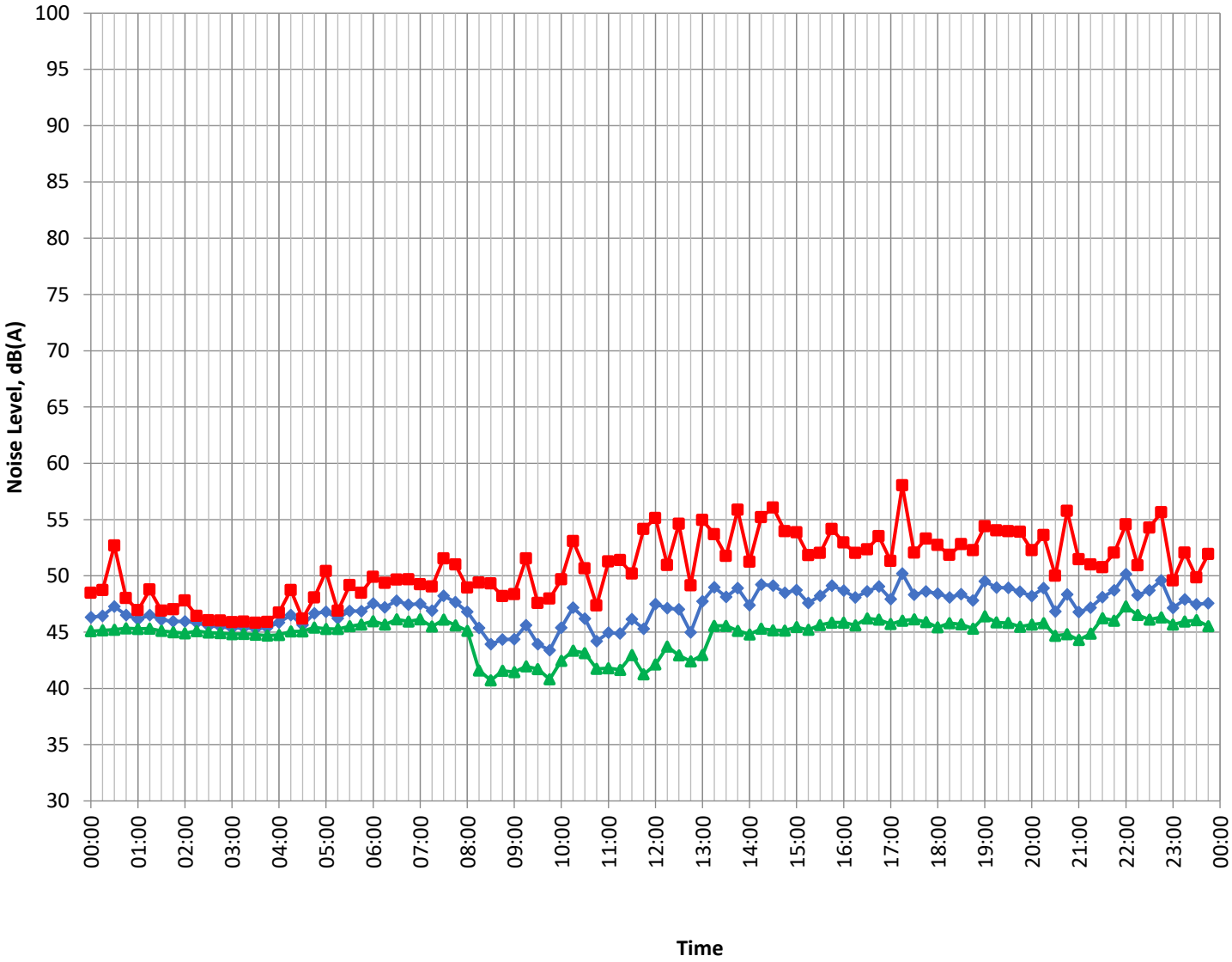
Liverpool Girls Boundary : Fri : 4/11/2022



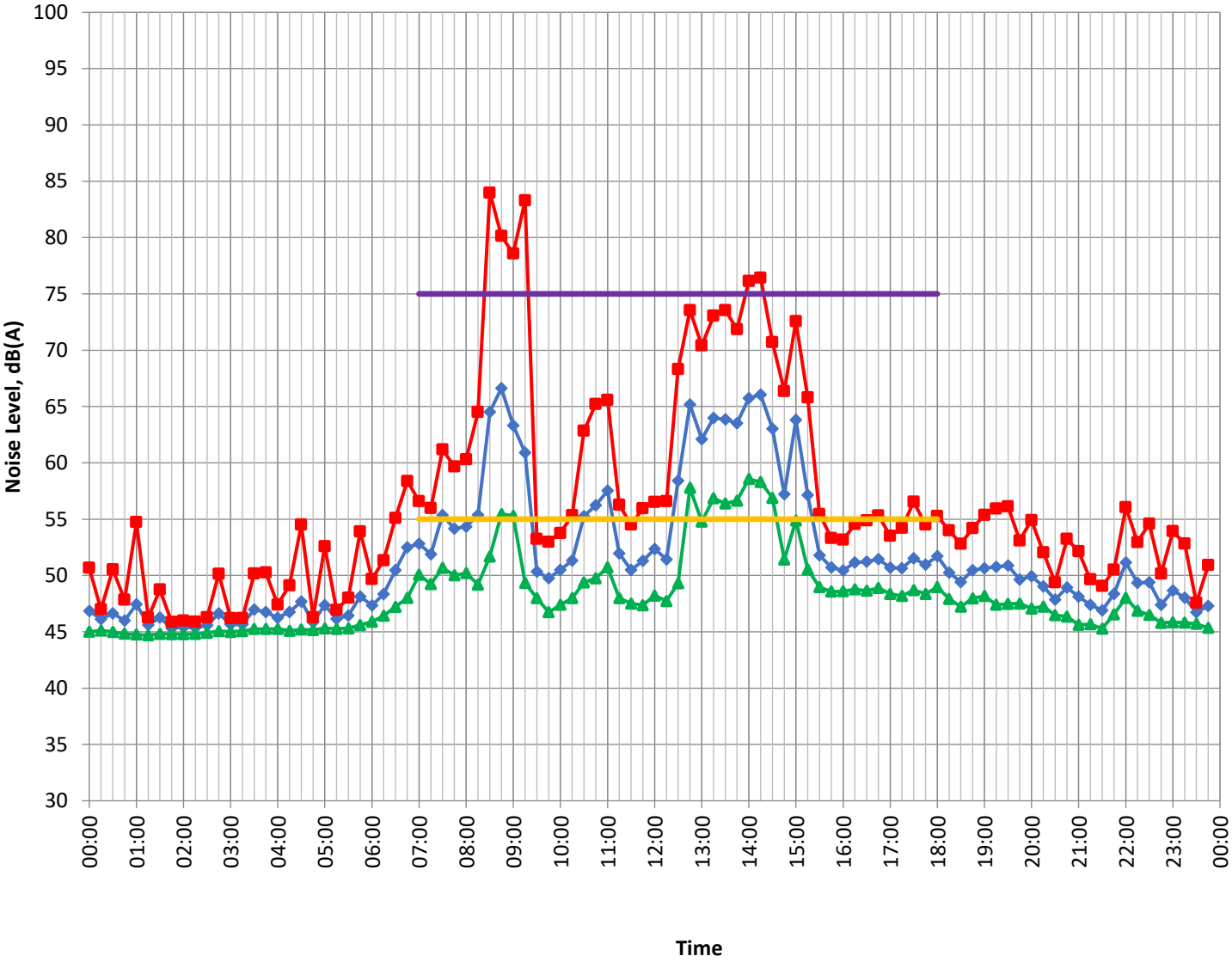
Liverpool Girls Boundary : Sat : 5/11/2022



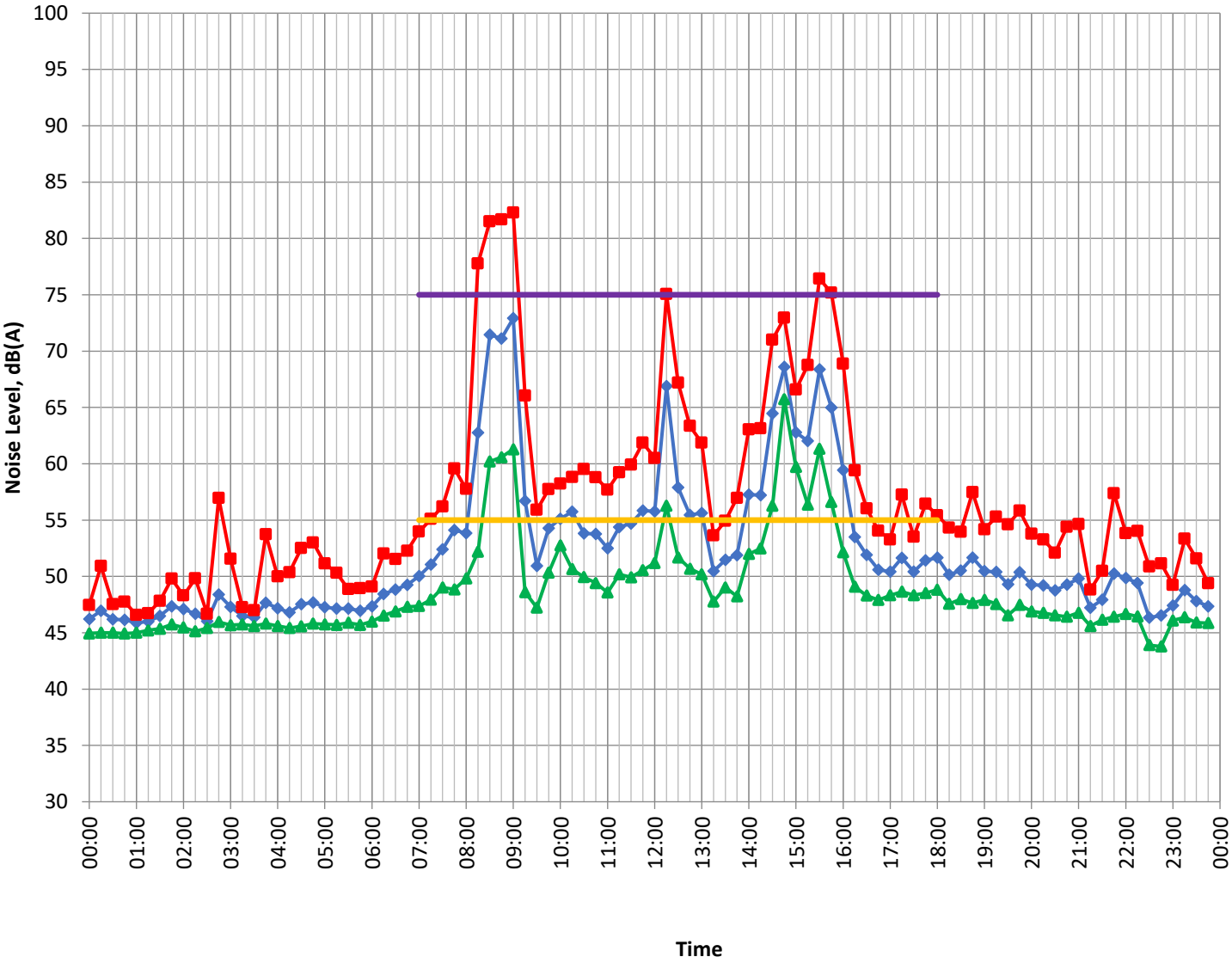
Liverpool Girls Boundary : Sun : 6/11/2022



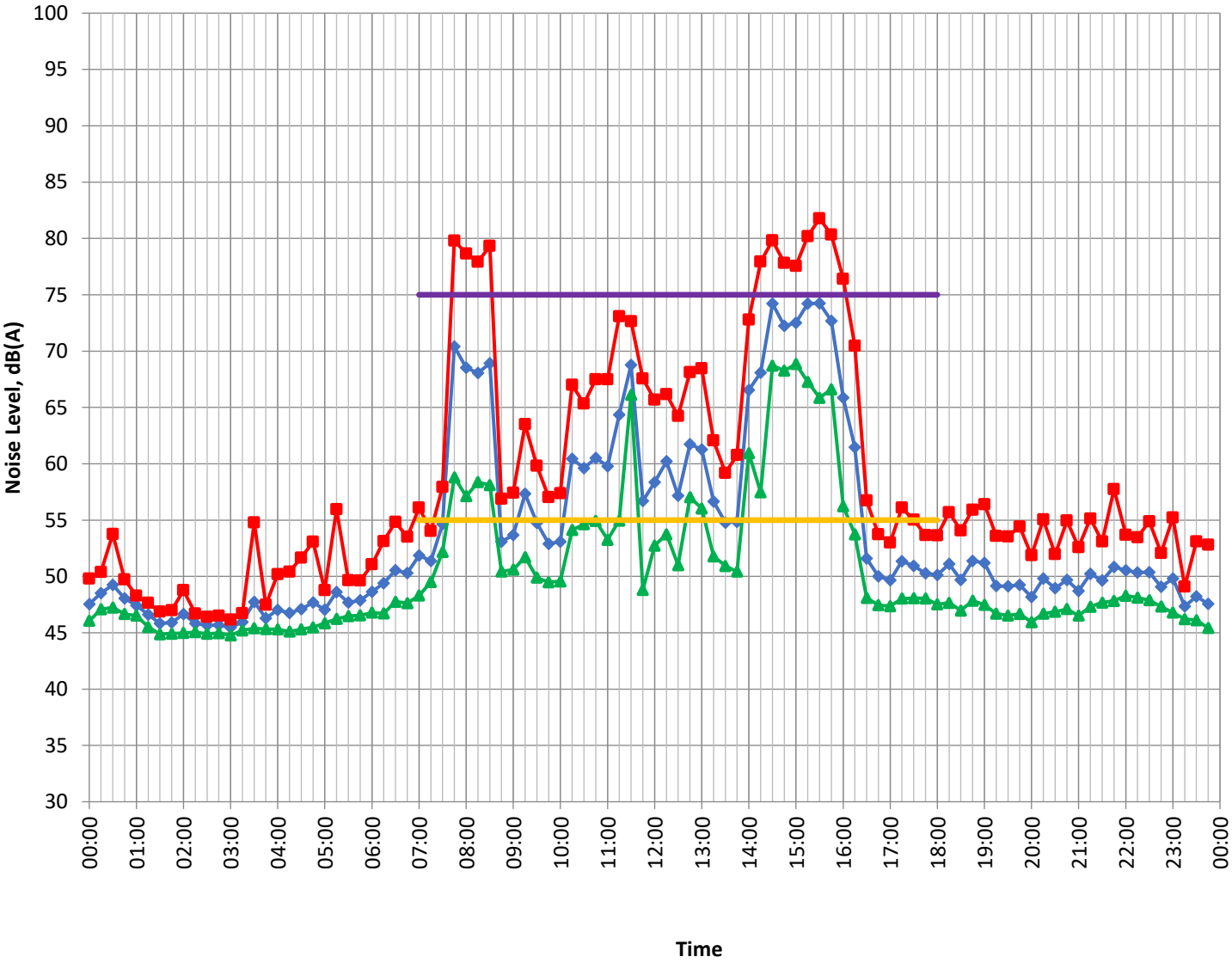
Liverpool Girls Boundary : Mon : 7/11/2022



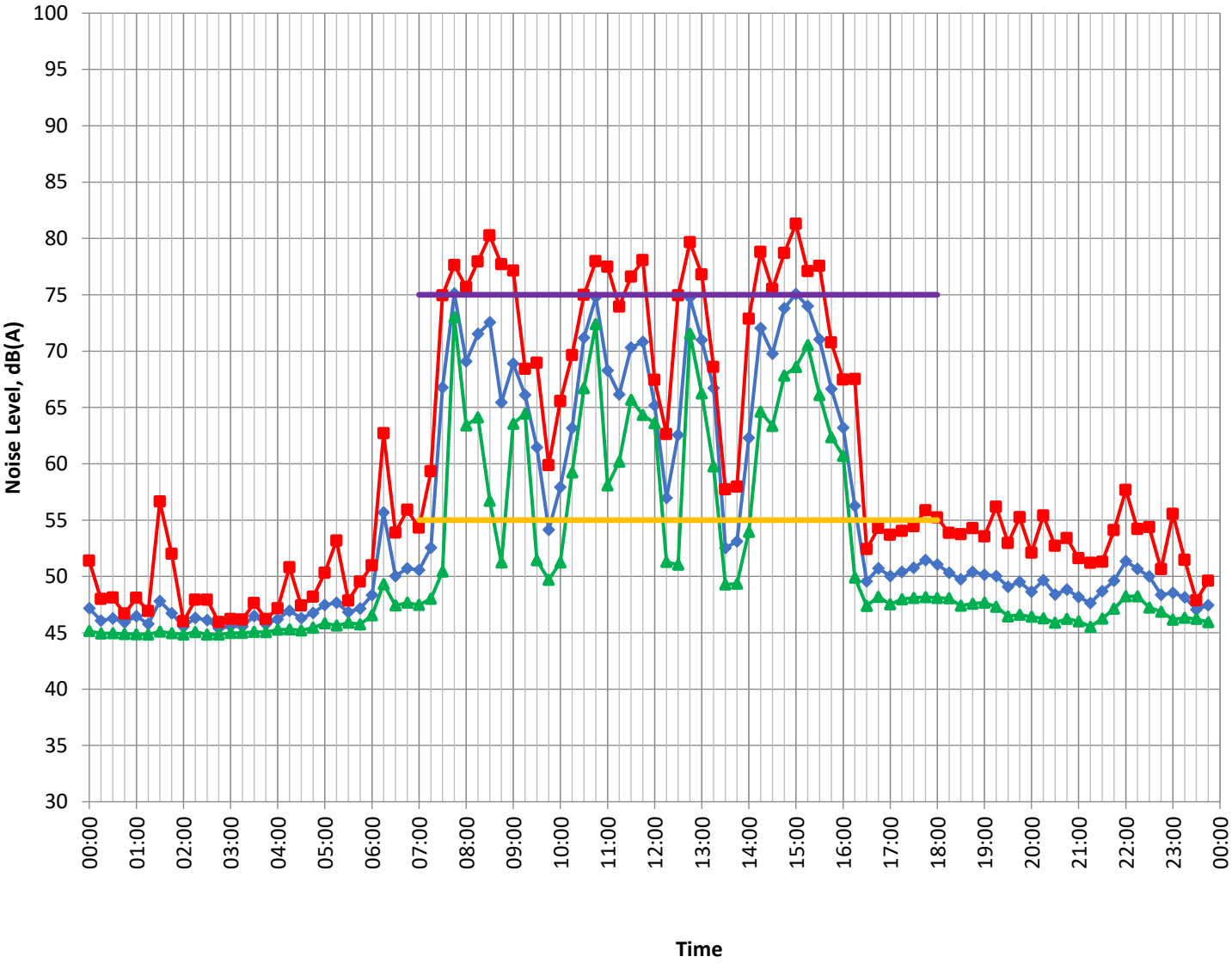
Liverpool Girls Boundary : Tue : 8/11/2022



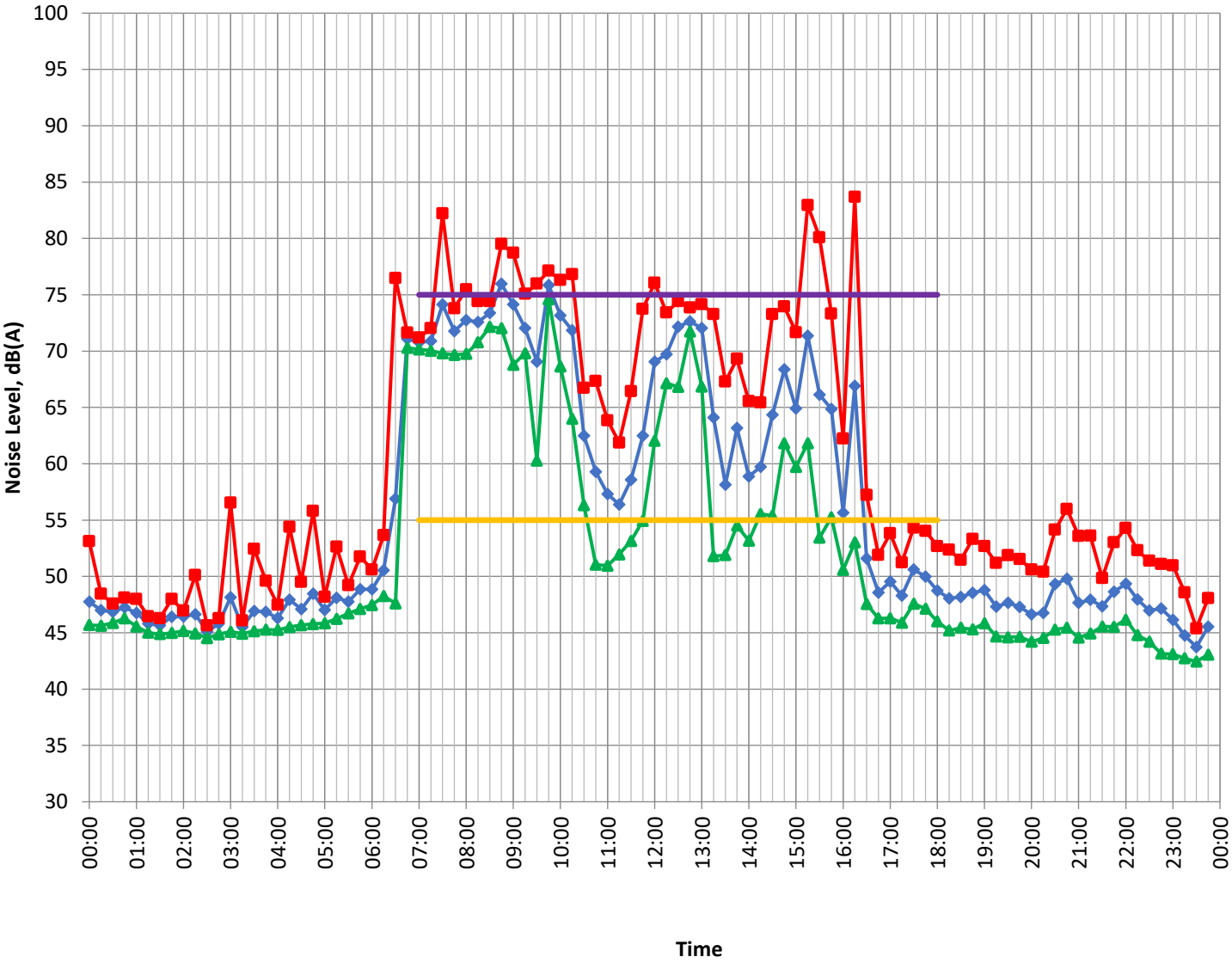
Liverpool Girls Boundary : Wed : 9/11/2022



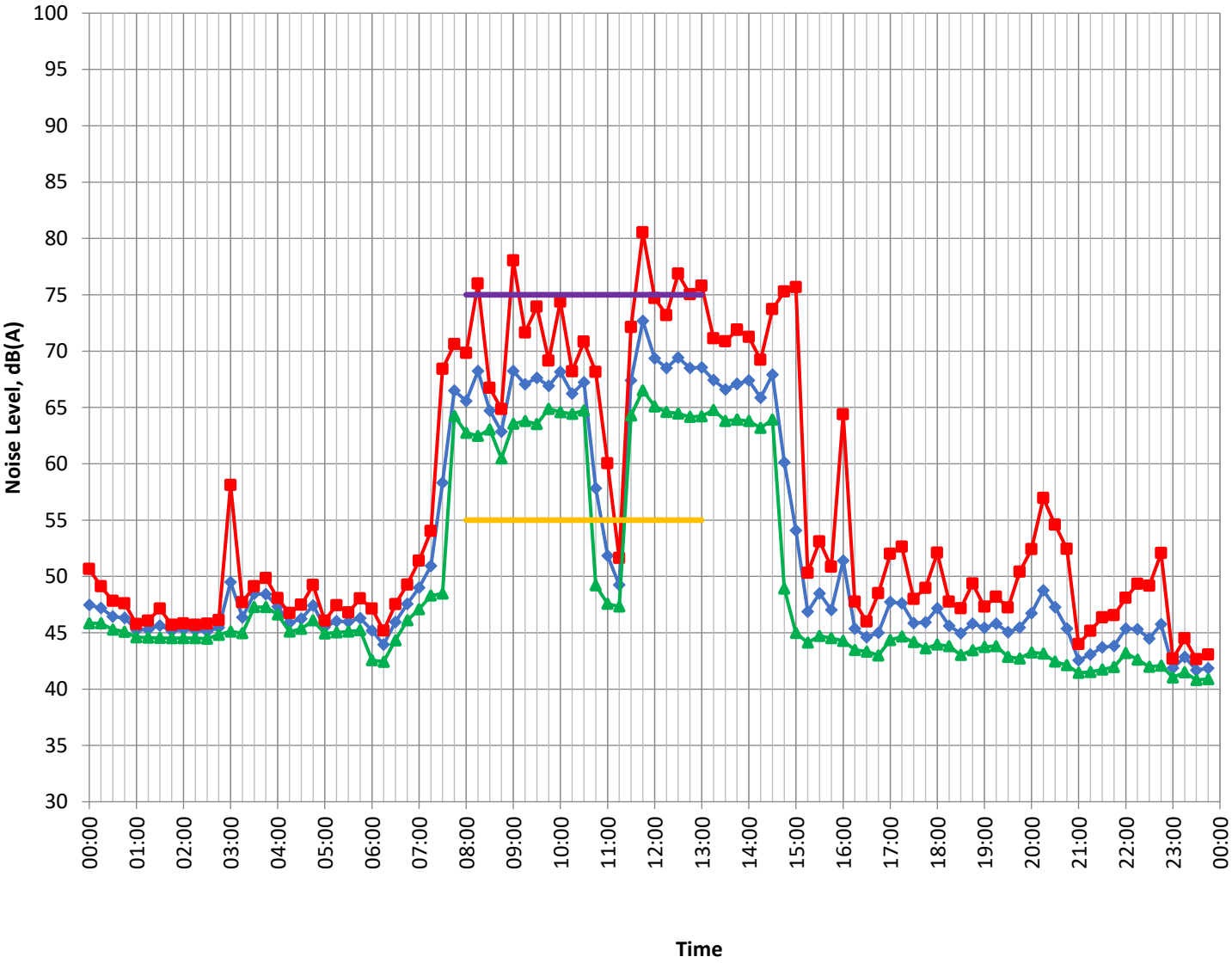
Liverpool Girls Boundary : Thu : 10/11/2022



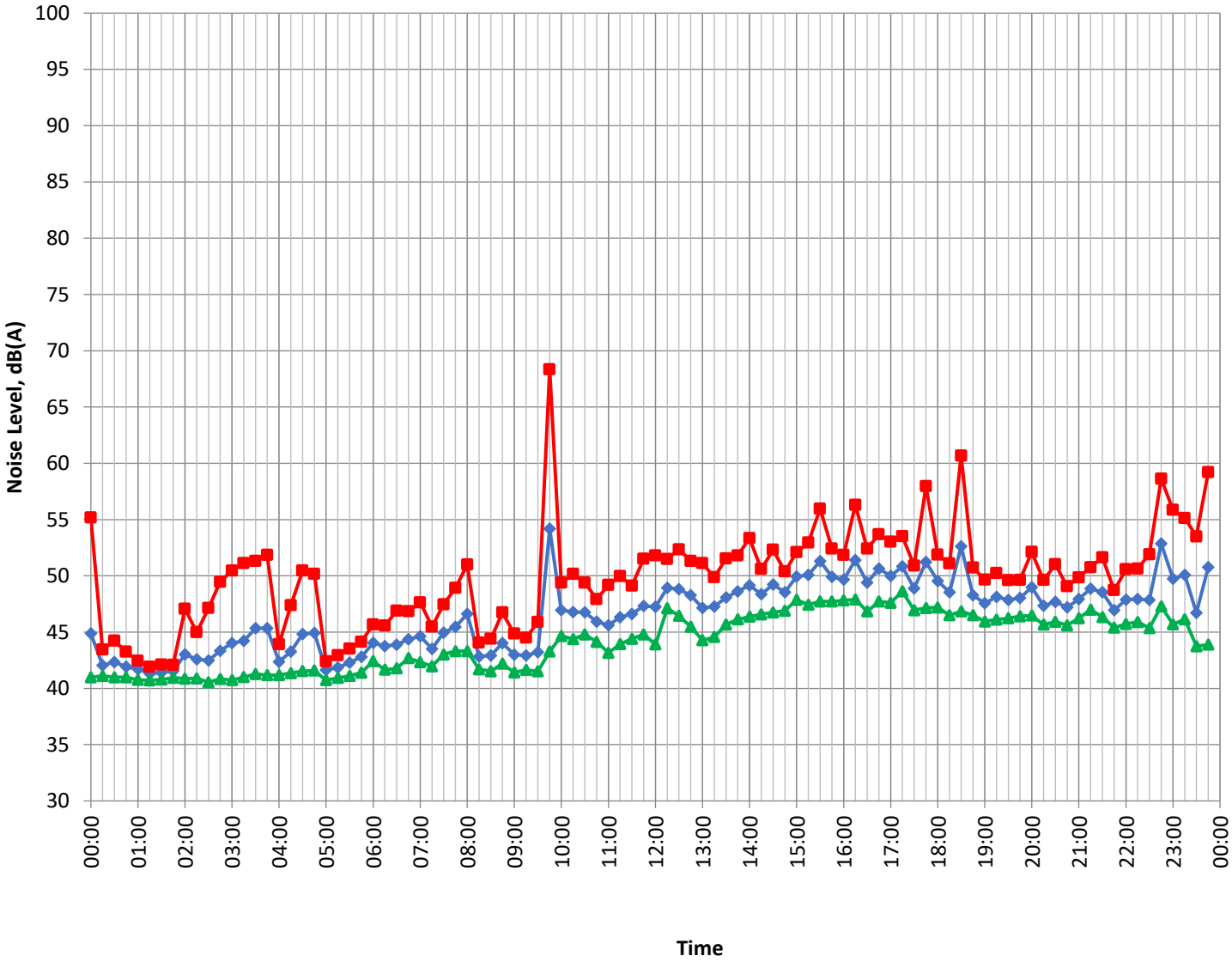
Liverpool Girls Boundary : Fri : 11/11/2022



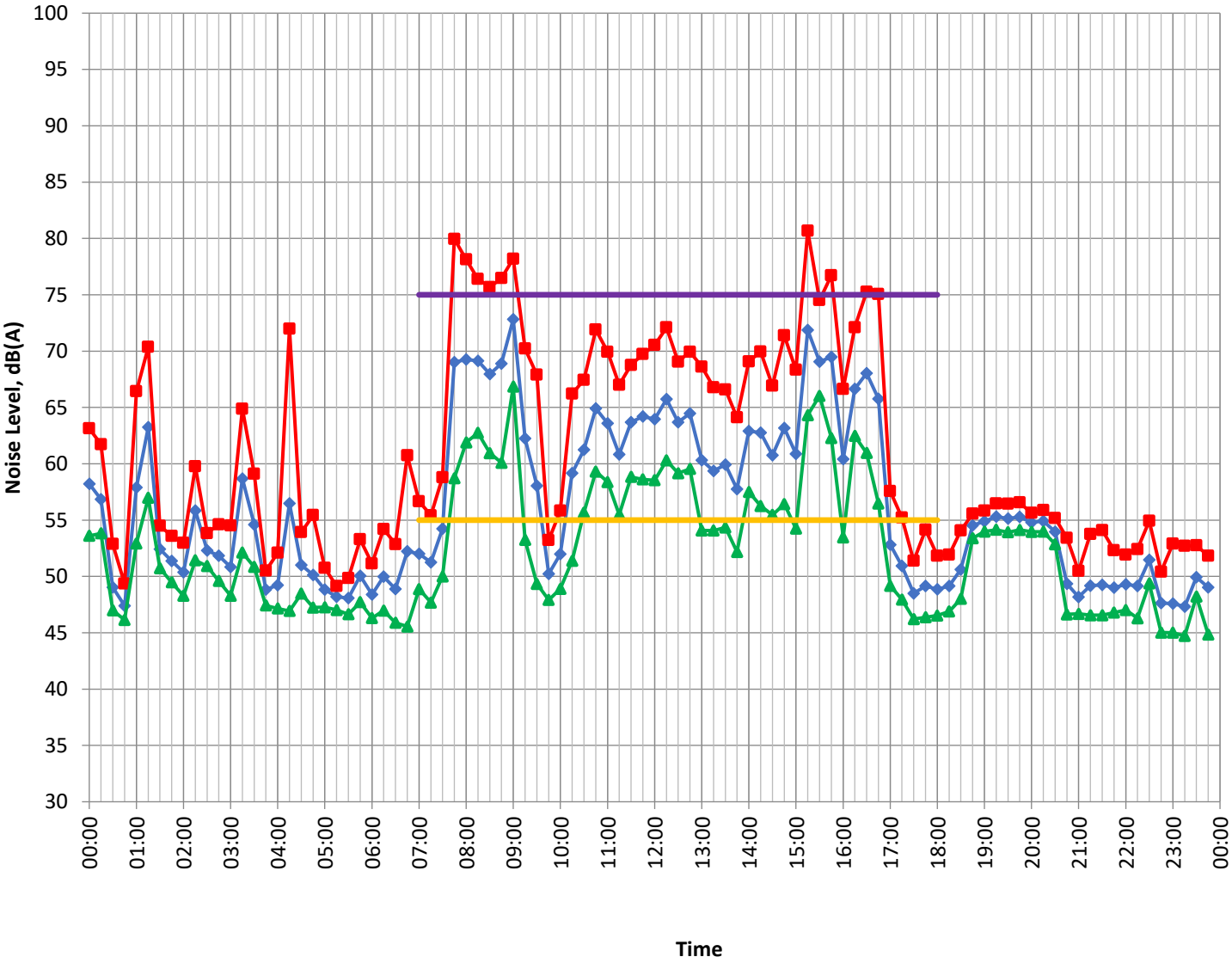
Liverpool Girls Boundary : Sat : 12/11/2022



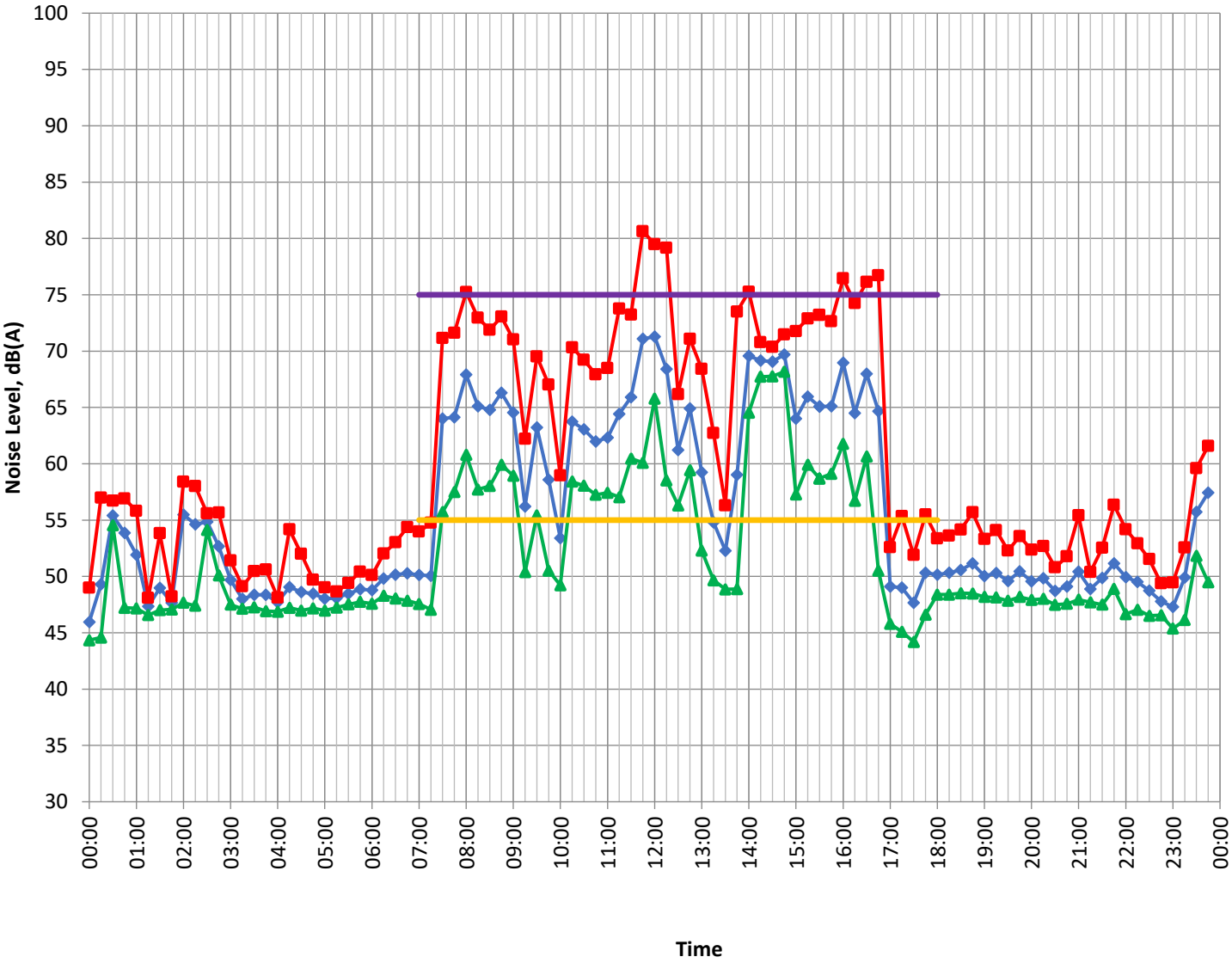
Liverpool Girls Boundary : Sun : 13/11/2022



Liverpool Girls Boundary : Mon : 14/11/2022



Liverpool Girls Boundary : Tue : 15/11/2022



Liverpool Girls Boundary : Wed : 16/11/2022