UNIVERSITY OF WALES TRINITY ST DAVID FACE BUILDING

Environmental Noise Assessment

Stride Treg

ABOUT US

MACH Acoustics is a fast- growing consultancy with a staff of 20, who all share a passion for acoustics and a commitment to sustainable architecture.

Based in Bristol and London, our exceptional team of highly qualified engineers, project managers, data analysts and acoustic modellers love solving acoustic challenges across all building sectors.

OUR APPROACH

We use rigorous mathematics and creativity to come up with simple, effective designs that solve a problem. For us the right solution also has to be aesthetically pleasing and cost effective.

SUSTAINABILITY

We work across all sectors, including educational, residential, commercial and arts/entertainment and always look for ways in which we can enhance the scope of the buildings we work on and the services we provide.

Sustainability is at the core of our work -for us it goes hand in hand with acoustics. We specialise in façade designs that allow for natural ventilation even on noisy sites and enable beautiful, low carbon buildings.

COMMUNICATION

To find the best acoustic solution, we must communicate and collaborate effectively with the design team. But acoustics are often invisible and complex, and decibels are meaningless to a non-acoustician.

There are two ways that we achieve this:

CLARITY

Firstly, we keep the jargon to a minimum and provide clear tables and marked up drawings indicating required performance targets, constructions and acoustic treatment.

VISUAL

Alternatively we can create simple visual simulations and auralisations (the aural equivalent of visualisations) that allow design teams to 'see' and hear the sound in a building. This ensures the team fully understands the performance requirements of a completed building and frequently it results in cost savings, as less noise mitigation is required than previously thought.

In this document are some of our example reports, exactly as they were delivered to past clients. Design reports are tailored to each individual client and include a high graphic content that demonstrates both the principles of acoustics and our design. Acoustic treatments and design solutions are set out with a greater level of precision and detail than many of our competitors' reports, as we always make clear exactly what the sound reduction will be and how we will achieve it.

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Revision	Description	Author	Checked/Issued By	Issue Date
00	First Issue	Zoe Vernon	Chris Jones	26/02/2016
01	Minor Updates	Zoe Vernon	-	27/04/2016

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ACOUSTIC TERMINOLOGY

Absorption Classes	The sound absorption of a material is rated from Class A to Class E, where Class A materials provide the highest levels of sound absorption.
Ambient Noise Levels	Noise levels measured in the absence of noise requiring control, frequently measured to determine the situation prior to the addition of a new noise source.
dB	Decibel. The logarithmic unit of sound level.
dBA	A-weighted decibel. The A-weighting approximates the response of the human ear.
$D_{nT,w}$	Weighted standardized level difference. A single number quantity of the sound level difference between two rooms. $D_{nT,w}$ is typically used to measure the on-site sound insulation performance of a building element such as a wall, floor or ceiling. Measured in accordance with BS EN ISO 16283-1 and weighted in accordance with BS EN ISO 717-1.
$D_{n,e,w}$	The weighted element-normalized level difference. A single number rating of the sound reduction provided by a sound passing through an individual element. $D_{n,e,w}$ is typically used to define the sound insulation provided by ventilators. Measured in accordance with BS EN ISO 10140-2:2010 and rated in accordance with BS EN ISO 717-1.
Flanking	Transmission of sound energy through paths adjacent to the building element being considered. For example, sound may be transmitted around a wall by travelling up into the ceiling space and then down into the adjacent room.
Frequency	Sound can occur over a range of frequencies extending from the very low, such as the rumble of thunder, up to the very high such as the crash of cymbals. Sound is generally described over the frequency range from 63Hz to 4kHz, roughly equal to the range of frequencies on a piano.
Impact Sound	Sound produced by an object impacting directly on a building structure, such as footfall noise or chairs scrapping on a floor.
$L_{Aeq,t}$	The equivalent continuous sound level measured in dBA. This is commonly referred to as the average noise level. "t" is the interval time for the measurement which is most often 30 minutes when demonstrating compliance with BB93.
$L_{A90,t}$	The noise level exceeded for 90% of the measurement period, measured in dBA. This is commonly referred to as the background noise level.
$L'_{nT,w}$	Weighted, standardized impact sound pressure level. A single number rating of the impact sound insulation of a floor/ceiling when impacted on by a standard 'tapper' machine. The lower the $L'_{nT,w}$, the better the acoustic performance. Measured in accordance with BBS EN ISO 140-7 and rated in accordance with BS EN ISO 717-2.
NR	Noise Rating. A single number rating which is based on the sound level in the octave bands 31.5Hz – 8kHz inclusive, generally used to assess noise from mechanical services in buildings.
Octave band	Frequencies are often grouped together into octaves for analysis. Octave bands are labelled by their centre frequency which are: 63Hz, 125Hz, 250Hz, 500Hz 1kHz, 2kHz and 4kHz.

Reverberation time (T_{mf})	Reverberation time is used for assessing the acoustic qualities of a space. It is defined as the time it takes for an impulse to decay by 60dB. T_{mf} is the arithmetic average of the reverberation time in the mid frequency bands (500Hz, 1k Hz and 2 kHz).
R_w	Weighted sound reduction index. A single number rating of the sound insulation performance of a specific building element. R_w is measured in a laboratory. R_w is commonly used by manufacturers to describe the sound insulation performance of building elements such as plasterboard and concrete. Measured in accordance with BS EN ISO 10140-2:2010 and rated in accordance with BS EN ISO 717-1
Sound Absorption	When sound hits a surface, some of the sound energy is absorbed by the surface material. Sound absorption refers to the ability of a material to absorb sound, rated from 0, complete reflection, to 1, complete absorption.
Sound Insulation	When sound hits a surface, some of the sound energy travels through the material. 'Sound insulation' refers to the ability of a material to prevent the travel of sound.
Structure-borne transmission	Transmission of sound energy as vibrations via the structure of a building.

1.0 INTRODUCTION

MACH Acoustics has been appointed by Stride Treglown to undertake an environmental noise assessment at the proposed site of the Library and FACE development, University of Wales Trinity St David, Swansea.

The proposed development is to be two new buildings, with the Library building including teaching spaces and library resources, and the FACE building includingautomotive workshops, computer labs, other teaching spaces and associated ancillary spaces.

A noise survey has been undertaken to establish the existing noise levels across the site. An additional survey has been undertaken to acertain noise levels of the machinery associated with the development. This report describes the noise surveys, the results, and the consequent noise break-in and break-out assessments.

1.1 Executive Summary

1.1.1 Noise Break-In Assessment

The purpose of this assessment is to determine the feasibility of a natural ventilation strategy based upon simple opening windows. This has been assessed in accordance with internal noise level targets as given within Building Bulletin 93 (BB93) 'Acoustic Design of Schools', using the environmental noise data collected by MACH Acoustics. In summary MACH Acoustics consider that the average noise level of the existing environment is acceptable to ventilate using open windows to the traditional teaching spaces.

1.1.2 Plant Noise Break-Out Assessment

The purpose of this assessment is to reduce the risk of complaints from local residents about noise break-out as a result of activities or plant associated with the development. Maximum plant noise levels at 1 m from the unit, or 1 m from a louvre in the façade are given in Section 7.2.

1.1.3 Operational Noise Break-Out Assessment

A detailed assessment has been regarding noise breaking out of the workshop areas. In summary the majority is likely to not cause a disturbance providing they are operating with windows and doors closed.

The rolling roads however are significantly louder than other noise sources associated with the workshops. There is a risk that this will disturb local residents, and the other teaching spaces in the FACE building itself unless mitigation options are taken forward. MACH have proposed that an acoustic enclosure with the automotive workshop to house the rolling road would be the optimal option. Another option would be to increase the performance of the roller shutter doors, and any glazing elements within the automotive workshop façade. Please see Section 8.7 for further details.

2.0 NOISE BREAK-IN CRITERIA

2.1 Building Bulletin 93

BREEAM 2014 corresponds to targets from Section 2.0 of the Acoustic Performance Standard for the Priority Schools Building Programme, however, for the purposes of assessment, and further design, targets from Building Bulletin 93 (BB93) 'Acoustic Design of Schools' 2014 have been used, as these are almost identical to those given by APS.

BB93 specifies maximum indoor ambient noise levels for all teaching and ancillary spaces. These levels are seen to be the overall noise levels, made up of the sum of building services noise, external noise break-in and any other noise sources present within the unoccupied, fully operational building.

Typically the most onerous indoor ambient noise level requirement for this development, as given within BB93 is 40 dB $L_{Aeq,30min}$, which applies to most teaching spaces.

BB93 sets a maximum "L1" noise level of 60 dB $L_{A1,30min}$ in teaching spaces. This is achieved by default for spaces with indoor ambient noise levels up to 40 dB $L_{Aeq,30min}$, but requires assessment in spaces with indoor ambient noise level targets of 45dB $L_{Aeq,30min}$ or above.

2.1.1 BB93 Relaxations

Natural/Hybrid Ventilation

Where a natural ventilation strategy is to be employed, the indoor ambient noise limits can be relaxed by 5dB $L_{Aeq,30min}$. However, this does not apply to spaces with an indoor ambient noise limit of 45dB $L_{Aeq,30min}$ or higher.

For hybrid ventilation systems, the mechanical system noise component must comply with the limits set out in Table 1, however the overall noise limit can also be relaxed by 5dB $L_{Aeq,30min}$.

BB93 states that the normal condition for a natural or hybrid ventilation mode is defined as when the system is operating to limit the daily average carbon dioxide concentration to no more than 1,500ppm with the maximum concentration not exceeding 2,000ppm for more than 20 consecutive minutes on any day. This would normally equate to a minimum ventilation rate of approximately 5l/s per person.

Summertime/Intermittent Boost Ventilation

BB93 also permits a further relaxation during the summertime. Summertime is defined as the hottest 200 hours in peak summertime. During summertime, natural and hybrid ventilation systems are permitted to relax indoor ambient noise limits to an upper limit of 55 dB $L_{Aeq,30min}$.

Mechanical Ventilation

Mechanical ventilation systems are permitted to relax indoor ambient noise limits by 5dB $L_{Aeq,30min}$. Again, this does not apply to spaces with an indoor ambient noise limits of 45 dB $L_{Aeq,30min}$ or higher.

2.1.2 BB93 Target

Typically, an open window will provide 10 to 15 dB(A) of sound insulation; therefore, in order to assess internal noise levels MACH Acoustics use 13 dB(A) of sound insulation for an open window.

By combining the maximum permissible internal noise limit for a naturally ventilated teaching space, 45 dB(A), and the 13-15 dB(A) of sound insulation for an open window, it can be seen that external noise levels should not normally exceed 58-60 dB L_{Aeq} to allow natural ventilation through openable windows.

2.2 BREEAM 2014 HEA 05

There are three credits in relation to acoustics under HEA 05 that can be targeted on this development. The second credit refers to internal noise level targets, which is relevant to the noise break-in assessment within this report. The following is an extract from BREEAM for this credit, with the relevant text underlined.

Second credit:

- Achieve the indoor ambient noise level standards set out within Section 2 of APS for all room types. For roofs with a mass per unit area less than 150kg/m^2 (lightweight roofs) or any roofs with glazing or rooflights, calculations using laboratory data with 'heavy' rain noise excitation as defined in BS EN ISO 140-18 are required (in accordance with the guidance in APS) for teaching/learning spaces to demonstrate that the reverberant sound pressure level in these rooms are not more than 25 dB above the appropriate limits presented within Section 2 of APS, table 1.

- For heavy weight roofs with a mass per unit area greater than 150kg/m^2 (including those with sedum planting) that do not have any glazing/roof-lights, as such the credit can be awarded on a default basis of compliance.

Testing Requirements

A programme of pre-completion acoustic testing should be carried out by a compliant test body in accordance with the APS requirements and the ANC Good Practice Guide, Acoustic testing of Schools. For internal noise levels thi would be conducted with all ventilation openings open and mechanical ventilation systems turned on.

3.0 NOISE BREAK-OUT CRITERIA

3.1 Plant Noise Break-Out

3.1.1 BREEAM Pol 05

There is one credit available within the Pollution section, where the aim is to reduce the likelihood of noise from the new development affecting nearby noise–sensitive buildings.

The following demonstrates compliance:

1. The credit can be awarded by default where there are or will be no noise-sensitive areas or buildings within an 800m radius of the assessed development
2. Where there are or will be noise-sensitive areas or buildings within an 800m radius of the assessed development a noise impact assessment in compliance with BS 7445:1991 has been carried out and the following noise levels measured/determined:

    a. Existing background noise levels at the nearest or most exposed noise-sensitive development to the proposed development; or at a location where background conditions can be argued to be similar.
    b. The rating noise level resulting from the proposed noise-source. This can be based upon reference to similar installations or sites, or determined by calculation.

    The noise impact assessment must be carried out by a suitably qualified acoustic consultant holding a recognised acoustic qualification and membership of an appropriate professional body. The primary professional body for acoustics in the UK is the Institute of Acoustics.

3. The noise levels from the proposed site/building, as measured in the locality of the nearest or most exposed noise-sensitive development, is a difference no greater than +5dB during the day (0700hrs to 2300hrs) and +3dB at night (2300hrs to 0700hrs) compared to the background noise level.

4. Where the noise source(s) from the proposed site/building is greater than the levels described in criterion 3, measures have been installed to attenuate the noise at its source to a level where it will comply with criterion 3.

3.1.2 BS 4142

BS 4142 describes a method of determining the level of noise of an industrial nature, together with the procedures for assessing whether the noise in question is likely to give rise to complaints from persons living in the vicinity. As such, an assessment to BS 4142 is typically called for within planning conditions.

The likelihood of complaints in response to a noise depends on various factors. BS 4142 assesses the likelihood of complaints by considering the margin by which the noise in question exceeds the background noise level. This standard also allows for an appropriate correction for the acoustic features present in the noise.

BS 4142 states that:

- A difference of around + 10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.
- A difference of around + 5 dB is likely to be an indication of an adverse impact, depending on the context.
- The lower the rating level is relative to the measured background sound level, the less likely it is that the specific sound source will have an adverse impact or a significant adverse impact. Where the rating level does not exceed the background sound level, this is an indication of the specific sound source having a low impact, depending on the context.

An acoustic correction should be added if one or more of the following features (see the list below), are present within the noise sources in question.

- Tonality – for sound ranging from not tonal to prominently tonal the joint Nordic method gives a correction of between 0dB and + 6 dB for tonality.
- Impulsivity – a correction of up to +9 dB can be applied for a sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level.
- Other sound characteristics – where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environmental. A penalty of 3 dB can be applied.

3.1.3 Planning Conditions

At this stage MACH Acoustics have not found or been informed of any particular planning conditions in regards to a target rating level, or whether this should be assessed in line with BS 4142. Therefore unless informed otherwise, targets seen in the previous subsection of +5dB during the day (0700hrs to 2300hrs) and +3dB at night (2300hrs to 0700hrs) compared to the background noise level will be targeted.

3.1.4 Design Target

MACH Acoustics will design plant noise break-out to BREEAM 2014 requirements, which are the most onerous targets associated with this development at this stage, as this is seen to be the most robust approach.

3.2 Operational Noise Break-Out

Within University of Wales Trinity St David, FACE building, there are additional design targets associated with noise break-out from activities associated with the development.

3.2.1 World Health Organisation: Guidelines on Community Noise

The World Health Organisation (WHO) document '*Guidelines for Community Noise*', sets out guidance as to noise levels at which there will be an unacceptable impact on the local community. This guidance considers many different types of noise sources. In paragraph 4.3.1 the impact of noise on dwellings is considered.

The WHO guidelines state that to protect the majority of people from being 'seriously annoyed' during the daytime (0700 – 2300), the sound pressure level on balconies, terraces and outdoor living areas should not exceed 55 dB $L_{Aeq,16hrs}$ for a steady, continuous noise. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound pressure level should not exceed 50 dB $L_{Aeq,16hrs.}$ The document does state that a lower target of 40 dB $L_{Aeq,16hrs}$ may also be considered *where feasible,* however it should be noted that this target would already be exceeded at nearby residencies due to road traffic.

The guidelines also state that at night (2300 – 0700), sound pressure levels at the outside façades of the living spaces should not exceed 45 dB $L_{Aeq,16hrs}$ and 60 dB L_{Amax}, so that people may sleep with bedroom windows open. It is understood that the workshop areas of the FACE building will operate no later than 22:00, hence targets for night time need not be considered.

These guidelines are typically adopted and applied to various noise sources with the criteria that noise levels at nearby noise sensitive receivers during the daytime (0700 – 2300) should not exceed 50 dBA $L_{Aeq,16hrs}$. This target is seen to be appropriate for the proposed noise break-out from workshops.

3.2.2 BS 8233: 2014 Guidance on Sound Insulation and Noise Reduction for Buildings

BS8233:2014 *'Guidance on sound insulation and noise reduction for buildings',* provides guidance for acceptable internal noise levels within dwellings. Although the recommendations of the World Health Organisation provide acceptable levels for external noise, the likelihood of disturbance within dwellings is perhaps the most important consideration. BS8233 states that, to achieve adequate living conditions, background noise levels should be 35 dB $L_{Aeq,}$ or less, within living rooms and bedrooms, and 40 dB L_{Aeq} within dining rooms during the period 0700 to 2300. The advised levels are tabulated below.

Activity	Location	0700 – 2300 (daytime)
Resting	Living Room	35 dB $L_{Aeq, 16\ Hour}$
Dining	Dining Room	40 dB $L_{Aeq, 16\ Hour}$
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq, 16\ Hour}$

Table 3.1: BS8233 Internal noise levels

3.3 Nearest Noise Sensitive Receivers

BREEAM 2014 considers the following noise sensitive locations which are to be used as assessment locations.

1. Residential areas
2. Hospitals, health centres, care homes, doctors surgeries etc.
3. Schools, colleges and other teaching establishments.
4. Libraries
5. Places of worship
6. Wildlife areas, historic landscapes, parks and gardens.
7. Located in an area of outstanding natural beauty or near a Site of Special Scientific Interest (SSSI).
8. Any other development that can be considered noise sensitive.

Based upon the list above it is considered that the nearest noise sensitive receptors within 800m of the proposed development are;

1. Residential along Kings Road, approximately 57m to the North East
2. Proposed residential approximately 32m to the North
3. Proposed University Buildings approximately 15m to the East
4. The more traditional teaching spaces on the south half of the FACE Building

Figure 3.1 illustrates the proposed development in relation to the nearest noise sensitive receptors. The location of the new building has been highlighted in red in Figure 3.1.

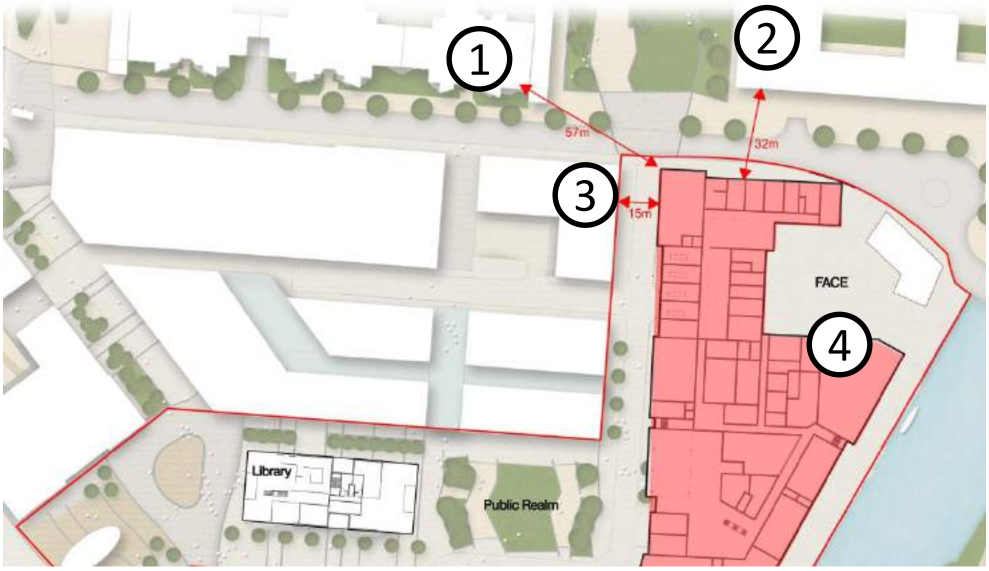


Figure 3.1: Nearest Noise Sensitive Receivers to development

4.0 SITE DESCRIPTION

The proposed development will be a four storey building which will accommodate a range of automotive workshops, computer laboratories, architectural studios and other. teaching, offices and associated ancillary spaces. The proposed site in relation to its surroundings is shown in the site map and aerial photograph presented in Figure 4.1 below.

Figure 4.1: Site Location

The proposed site will be surrounded by other new university buildings, with existing residential tower blocks to the north west, along Kings Road, and another building to the north of site, to the east of the existing residential.

A recycling centre has also been granted planning permission on the south west corner of the dock building seen in the bottom right hand corner of Figure 4.1.

5.0 ENVIRONMENTAL NOISE SURVEY

5.1 Methodology

A subjective assessment of the was carried out to identify any significant noise sources. The predominant noise sources have be identified to be traffic along Kings Road and industrial noise from the nearby shipping yards. Due to the locations of these noise sources noise levels across the site are considered to be consistent.

To establish the existing environmental noise levels on site continuous samples of the acoustic parameters $L_{Aeq, T}$, $L_{A90, T}$, and $L_{Amax,T}$ were measured between 12:15 on the 15/02/16 and 11:40 on the 19/02/16 at a fixed microphone position on site. The fixed long term meter was set to measure consecutive 'A' weighted 5 minute time samples. The fixed microphone position was used to determine the change in noise levels during typical operating hours of the development. Measurements have been taken in free-field conditions, or have been corrected where appropriate.

Measurement locations are shown in Figure 5.1 below. Appendix A of the report presents photographs taken during the noise survey, which help provide a good understanding of the site. The full tabulated data of the environmental noise survey is available upon request.

Figure 5.1: Measurement location map

5.1.1 Measurement Equipment

Name	Serial Number	Last Calibrated	Calibration Due
Norsonic Precision Sound Analyser Type 140	1403249	Sep-15	Sep-17
Norsonic Type 1209 Pre-amplifier	12563	Sep-15	Sep-17
Norsonic Type 1225 Microphone	68830	Sep-15	Sep-17
Norsonic Sound Calibrator Type 1251	32090	Jul-15	Jul-16

Table 5.1: Measurement Equipment

5.1.2 Weather Conditions

The following climate conditions were recorded for the site:

Wind: Less than 5 m/s.
Humidity: Generally clear/cloudy with short spells of light rain on a couple of days.
Temperature: 0-10^{o}C.

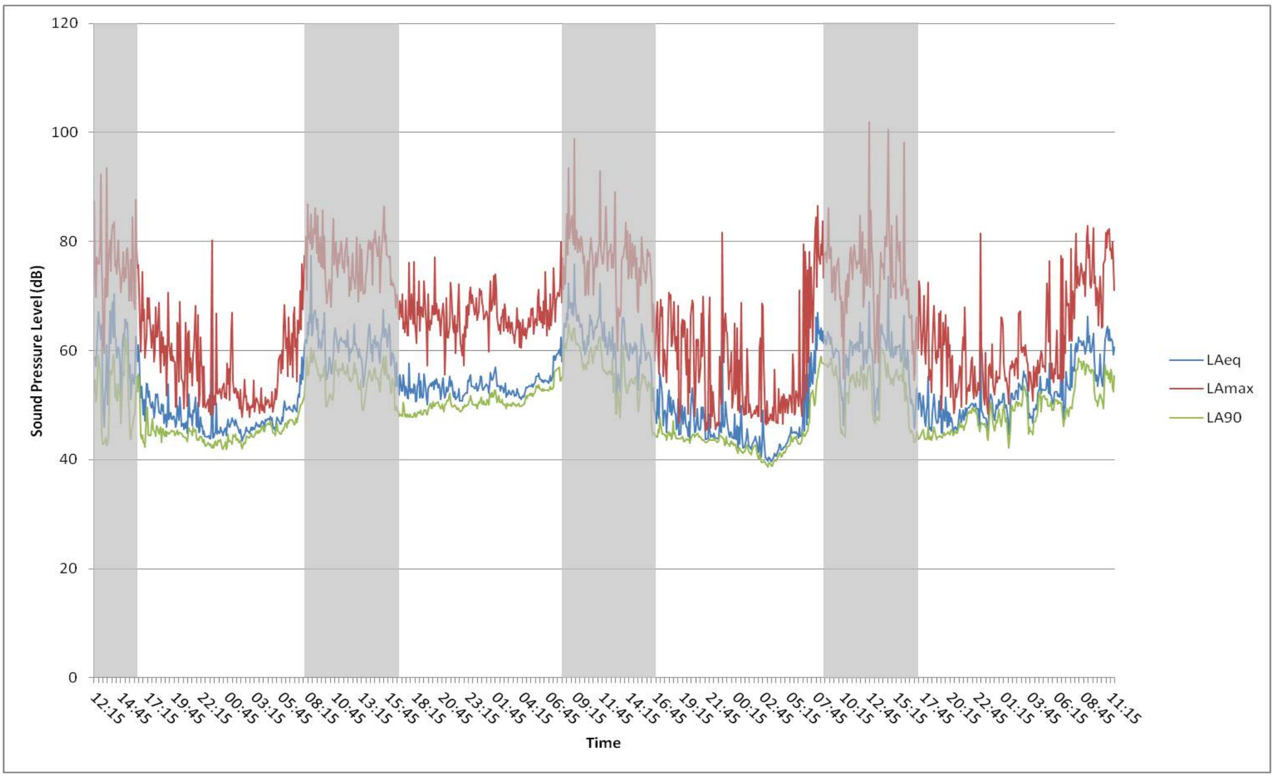
The above weather conditions are suitable for the measurement of environmental noise in accordance with BS7445 *Description and Measurement of Environmental Noise.*

5.2 Results

The following sections give a graphical representation of noise levels measured on site, with analysis of results for assessment within sections 6.1 and 7.1. Anomalous results, due to nearby construction works have been identified and highlighted grey in both the graph and subsequent analysis tables throughout this section. These will be omitted from noise break-in and break-out assessments.

5.2.1 Fixed Measurement Results

The following table and graph show measured noise levels at the fixed measurement location (F) on site. All measurements are shown in dB(A). The complete set of measurement data is available on request. The graph in Figure 3 below provides the L_{Amax}, L_{Aeq} and L_{A90} levels measured over the survey period.



Period	Parameter	Maximum	Minimum	Average
Daytime (07:00 to 23:00)	L_{Aeq}	63	45	55
	L_{A90}	56	42	49
	L_{fmax}	88	54	72
Night time (23:00 to 07:00)	L_{Aeq}	64	40	51
	L_{A90}	54	39	48
	L_{fmax}	82	46	66

Table 5.2: Summary of measured noise levels

6.0 NOISE BREAK-IN ASSESSMENT

6.1 BB93 Average Noise Levels

BB93 requires that noise levels are assessed over 30 minute periods during the operational hours of the school. The fixed measurement data has therefore been transformed into 30 minute average noise levels ($L_{Aeq,30min}$) by means of logarithmically averaging the above fixed measurement data. Note the data presented in the table below is taken between 15:45 and 17:30, excluding data skewed by construction noise nearby.

Start Time	LAeq,30min (dB(A))
15:45	58.2
16:15	57.4
16:45	51.6
17:15	50.9
15:45	61.3
16:15	56.2
16:45	54
17:15	53.8
15:45	59.2
16:15	54
16:45	52.3
17:15	50
15:45	61.7
16:15	55.8
16:45	50.1
17:15	50.9

Table 6.1: 30 minute 'average' noise levels ($L_{Aeq,30min}$)

Table 6.2 shows that the highest logarithmically averaged $L_{Aeq,30min}$ noise level, excluding construction noise, at the fixed position was 59 dB(A) during the survey. On average after 4pm, and also around lunctime at 1pm), when construction work on the adjacent site to microphone position ceased, $L_{Aeq,30min}$ levels are in the region of 50 to 57 dB(A). Therefore assessing to 59 dB(A) is a worst case assessment. On average without construction noise, average levels are considerably lower.

Traffic along the road is also largely for the car park adjacent to site, which as part of the future development of the area will not be present.

6.2 Façade Assessment

6.2.1 Existing Noise Climate

Table 6.2 shows the predicted internal noise level at the worst case façade, based upon measured external levels, the most onerous BB93 indoor ambient noise level target and a 15 dB sound reduction for the acoustic performance of an open window.

	$L_{Aeq,30min}$ (dB)
Highest Measured	59
Open window attenuation	-15.0
Predicted Indoor Ambient Noise Level	44

Table 6.2: Predicted BB93 indoor ambient noise level

Table 6.2 shows that using the measured noise level the indoor ambient noise level would be predicted to be 44 dB. This is below the internal noise target of 45 dB L_{Aeq}, hence this building can be naturally ventilated through simple open able windows. This is based upon the existing noise climate, accounting for all buildings currenty present including industrial noise sources within the general vicinity (< 1km).

6.2.2 New Noise Climate – Recycling Centre

A recycling centre has been granted planning permission to be constructed at a distance of around 130 m to the south east of site. Over this distance, a distance attenuation in noise levels is calculated to be around 42 dB. This means that to match the highest 30 minute average noise level used within the assessment (59 dB(A)), the level at source would have to regularly exceed 100 dB.

MACH Acoustics have conducted measurements of machinery (at source) at recycling centres as part of previous projects, as well as also conducting surveys at proposed sites close to recycling centres. Based on this experience it is highly unlikey that noise levels would regularly exceed 100 dB at 1m from the recycling centres facade, or at 1m from any outdoor machinery. Therefore at this stage MACH Acoustics do not consider that this will cause internal noise levels to exceed requirements based on an open window ventilation strategy.

6.2.3 New Noise Climate – Operational Noise from the FACE Building

Operational noise from the construction areas of the FACE building, in particular areas containing Dyno and rolling road testing are likely to exceed internal noise levels in adjacent traditional teaching spaces when windows are open. This is covered in more detail in Section 7.0.

7.0 NOISE BREAK OUT – PLANT NOISE

7.1 Target Assessment Level

BREEAM Pol 05 requires that noise levels be assessed to background noise levels. Noise limits have been provided for daytime, night-time and the operating periods. Table 7.1 below gives the lowest measured background noise levels, L_{A90}, for the various periods of assessment.

The background noise levels to be assessed to are provided within Section 0 of this report. The table below, therefore, provides the maximum plant noise level targets at the nearest residential window, based upon these measured levels. These levels are 5 dB above existing background noise levels, as detailed within Section 3.1.

Measurement Period		Lowest Measured Background Noise Level dB (A) L_{A90}	Target Plant Level at Receiver dB (A) $L_{Aeq,T}$
Day time	07:00 -23:00	42	47
Night-time	23:00 – 07:00	39	44
Hours of Operation	08:00 - 1800	42	47

Table 7.1: Target background noise at nearest residential window

7.2 Plant Noise Rating Limits

7.2.1 Mandatory Plant Noise Rating Limits

At this stage MACH Acoustics are not aware of the exact plant equipment that will be at the development. As it is unclear where the plant will be situated, the closest facade of the development has been chosen.

Therefore, the equation below has been used to establish the level of distance attenuation from the proposed plant room.

$$\text{Distance Attenuation} = 20 \times \text{Log}_{10} (1 / 15) = 24 \text{ dB}$$

Using the equation above it can be established that plant noise level when measured at 1m from the façade of this development should not exceed the noise levels listed in Table 7.2 below.

Measurement Period		Target Plant Level at 1m from receiver facade dB (A) $L_{Aeq,T}$	Plant Noise Rating Limit @1m from the FACE building facade, dB $L_{Aeq,15min}$
Day time	07:00 - 23:00	47	71
Night-time	23:00 - 07:00	44	68
Hours of Operation	08:00 - 18:00	47	71

Table 7.2: Target Plant Noise Rating Levels

Further indication on the type of plant machinery and its location is required for a further evaluation.

7.2.2 Advisory Plant Noise Rating Limit

To meet the criteria specified within Section 3.1 plant noise must not exceed the noise limits as detailed within Table 7.2 . This target, however, has significant risk in adversely affecting users within the FACE building. Therefore, MACH Acoustics would propose that plant noise levels do not exceed 53dB at the windows of any acoustically sensitive spaces within the development.

	dB $L_{Aeq,15min}$
Plant Noise Rating Limit at 1m outside windows to acoustically sensitive spaces within the development	53.0

Table 7.3: Advised Plant Noise Rating Limit

When further information is available in regards to the chosen plant, MACH Acoustics will provide advice on plant noise rating limits so to achieve the above target.

8.0 NOISE BREAK OUT – OPERATIONAL NOISE

8.1 Description of Operations

MACH Acoustics understand that the workshops within the development will house a host of automotive / construction / resistant material machinery. Therefore noise pollution from these activities to the receptors considered in Figure 3.1 should be considered. Figure 8.1 indicates areas that are considered to be the noisier areas of the FAÇE building on the ground floor.

The rooms highlighted are those used to form the break-out assessments, based upon the understood locations of the machinery. Many points of the façade shutter doors which are likely to be the weakest points in terms of sound insulation. <u>MACH Acoustics also understand that these roller shutter doors are to be kept shut whilst machinery is in operation.</u>

Figure 8.1: Plan of the workshop façades

8.2 Measurement of Existing Equipment / Internal Operational Noise Levels

MACH Acoustics understand that the large majority (if not all equipment) is at this stage to be moved from the existing facilities at Mount Pleasant to the new development.

Therefore MACH Acoustics have been to the existing facilities to measure noise levels of existing equipment in operation, in order to accurately assess the noise break out. This involved testing of machinery one by one, measuring noise levels at 1m away from the machine in order to accurately quantify noise contributions from each individual machine. Discussions with the staff of the university aided in understanding the frequency and duration of use for each piece of equipment, as well as whether machinery would run simultaneously, and whether noise complaints have been an issue in the past from residents around the existing facility, or adjoining rooms in the building.

An understanding was gained about which rooms existing machinery would be moved into, and how compressors would operate. It is understood that at this point it is planned to move the existing compressors to the new building. However this plan may change at a later date with a central compressor or group of compressors serving the whole building. For the time being MACH Acoustics have assessed based on the current plan, using measurements taken of the compressors.

A list of the currently proposed equipment, and the rooms they will be in, at the time of writing is given within Appendix B. The unhighlighted rooms shown in Figure 8.1 are understood to contain smaller and quieter, or no, equipment and therefore are not considered to be an issue in regards to noise pollution.

Based upon discussions MACH understands it is highly unlikely that all machinery in the rooms will be operational at the same time. However it is understood that there may be several machines running simultaneously within the mechanical workshop and Construction/arch workshop and that the Rolling Roads can sometimes reach upto 130 dB when under full load (whereas measurements were taken at reduced load). These have been allowed for within the calculations that determine the maximum internal noise level within each of the construction and automotive testing rooms.

8.3 Façade Noise Break-Out Calculations

Based on this internal level, MACH Acoustics have conducted a series of noise breakout assessments through the façades indicated in Figure 8.1, with the roller shutter doors closed, to a distance of 1m from the façade in question.

The sound reduction indices of the façade elements used represent typical constructions. The weakest elements are the roller shutter doors. MACH Acoustics have assumed an area of glazing to each room but worked on the basis that these are closed windows.

The sound reduction indices for each element used within the calculation is shown below. These are considered to be likely performances of fairly standard constructions, i.e. typical double glazing and non acoustic roller shutter doors.

Element	Sound Reduction Indices						
	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	**Rw**
External Wall	43	47	55	55	55	55	**55**
Glazing	20	22	28	32	33	33	**31**
Roller Shutter Door	8	10	21	35	43	34	**24**

Table 8.1: Sound reduction indices of standard façade elements used in the noise break out calculations

Noise break-out calclulations have be based upon a more likely worst case scenario for each space. Appendix C shows these calculations.

8.4 Noise Propagation into Surrounding Environment – Noise Mapping

In order to accurately assess propagation of noise across the site at University of Wales Trinity St David, survey data collected by MACH Acoustics has been used to calibrate a detailed noise model. The model has been created using CadnaA noise prediction software. CadnaA (Computer Aided Noise Abatement) is the leading software for calculation, presentation, assessment and prediction of environmental noise. Appendix D contains screenshots of an indicative noise map from the assessment.

The noise break-out calculations through the facade have then been used a part of a detailed noise map, to account for the attenuation over distance and the attenuation provided by screening from the building to each of the four receptors in Figure 3.1. This allows the noise from each room to be assessed accurately, with results at each noise sensitive receiver summarising the expected noise contribution from each room.

8.5 Noise Rating Level – BS4142 Correction

As per section 3.1.2 a correction is applied by BS4142 based on whether the noise source is tonal, impulsive or intermittent, or has any other distinguishable characteristics.

The correction should only be applied when it is distinguishable at the noise sensitive receptor. Therefore for example an impulsive noise at source, i.e. drilling, hammering, should only have a correction applied if determined to be audible at the receptor.

Hence the correction applied to each noise source is varied dependant on the proximity to a noise sensitive receptor, i.e. noise from the west façade of the FACE building is louder at the facades directly opposite, as opposed to buildings on the other side of the development. MACH Acoustics have applied corrections where deemed necessary.

8.6 Predicted Receiver Noise Levels

As per Figure 3.1, calculations have been made to 4 noise sensitive receiver locations:

1. Existing Residential along Kings Road (site of acoustic survey) to the North East
2. Proposed residential approximately to the North across Kings Road
3. Closest proposed buildings as part of the Innovation Quarter to the East
4. The more traditional teaching spaces on the south half of the FACE Building

The following tables provide noise contributions in respect of each main noise producing room on the façade (highlighted in Figure 8.1), at each noise sensitive receiver (above).

The tables has been split into contributions from different rooms in the building to identify which are the main source of noise. Given the infrequent nature of noise it is seen to be appropriate to consider these sources one by one, rather than assume they are all running simulatenously, which is highly unlikely to be the case.

In some rooms where there is more than 1 façade, i.e. the automotive space where a solid façade without doors faces north, and a roller shutter door sits in the south façade, the contributions have been calculated for both areas of façade.

To reiterate these calculations all assume roller shutter doors and windows are closed.

The right hand side of the table indicates the noise level in respect of the target used to assess plant noise, as defined in Section 7.1. To reiterate a daytime target of the lowest L_{A90} +5 dB has been applied, resulting in a target level of 47 dB(A) L_{Aeq} at the receptors façade.

It is up for debate as to whether this target is strictly applicable to operational noise break out. An alternative set of targets for residential is given by WHO guidelines as detailed in Section 3.2.2. At this point MACH considers that these targets and an assessment along the lines of BS 4142 is a suitable approach, given the industrial nature of the machinery noise.

MACH Acoustics have used the lowest measured L_{A90} to provide a robust assessment. BS4142 indicates that the assessment level isn't strictly this lowest level and can be based upon the modal or average L_{A90} noise level.

8.6.1 Receptor 1 – Existing Residential (North East)

Table 8.2 indicates the predicted levels at the existing residential buildings along Kings Road to the north east.

It is seen these are under the target rating levels and therefore a good indication that complaints will be unlikely.

							Noise Levels at Receptor		
Receptor	Noise Source		Internal Workshop Level	Level @ 1m from Workshop Facade	Level @ 1m from Noise Sensitive Receiver	BS4142 Acoustic Feature Correction	Target Rating Level (LAeq,T)	Predicted Rating Level (LAeq,T)	Difference
Existing Residential along Kings Road	Rolling Roads (2 Roller Shutters)		125 dB(A)	104 dB(A)	42dB	+6 dB	47 dB(A)	48 dB	+1 dB
	Auto Project Rooms (No Roller Shutters)		91 dB(A)	65 dB(A)	24 dB	-	47 dB(A)	24 dB	- 23 dB
	Dyno Cells	Solid Façade	93 dB(A)	64 dB(A)	23 dB	-	47 dB(A)	23 dB	-24 dB
		Shuttered façade		72 dB(A)	22 dB	-	47 dB(A)	22 dB	-25 dB
	Engine Rigs	Solid Façade	78 dB(A)	52 dB(A)	15 dB	-	47 dB(A)	15 dB	-32 dB
		Shuttered façade		62 dB(A)	24 dB	-	47 dB(A)	24 dB	-23 dB
	Constr / Arch Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	2 dB	-	47 dB(A)	2dB	-45 dB
	Mechanical Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	5 dB	-	47 dB(A)	5 dB	-42 dB
	Buck Sanding (1 Roller Shutter)		69 dB(A)	41 dB(A)	22 dB	-	47 dB(A)	22 dB	-25 dB

Table 8.2: Predicted noise levels from workshop activity noise at Receptor 1

8.6.2 Receptor 2 – Existing Residential (North East)

Table 8.3 indicates the predicted levels at the proposed residential buildings along Kings Road to the north.

It is seen that the majority of noise sources produce levels lower than target rating levels and therefore a good indication that complaints will be unlikely.

However this is with the exception of the areas containing rolling roads. An analysis of this with suitable mitigation options is given in Section 8.7.

							Noise Levels at Receptor		
Receptor	Noise Source		Internal Workshop Level	Level @ 1m from Workshop Facade	Level @ 1m from Noise Sensitive Receiver	BS4142 Acoustic Feature Correction	Target Rating Level (LAeq,T)	Predicted Rating Level (LAeq,T)	Difference
Proposed Residential building (North) along Kings Road	Rolling Roads (2 Roller Shutters)		125 dB(A)	104 dB(A)	52 dB	+6 dB	47 dB(A)	58 dB	+11 dB
	Auto Project Rooms (No Roller Shutters)		91 dB(A)	65 dB(A)	39 dB	+3 dB	47 dB(A)	42 dB	-5 dB
	Dyno Cells	Solid Façade	93 dB(A)	64 dB(A)	35 dB	-	47 dB(A)	35 dB	-12 dB
		Shuttered façade		72 dB(A)	37 dB	+ 3 dB	47 dB(A)	40 dB	-7 dB
	Engine Rigs	Solid Façade	78 dB(A)	52 dB(A)	27 dB	-	47 dB(A)	27 dB	-20 dB
		Shuttered façade		62 dB(A)	26 dB	-	47 dB(A)	26 dB	-21 dB
	Constr / Arch Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	8 dB	-	47 dB(A)	8 dB	-39 dB
	Mechanical Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	12 dB	-	47 dB(A)	12 dB	-35 dB
	Buck Sanding (1 Roller Shutter)		69 dB(A)	41 dB(A)	-13 dB	-	47 dB(A)	-13 dB	-60 dB

Table 8.3: Predicted noise levels from workshop activity noise at Receptor 2

8.6.3 Receptor 3 – Closest Proposed Innovation Hub Building (East)

Table 8.4 indicates the predicted levels at the proposed residential buildings along Kings Road to the north.

It is seen that the majority of noise sources produce levels lower than target rating levels and therefore a good indication that complaints will be unlikely.

However this is with the exception of the areas containing rolling roads. An analysis of this with suitable mitigation options is given in Section 8.7.

It should be noted however that these targets are based upon noise pollution to residents, from lowest background noise level. Noise break in to the building is more likely to be assessed to average noise levels, i.e. in this case as per Section 6.1, 59 dB $L_{Aeq,30min}$. Therefore in this case the rating level matches this average level.

							Noise Levels at Receptor		
Receptor	Noise Source		Internal Workshop Level	Level @ 1m from Workshop Facade	Level @ 1m from Noise Sensitive Receiver	BS4142 Acoustic Feature Correction	Target Rating Level (LAeq,T)	Predicted Rating Level (LAeq,T)	Difference
Closest Proposed Innovation Hub Building (East)	Rolling Roads (2 Roller Shutters)		125 dB(A)	104 dB(A)	53 dB	+6 dB	47 dB(A)	59 dB	+12 dB
	Auto Project Rooms (No Roller Shutters)		91 dB(A)	65 dB(A)	24 dB	-	47 dB(A)	24 dB	-23 dB
	Dyno Cells	Solid Façade	93 dB(A)	64 dB(A)	19 dB	-	47 dB(A)	19 dB	-28 dB
		Shuttered façade		72 dB(A)	25 dB	-	47 dB(A)	25 dB	-22 dB
	Engine Rigs	Solid Façade	78 dB(A)	52 dB(A)	15 dB	-	47 dB(A)	15 dB	-32 dB
		Shuttered façade		62 dB(A)	37 dB	+3 dB	47 dB(A)	40 dB	-7 dB
	Constr / Arch Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	27 dB	-	47 dB(A)	27 dB	-20 dB
	Mechanical Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	36 dB	-	47 dB(A)	36 dB	-11 dB
	Buck Sanding (1 Roller Shutter)		69 dB(A)	41 dB(A)	10 dB	-	47 dB(A)	10 dB	-37 dB

Table 8.4: Predicted noise levels from workshop activity noise at Receptor 3

8.6.4 Receptor 4 – Other Teaching Spaces in the FACE Building

Table 8.5 indicates the predicted levels at the proposed residential buildings along Kings Road to the north.

It is seen that the majority of noise sources produce levels lower than target rating levels and therefore a good indication that complaints will be unlikely.

However this is with the exception of the areas containing rolling roads, which is 30 dB(A) over the target level. It should be noted however that these targets are based upon noise pollution to residents, from lowest background noise level. Noise break in to the building is more likely to be assessed to average noise levels, i.e. in this case as per Section 6.1, 59 dB $L_{Aeq,30min}$.

However even based upon this, it is a clear indication that the rolling roads are likely to cause a noise disturbance to the teaching areas that face on to it, or are along the east façade of the FACE building.

An analysis of this with suitable mitigation options is given in Section 8.7.

							Noise Levels at Receptor		
Receptor	Noise Source		Internal Workshop Level	Level @ 1m from Workshop Facade	Level @ 1m from Noise Sensitive Receiver	BS4142 Acoustic Feature Correction	Target Rating Level (LAeq,T)	Predicted Rating Level (LAeq,T)	Difference
Other Teaching Spaces in the FACE Building	Rolling Roads (2 Roller Shutters)		125 dB(A)	104 dB(A)	71 dB	+6 dB	47 dB(A)	77 dB	+30 dB
	Auto Project Rooms (No Roller Shutters)		91 dB(A)	65 dB(A)	26 dB	-	47 dB(A)	26 dB	-21 dB
	Dyno Cells	Solid Façade	93 dB(A)	64 dB(A)	14 dB	-	47 dB(A)	14 dB	-33 dB
		Shuttered façade		72 dB(A)	24 dB	-	47 dB(A)	24 dB	-23 dB
	Engine Rigs	Solid Façade	78 dB(A)	52 dB(A)	2 dB	-	47 dB(A)	2 dB	-45 dB
		Shuttered façade		62 dB(A)	9 dB	-	47 dB(A)	9 dB	-38 dB
	Constr / Arch Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	10 dB	-	47 dB(A)	10 dB	-37 dB
	Mechanical Workshop (1 Roller Shutter)		82 dB(A)	61 dB(A)	7 dB	-	47 dB(A)	7 dB	-40 dB
	Buck Sanding (1 Roller Shutter)		69 dB(A)	41 dB(A)	10dB	-	47 dB(A)	10 dB	-61 dB

Table 8.5: Predicted noise levels from workshop activity noise at Receptor 4

8.7 Analysis and Conclusions

The tables within the previous subsections give a clear indication that the majority of activity noise within the industrial type teaching spaces of the FACE building should be unlikely to cause a noise nuisance to the surrounding environment.

This is based upon a sealed façade, windows closed and doors closed. MACH Acoustics do not recommend that noisy activites occur with either windows or doors open. It is acceptable to open after operation for purge ventilation, but not recommended whilst the noise source is in operation.

The main potential issue is the rolling road testing in the automotive area. It is considered that noise from the testing of cars and bikes is likely to reach 130 dB at times at 1m from the source. Noise break out assessments indicate an exceeding of target rating levels at the proposed residential buildings to the north, new buildings in the innovation hub to the east and the other teaching areas in the FACE building itself, the latter significantly.

MACH consider the latter teaching spaces to be naturally ventilatable through open windows based on the existing noise climate, however the occasional noise from the rolling road may lead to complaints, even when windows are closed.

There are two main mitigation options that could be applied around the rolling roads.

8.7.1 Acoustic Enclosure

Discussions with staff onsite at the existing facilities indicated that were considering constructing a separate test cell within the automotive workshop, as a form of acoustic enclosure. The existing facility has such a test cell within the Dyno labs, but not for the rolling roads. Having measured both, MACH considers that the rolling road is considerably louder that the dyno testing.

The use of an acoustic testing enclosure would be the optimal option. This will reduce noise breakout of the building significantly. It is highly unlikely that noise breakout will be a cause for complaint in this case.

As well as reducing noise breakout of the building, this would also reduce noise within the automotive workshop, and noise transmission within the building to the other construction teaching areas.

8.7.2 Upgraded Façade – Roller Shutter Door / Glazing

The alternative mitigation method is to use a higher performance roller shutter door and glazing within the façade to the Automotive Studio.

As per Table 8.1, the breakout has been based upon standard glazing and roller shutter doors that achieve 31 dB R_W and 24 dB R_W respectively.

For the roller shutter doors it is recommended to use significantly upgraded product that achieves at least 45 dB R_W. Appendix E gives a table of products available from SAFE Door Industries Ltd that can achieve this.

For any glazing in the façade it is recommended that a product that achieves at least 40 dB R_w should be used.

It has to be noted that these upgraded constructions does certainly not mean that noise will be inaudible. It only means that noise will be reduced to a more acceptable level. However, this will still likely be a distinguishable source of noise around site, particularly around the East façade of the FACE building. This is a lesser performing option than an internal acoustic enclosure as per Section 8.7.1.

APPENDIX A – SITE PHOTOGRAPHS

APPENDIX B – EQUIPMENT MEASUREMENTS

Note that the table below does not contain all measurements taken at Mount Pleasant, it summaries the equipment considered to be the loudest within each room type.

Room	Machine Name	Duration	Instances	LAeq	LAFmax	63 Hz	125 Hz	250 Hz	500 Hz	1.0 kHz	2.0 kHz	4.0 kHz
Construction / Arch Workshop Mechanical Workshop	Bigger Lathe (Assuming 3 Simultaneously)	10 mins	5 times a week	84.3	88.4	62.4	69.8	79.8	81.6	79.5	77	74.4
Buck Sanding	Sander	10 mins	1-2 times a week	75.4	77	58.6	53.7	56.4	71.2	64.7	65	70.4
Rolling Roads	Car rolling road *Noted can reach 130dB for bikes – has been corrected accordingly within calculations	2 hours	5-6 times a month	115.5	120.6	97.9	108.4	105.5	116.4	107.7	104.8	103.7
Auto Projects	Circular Saw	10-30 mins	1-2 times a week	98.9	103.6	69	74.3	90.8	90.1	97.2	88.2	84.3
Dyno Cells	Dyno test	2 hours	2 days a month	99.8	105	82.2	105.3	99.5	94.7	93.1	91.8	91.5
Engine Rigs	Engine test	3 hours	2 days a week	85.2	99	96.7	93.5	79.7	81.4	77.6	77.4	75.9

APPENDIX C – NOISE BREAK-OUT CALCULATIONS

1 – Rolling Roads Room– Through Roller Shutters

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		117.6	114.7	125.6	116.9	114.0	112.9	**125**
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	16.5 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**45.0 m2**							
Element 1	22 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		77.0	70.1	73.0	64.3	61.4	60.3	72.5
Element 2	9 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		96.2	91.3	96.2	83.5	79.6	78.5	94.3
Element 3	14 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		110.2	105.3	105.2	82.5	71.6	79.5	103.7
Combined Noise Levels (1+2+3+4+5)		**110.4**	**105.5**	**105.7**	**86.0**	**80.3**	**82.0**	**104.2**

2 – Auto Projects Room– Solid Façade

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		66.6	83.1	82.4	89.5	80.5	76.6	**91**
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	23.3 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**214.0 m2**							
Element 1	171 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		34.9	47.4	38.7	45.8	36.8	32.9	47.7
Element 2	43 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		51.9	66.4	59.7	62.8	52.8	48.9	65.2
Element 3	0 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0
Combined Noise Levels (1+2+3+4+5)		**52.0**	**66.5**	**59.8**	**62.9**	**52.9**	**49.0**	**65.3**

3 – Dyno Cells – Soid Façade

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		98.9	93.1	88.3	86.7	85.4	85.1	93
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	14.7 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**29.3 m2**							
Element 1	23 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		58.6	48.8	36.0	34.4	33.1	32.8	45.8
Element 2	6 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		75.6	67.8	57.0	51.4	49.1	48.8	63.6
Element 3	0 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0
Combined Noise Levels (1+2+3+4+5)		**75.7**	**67.8**	**57.0**	**51.5**	**49.2**	**48.9**	**63.7**

3a – Dyno Cells – Through Roller Shutters

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		95.1	89.3	84.5	82.9	81.6	81.3	90
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	13.6 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**23.0 m2**							
Element 1	11 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		51.5	41.7	28.9	27.3	26.0	25.7	38.7
Element 2	5 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		70.7	62.9	52.1	46.5	44.2	43.9	58.8
Element 3	8 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		84.9	77.1	61.3	45.7	36.4	45.1	71.8
Combined Noise Levels (1+2+3+4+5)		**85.0**	**77.2**	**61.8**	**49.2**	**44.9**	**47.6**	**72.0**

4 – Engine Rigs – Solid Façade

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		86.6	72.8	74.5	70.7	70.5	69.0	**78**
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	17.7 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**58.7 m2**							
Element 1	47 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		49.3	31.5	25.2	21.4	21.2	19.7	34.6
Element 2	12 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		66.3	50.5	46.2	38.4	37.2	35.7	52.0
Element 3	0 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		-99.0	-99.0	-99.0	-99.0	-99.0	-99.0	0.0
Combined Noise Levels (1+2+3+4+5)		**66.4**	**50.6**	**46.2**	**38.5**	**37.3**	**35.8**	**52.1**

4a – Engine Rigs – through Roller shutter

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		86.6	72.8	74.5	70.7	70.5	69.0	**78**
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	17.2 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**52.7 m2**							
Element 1	34 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		48.0	30.2	23.9	20.1	19.9	18.4	33.3
Element 2	11 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		65.8	50.0	45.7	37.9	36.7	35.2	51.5
Element 3	8 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		76.5	60.7	51.4	33.6	25.4	32.9	61.3
Combined Noise Levels (1+2+3+4+5)		**76.9**	**61.1**	**52.5**	**39.4**	**37.1**	**37.3**	**61.7**

5 – Construction / Arch Workshop– Through Roller Shutters

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		67.1	77.1	78.9	76.8	74.3	71.7	82
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	18.2 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**65.5 m2**							
Element 1	38 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		28.9	34.9	28.7	26.6	24.1	21.5	32.6
Element 2	13 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		47.3	55.3	51.1	45.0	41.5	38.9	52.3
Element 3	14 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		59.6	67.6	58.4	42.3	31.8	38.2	60.7
Combined Noise Levels (1+2+3+4+5)		**59.9**	**67.9**	**59.1**	**46.9**	**42.0**	**41.6**	**61.3**

5a – Mechanical Workshop – Through Roller Shutters

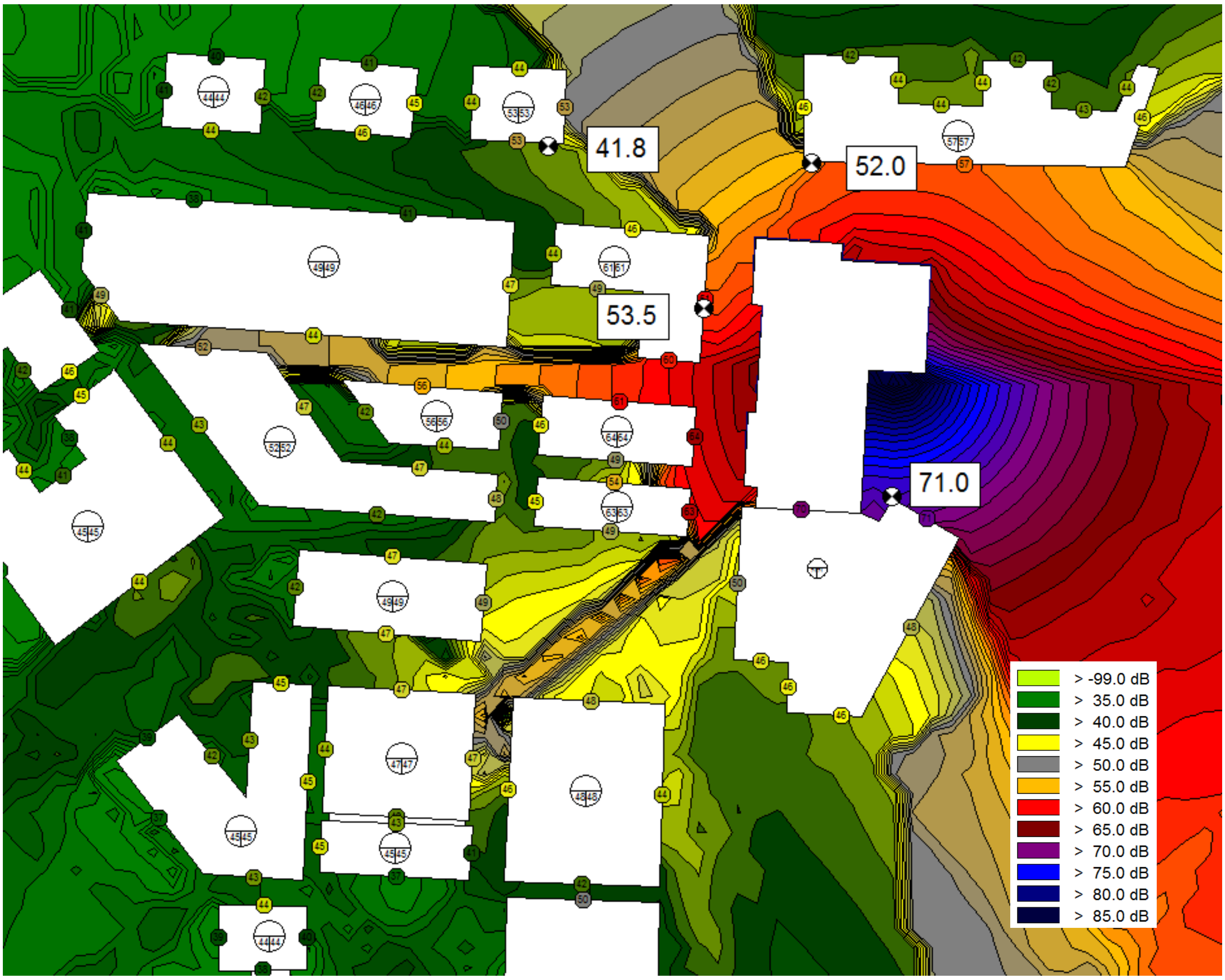
Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		67.1	77.1	78.9	76.8	74.3	71.7	82
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	17.0 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**50.5 m2**							
Element 1	25 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		27.2	33.2	27.0	24.9	22.4	19.8	30.8
Element 2	10 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		46.2	54.2	50.0	43.9	40.4	37.8	51.2
Element 3	15 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		59.9	67.9	58.7	42.6	32.1	38.5	61.0
Combined Noise Levels (1+2+3+4+5)		**60.1**	**68.1**	**59.2**	**46.3**	**41.0**	**41.2**	**61.4**

6 – Buck Sanding Room – Through Roller Shutter

Noise Break-Out Calculation From One Facade		125	250	500	1000	2000	4000	dB(A)
Sound Pressure Level within Room, i.e. on internal facade		48.6	51.3	66.1	59.6	59.9	65.3	69
3dB Safety	3 dB	3.0	3.0	3.0	3.0	3.0	3.0	
Directivity of facade, **Q**	2							
10*log(S)	13.0 m2							
Distance to reciever	1 m2							
Screening Losses		0	0	0	0	0	0	
FAÇADE Elements								
Façade Area	**20.0 m2**							
Element 1	9 m2	43	47	55	55	55	55	
2x100mm block-50mm gap+plaster								
Predicted noise level in building from glazing		3.9	2.6	9.4	2.9	3.2	8.6	12.7
Element 2	4 m2	20	22	28	32	33	33	
4mm single glazing								
Predicted noise level through solid façade		23.6	24.3	33.1	22.6	21.9	27.3	33.3
Element 3	8 m2	8	10	21	35	43	34	
Roller shutter Door								
Predicted noise level through solid façade		38.4	39.1	42.9	22.4	14.7	29.1	40.7
Combined Noise Levels (1+2+3+4+5)		**38.5**	**39.2**	**43.3**	**25.5**	**22.7**	**31.3**	**41.4**

APPENDIX D – CADNAA NOISE MAPPING

The image below is an indicative screenshot from the CadnaA noise mapping, it should not be used as the basis for conclusions. In general the main noise source when in operation will be the rolling road, the dark blue area below indicates noise breaking out through the roller shutter doors on the south facing façade of the Automotive testing facility.



APPENDIX E – ROLLER SHUTTER DOOR PERFORMANCE

Product Reference	Frequency (Hz)							Rw (dB)
	63	125	250	500	1000	2000	4000	
Soundroll 30	18.8	22.2	24.3	22.3	31.7	35.1	38.5	30
Soundsec 30	23.1	25.4	29.0	29.0	26.4	33.5	59.5	30
Soundroll 31	20.4	23.0	25.0	24.6	30.3	42.6	43.0	31
Soundmax 48	23.7	31.8	35.4	44.1	51.5	50.4	50.9	48
Soundslide 50	25.8	30.5	43.6	46.4	50.3	54.8	61.8	50
Soundslide 53	35.0	38.1	42.1	47.3	55.5	65.2	66.8	53
Soundroll 53	34.3	42.0	47.0	43.4	66.6	80.7	70.4	53
Soundmax 54	26.6	33.0	43.7	51.3	60.2	69.4	69.1	54
Soundslide 57	30.9	37.2	47.5	52.5	57.7	63.6	66.7	57
Soundroll 30 + Soundsec 30	34.6	44.0	51.3	52.8	61.9	71.6	70.1	60
Soundslide 57 + Soundroll 30	40.5	46.7	55.3	64.4	78.9	84.9	66.8	67
	Sound reduction R (dB)							

Table 8.6: Sound reduction data of doors available from SAFE-door Industries Ltd

APPENDIX F – GLAZING PERFORMANCE

R_W Rating	Description
38dB R_W	10.8mm laminated glazing
	6mm glazing/12mm gap/6.8mm laminated glazing
40dB R_W	12.8mm laminated glazing
	5mm glazing/16mm gap/8.8mm laminated glazing
45dB R_w	10mm glazing/16mm gap/8.8mm laminated glazing
50dB R_w	9.1mm laminated glazing/20mm gap/13.1mm laminated glazing

Table 8.7: Glazing Configurations And Corresponding R_w Ratings