Azymuth Acoustics UK

Professional Acoustic Services

Noise Impact Assessment

Ref: AA0417

Mansell Building Solutions
Crown Lane,
Horwich,
Bolton BL6 5HP

On behalf of

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Contents

1.0 Introduction

Azymuth Acoustics UK (AAUK) was appointed by Mansell Building Solutions to provide a Noise Impact Assessment in relation to noise complaints concerning the Mansell Building Solutions building on Crown Lane, Horwich.

There have been multiple noise complaints from nearby residents regarding the operational noise of the building in question. The main noise sources have been described as 'banging' and 'drilling'. The noise is more pronounced when the main building shutters are left open. We understand from the complaints received, although this is disputed, that this has happened in the past for long periods of time. There have also been noise complaints surrounding the movement and loading of steel frames onto vehicles towards the rear of the building.

The site has previously been unoccupied for a period of time and Covid has resulted in a 'resetting' of the baseline ambient noise situation i.e. the neighbours have become used to the lack of noise from the site. The recurrence of commercial activities is, therefore, likely to be perceived as a significant noise intrusion for the neighbours.

A previous technical memorandum was produced by Echo Acoustics in Oct 2021 and the noise monitoring results identified are generally consistent with the noise levels we have measured.

Mansell Operational times:

According to the conditions attached to the grasscrete hardstanding, loading can be performed on the site from 7.30am to 6pm Monday to Friday. Mansell state that "there have been a couple of occasions where they have worked until 6pm to move the panels, but invariably the company stops at 5pm."

Mansell have stated that on an infrequent basis "they have worked Saturday from 8am until 1pm. We ordinarily do not work weekends, either in the production facility or loading outside…but may work the occasional Saturday due to production schedules, albeit infrequently, and we will use our best endeavours to notify residents of any such days in advance."

Mansell have already introduced some noise mitigation improvements since the initial complaints received from residents. A Noise Register with potential noise mitigation has been produced by Mansell and we have reviewed this. We noted the use of rubber mallets on site and installation of a crane. In March 22 matts and acoustic layers were installed on the jigs.

This noise impact assessment is intended to provide information relating to noise levels emanating from the site, in order to identify a mitigation strategy that will satisfy Mansell Building Solutions and also local residents.

In particular, the report sets out the following details:

1. The results of a baseline noise survey undertaken in the vicinity of the Mansell Building.
2. The results of a noise survey undertaken inside the Mansell Building to capture noise levels of day-to-day operations.
3. Possible mitigation strategies.

2.0 Baseline Noise Survey

2.2 Measurement Procedures

The instrumentation used for the baseline site boundary noise survey consisted of a SvanTek 977 precision sound level meter, the instrumentation for all other noise measurements consisted of a Svantek 959 sound level meter. The equipment was calibrated before and after the noise measurements. The sound level meters measured at A-weighted (fast response) noise levels as well as octave bands noise levels for all measurement record.

Measurements were undertaken between 11:15am and 14:15am on Tuesday 15th March 2022 during a working day in which the noise levels would be high. The weather during the measurement procedure was dry with winds of ~5mph.

The noise measurements were undertaken using the sound level meters at the positions shown in figure 1:

- Position 1: Baseline noise survey (loading yard)
- Position 2/3/4: Internal ocupational noise
- Position 5: Shutter door 1m inside
- Position 6: Shutter door 1m outside
- Position 7: Closed shutter
- Position 8: 5 Crown Lane
- Position 9: 4 Butterwick Fields (facing Crown Lane)
- Position 10: 18 Avonhead Close

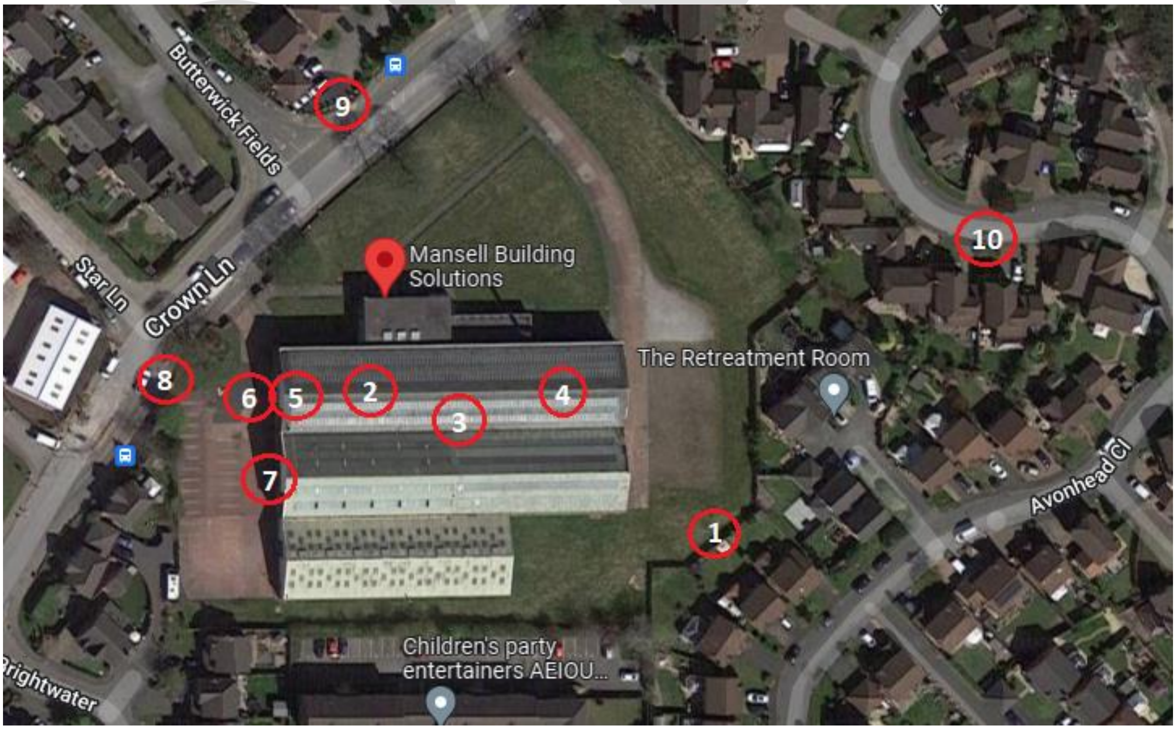

Figure 1 - Noise Measurement Locations

2.3 Results of Noise Measurements

Full results of the noise levels recorded during the survey are included in Appendix B of this report.

Table 1 summarises the results of the baseline environmental noise survey and Table 2 summarises the results of all other noise measurements (nearfield and noise source) undertaken during the day at each measurement position.

Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
1) Baseline site boundary noise survey location	11:15 –14:15	67.6	55.4	56.2	53.5	51.3
8) 5 Crown Lane	13:15 – 13:39	78.8	68.8	72.2	65.6	59.2
9) 4 Butterwick Fields (facing Crown Lane)	13:41 – 13:45	79.3	69.1	73.0	66.3	59.6
10) 18 Avonhead Close	13:58 – 14:18	62.5	53.3	55.1	51.7	50.1

Table 1 - Results of Azymuth baseline environmental noise survey.

Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
2,3,4) Internal Ocupational and Source Noise	11:30 – 11:55	89.3	81.8	79.8	69.4	62.7
5) Shutter Door 1m Inside	11:57 – 12:08	89.6	79.8	81.2	67.1	60.3
6) Shutter Door 1m Outside Open	12:10 – 12:18	87.0	73.5	73.9	63.2	59.2
7) Shutter Door 1m Closed Shutter	12:18 – 12:28	78.7	66.4	70.2	59.9	56.8

Table 2 - Results of Azymuth nearfield and source noise measurements.

2.4 Description of Noise Climate

The internal noise climate of the Mansell Building consisted of noise from the drilling/hammering of metal and wood during frame fabrication and construction. Externally, the main source of noise was generated by the transportation of metal frames out of the warehouse, ie noise associated with the lifting of metal frames, placement of metal frames on the ground or onto the loading platform of a goods vehicle.

The ambient noise levels along Crown Lane are dominated by road traffic noise and as such noise from Mansell operations are largely masked by this traffic noise. In addition road traffic noise from the M61 motorway also contributes to the ambient and wider background noise levels.

The lowest typical background sound level along the site boundary is ~49.5 dB L_{A90}. A value of 49 dBA has been assumed for the worst-case background sound level present at positions along Avonhead Close and on Rotherhead Close. The worst-case day-time background sound level along Crown Lane has been found to be ~56dB L_{A90}.

3.0 Assessment Criteria

In order to assess the extent of any measures required to comply with suitable conditions relating to potential noise sources, Azymuth Acoustics UK has reviewed various guidance documents and standards, these include:

- ProPG: Professional Practice Guidance on Planning and Noise (New residential development)
- National Planning Policy Framework (NPPF 2018)
- British Standard 8233:2014
- World Health Organisation 2018 Environmental Noise Guidelines (ENG)
- British Standard 4142:2014

3.1 National Planning Policy Framework (NPPF) 2018

The NPPF provides guidance to local authorities taking into account noise in making planning decisions. Paragraph 180 of the National Planning Policy Framework (NPPF) states that planning policies and decisions should aim to:

- Avoid noise giving rise to significant adverse impacts on health and quality of life as a result of new development
- Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions

The National Planning Policy Framework states that the planning system should 'prevent both new and existing development from contributing to or being put at unacceptable risk from, or being adversely affected by unacceptable levels of soil, air, water or noise pollution or land instability'.

3.2 British Standard 8233: 2014

BS 8233 provides a code of practice for the sound insulation of a variety of building types affected by general environmental noise. It provides recommendations for control of noise in and around buildings and suggests appropriate internal ambient noise level criteria / limits for a variety of different situations including residential properties.

The following table summarises the noise limits suggested by BS 8233 applying to residential properties:

Activity	Room	Good Design Range $L_{Aeq,T}$ dB	
		07:00-23:00hrs	23:00-07:00
Resting	Living Room	35	-
Dining	Dining Room / Area	40	-
Sleeping (daytime resting)	Bedroom (at night)	35	30

Table 3 – Noise Limits for Residential Properties Suggested in BS 8233

3.3 World Health Organisation Environmental Noise Guidelines (ENG) 2018

The main purpose of the 2018 WHO Environmental Noise Guidelines (ENG) guidelines is to provide recommendations for protecting human health from exposure to environmental noise originating from the following sources: transportation (road traffic, railway and aircraft), wind turbines and leisure activities.

The guidelines set out to define recommended exposure levels for environmental noise in order to protect population health. Exposure limits are average levels defined over a period of one year, measured outdoors in free field at the most exposed façade. It should be noted that the document does not provide guideline limit values for multiple noise sources in combination.

The 2018 WHO guidelines supersede the Community Noise Guidelines (CNG) from 1999. Nevertheless, the document recommends that all CNG indoor guideline values and any values not covered by the current guidelines should remain valid. As such, the following guidance would remain appropriate:

For protection against sleep disturbance inside dwellings, night-time noise levels should not exceed 30dB LAeq for continuous noise and 45dB L_{Amax} for typical single sound events (which are exceeded 15times or more per night – see ProPG Appendix A.12 for more details).

To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise (interpreted as noise from all sources combined) should not exceed 55dB LAeq on balconies, terraces and in outdoor living areas.

It should be noted that exposure levels defined in ENG and CNG are for guidance purposes as relates potential adverse health impacts and should not be interpreted as absolute limits or regulations.

3.4 British Standard 4142:2014

British Standard 4142: 2014 "Methods for assessing and rating industrial sound" describes methods for rating and assessing sound of an industrial and/or commercial nature. The methods described in this British Standard use outdoor sound levels to assess the likely effects of sound on people who might be inside or outside a dwelling or premises used for residential purposes upon which sound is incident.

- Typically, the greater the difference between background sound and industrial/commercial noise, the greater the magnitude of the impact.
- 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.
- A difference of around +5dB is likely to be an indication of an adverse impact, depending on the context.
- A difference of around + 10dB or more is likely to be an indication of an adverse impact, depending on the context.

BS 4142 notes that: *"Adverse impacts include, but are not limited to, annoyance and sleep disturbance. Not all adverse impacts will lead to complaints and not every complaint is proof of an adverse impact."*

3.5 Recommended Noise Assessment Criteria

Based on the guidance above it is recommended that the following criteria would be reasonable with the aim of minimising the impact of the environmental noise on the proposed residential accommodation:

- L_{dAeq} (rating level) at worst case noise receptors to not exceed the background noise level, L_{A90}. This equates to 50dBA.
- Gardens to be below 55dBA for the enjoyment of outdoor space.

4.0 BS4142 Assessment of Results

The following figure 2 sets out the existing scenario with no noise mitigation in place as calculated by the Soundplan model. Soundplan is a recognised modelling tool for predicting noise levels to meet BS4142. We have taken the results of the noise survey and Mansell's plant and operations and projected the impact on the surroundings, including the noise sensitive receptors (residential). This covers the existing noise propagation in a typical day when the outdoor yard area is in use and one of the roller shutter doors is open from time to time for access.

The noise levels are colour coded in 5dB bands with reds being the high noise levels and greens being the lowest noise levels predicted. This allows us to visualise the noise levels across the whole of the study area from Mansell's operation. The noise levels at the receiver points are identified below and in Table 4.

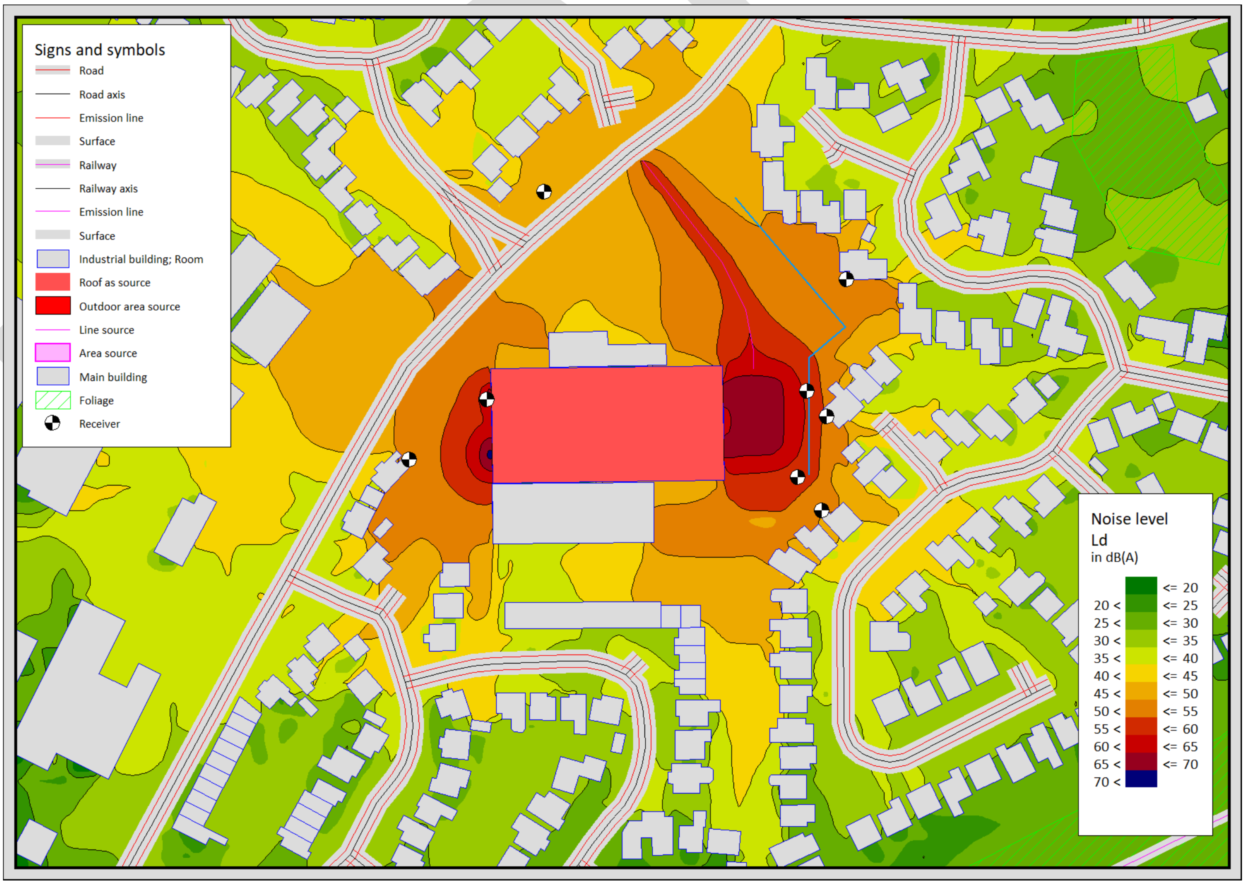

Figure 2 – Soundplan baseline noise model of Mansell Building and outside yard

The following Table 4 identifies the worst-case receptor levels (existing) as modelled using the Soundplan and compares these levels against the worst-case background sound levels. Ie Rating level ref:B minus background sound level ref:A provides the exceedance value in decibels (dB).

Receptors	Nearest Measurement Location	Measured Level		Rating Level (ref:B - calculated from source levels dBA)	Exceedance (dB)
		Ambient (L_{Aeq} dB)	Background Sound Level (ref:A - L_{90} dB)		
Baseline site boundary noise survey location	1	55.4	51.3 mean	56.6	N/A
5 Crown Lane	8	68.8	56 worst case	53.5	None
4 Butterwick Fields (facing Crown Lane)	9	69.1	56 worst case	46.2	None
18 Avonhead Close	10	53.3	49 worst case	50.7	1.7
7 Rotherhead Close	1	55.4	49 worst case	57.9	8.9
17 Rotherhead Close	1	55.4	49 worst case	54.4	5.4

Table 4 – Assessment of existing operational noise levels from Mansell Building Solutions

It can be seen from Table 4 that the existing noise levels from the Mansell site can potentially exceed the background sound level by up to 9dB with the most affected locations currently around 7 Rotherhead Close (exceedances identified in red).

The exceedances are generally created by the operation of the loading yard and access from the main warehouse. Due to these exceedances we have reviewed the potential mitigation measures as detailed in Section 5 below.

5.0 Recommendations for Noise Mitigation

The target noise level using BS4142 as a guide is LdAeq (rating level) at worst case noise receptors to not exceed the background noise level, LA90. This equates to 50dBA.

The noise levels generated by the Mansell building at the worst-case noise receptors on Rotherhead Close were predicted to be 57.9dBA as per the Soundplan model.

As previously indicated the exceedances are generally created by the operation of the loading yard and access from the main warehouse. The noise risk register has identified working practices to reduce the noise levels but this will not address the noise created closest to the existing residential dwellings.

The methods explored for the noise mitigation to meet the target (50dBA at the nearest residential receptors) included:

1) noise barriers/fencing,

2) the relocation of the loading yard and

3) increased internal acoustic absorption.

5.1 Noise Barrier and Fencing

From the Soundplan grid map, we can identify the worst affected areas as the residential properties towards the rear of the building. These buildings are the closest to the yard, where the frames are transported out of the warehouse.

Azymuth tested the effectiveness of the existing fence of height 1.35m to the rear of the properties near Rotherhead Close and Avonhead Close.

As well as fencing, Azymuth also tested whether the addition of a 2.05m high close boarded timber tongue and groove minimum 25kg/m2 noise barrier around the Mansell yard would reduce the noise levels experienced by the worst-case noise receptors (refer to www.jacksons-fencing.co.uk/acoustic-fencing or equal and approved).

Figure 3 – Proposed 2.05m high noise barrier / fencing

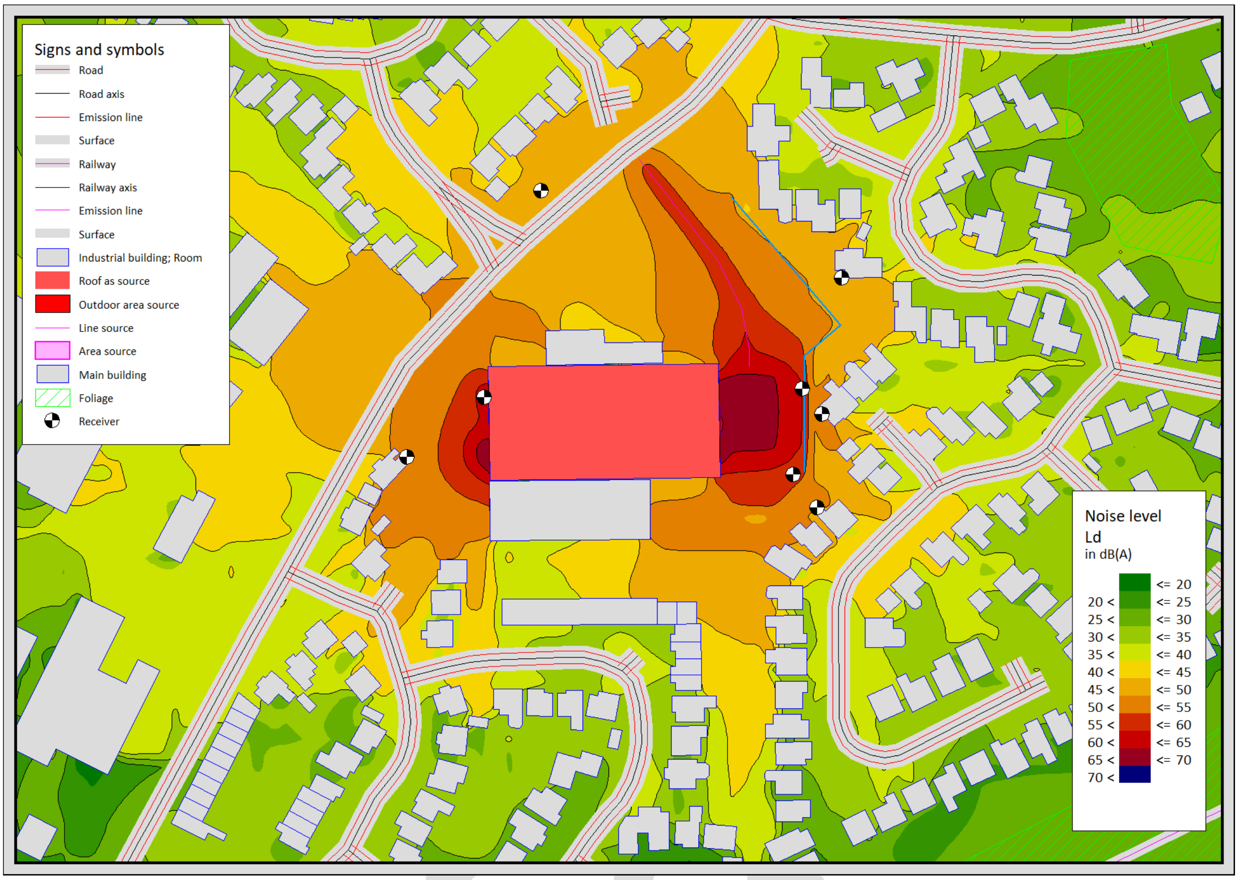

Figure 4 – Soundplan model for noise barrier and fencing only

The noise barrier and fencing was predicted to provide a noise reduction of up to 6dB to the worst case noise receptors, which in isolation will not achieve the noise mitigation targets but as a package of measures it will assist with reducing noise complaints.

5.2 Relocation of Yard with Noise Barrier and Fencing

In addition to the introduction of a 2.05m noise barrier to the rear of the properties near Rotherhead Close and Avonhead Close, Azymuth recommends increasing the distance between the loading yard and the nearest worst case noise receptors by relocating the loading yard towards the front of the Mansell Building as shown in figure 5 below.

Figure 5 – Soundplan model for relocated loading yard with noise barrier and fencing

Azymuth believes that this strategy would be the most effective in reducing the external noise levels experienced by local residents.

The relocation of the yard would reduce the noise level at the worst-case noise receptors by up to ~9dB resulting in a L_d of 49dBA, equal to the worst-case measured background noise, L_{A90}.

5.3 Acoustic Absorption Treatment in Warehouse

In order to reduce the internal noise level, Azymuth would recommend adding noise baffles to the ceiling of the warehouse to increase sound absorption in the warehouse.

The A-weighted reverberation Sound Pressure Level (SPL) was measured to be 77dBA inside the fabrication area of the warehouse. Reverberation time of the warehouse was calculated to be 2.31 seconds for mid frequency octave bands (500Hz to 2kHz).

AAUK would recommend aiming for a reverberation time of ~1.5 seconds for mid frequency octave bands. This could be achieved through the installation of 659m^2 of Rockfon Industrial Acoustic Baffles, approximately 730 baffles in total. The addition of the Rockfon baffles has been calculated to reduce the mid frequency (500Hz to 2kHz) reverberation time to ~1.6 seconds.

This configuration has been estimated to reduce the reverberant SPL by ~2dB to 75dBA. This is a small but possibly worthwhile noise mitigation. AAUK has not included this in the final noise mitigation recommendations, however it can be included at a later time if further mitigation is required.

5.4 Mitigation Options Compared

For the purposes of the noise assessment 4No. possible scenarios have been modelled by Azymuth (baseline plus the combination of 2 mitigation options both separately and together). The results of the noise calculations for the various noise mitigation options are tabulated below.

Receptor	Background sound level	Current Operations	Noise Barrier Only	Yard Relocation Only	Combined Noise Barrier and Yard Relocation
Baseline site boundary noise survey location	50	57	57	50	51
5 Crown Lane	56	54	54	54	54
4 Butterwick Fields (facing Crown Lane)	56	46	46	48	48
18 Avonhead Close	49	51	45	50	45
7 Rotherhead Close	49	58	52	49	49
17 Rotherhead Close	49	54	52	49	49

Table 5 – Analysis of different noise mitigation measures dBA as modelled in Soundplan 8.2.

The table 5 above shows the calculated noise level at each receptor for each of the mitigation options. Based on these results Azymuth recommends a combination of relocating the yard and adding a 2.05m high close boarded tongue and groove timber minimum 25kg/m2 noise barrier. The effect of the combined mitigation options is to provide a noise reduction of typically 6-9dBA. The resulting combined noise mitigation levels are typically less than or equal to the background sound level at all the receptor locations.

6.0 Summary

Mansell Building Solutions have been receiving noise complaints in relation to their day-to-day operations. Mansell produce steel frames for the construction industry and it is understood that complaints have been issued regarding the production and transportation of these frames. The noise has been described as 'drilling' and 'banging' with other complaints centred around the loading and transportation of steel frames occurring at the rear of the building.

Throughout this report we have assumed that Mansell will adhere to the conditions of the site, operational times and best working practices as agreed with the planners, EHO and residents. It is advised that Mansell continue to keep the warehouse roller shutters closed as much as possible throughout the day to minimise the noise propagation from the fabrication area.

Azymuth have undertaken a noise impact assessment to evaluate the internal noise levels of the warehouse as well as the external noise levels due to the loading and transportation of the completed steel frames.

The results of a baseline noise survey found the typical daytime background noise level, L_{A90}, to be 51.3dB along the site boundary with the lowest typical background sound level representative of locations along Avonhead Close and Rotherhead Close is 49dB L_{A90}. Whereas noise levels along Crown Lane are dominated by general road traffic and the lowest daytime background sound level is 56dB L_{A90}.

Through a sound propagation model, Azymuth were able to identify the worst noise affected areas before testing several mitigation strategies to reduce the daytime noise level, L_d, to a level closer to the measured background level, L_{A90}. The noise level at the worst-case noise receptor was found to be 58dB and as such a target noise reduction of ~9dB has been set.

To achieve the appropriate external noise level, Azymuth recommends the relocation of the grasscrete loading yard towards the front of the building as well as the addition of a 2.05m high close boarded tongue and groove timber minimum 25kg/m2 noise barrier along the Avonhead Close and Rotherhead Close boundaries. We believe that in turn this strategy can reduce the L_d (daytime L_{Aeq}) level by up to 9dB and remain compliant with BS4142.

Appendix A – Glossary of Acoustic Terms

Decibel (dB)
This is the unit used to measure sound. The human ear has an approximately logarithmic response to acoustic pressure over a very large dynamic range (typically 20 micro Pascal to 100 Pascal).

dB (A)
This is a measure of the overall noise level of sound across the audible spectrum with a frequency weighting (i.e. A-weighting) to compensate for the sensitivity of the human ear to sound of different frequencies. The A-weighting curve is implemented in sound level meters using an electronic filter that approximately corresponds to the frequency response of the ear.

Octave Band Noise Level
The human ear is sensitive to sound over a range of frequencies between approximately 20 Hz to 20 kHz. The ear is also generally more sensitive to medium and high frequencies than to low frequencies. In order to define the frequency content of a noise, the spectrum can be divided into frequency bands. The most commonly used frequency bands are octave bands, in which the mid-frequency of each band is twice that of the band below it.

L_{Aeq}
This is the equivalent steady sound level in dB (A) containing the same acoustic energy as the actual fluctuating sound level over a given time period.

Reverberation Time (RT or sometimes T_{30} or T_{60})
This is the time taken for the reverberant sound energy in an enclosure to decay one millionth of its equilibrium value, i.e. by 60 dB, after the source has been switched off, is known as the reverberation time. The reverberation time is frequency dependent and it is customary to measure its value in octave or one-third octave bands. Reverberation occurs when sound waves are repeatedly reflected from each surface of the room.

Sound Reduction Index (SRI)
Difference measured between the amount of energy flowing towards the wall in the source room and the total amount of energy flowing towards the wall in the source room and the total amount of energy entering the receiving room (usual range 100 - 3150 Hz for one third octave band values). The SRI varies with frequency and is measured in a laboratory in either octave or one-third octave bands.

SRI = L1 - L2 + 10 log (S/A), where:

L1 = Noise level in the source room
L2 = Noise levels in the receiving room
S = Surface area of test specimen
A = Equivalent acoustic absorption area in the receiving room

Weighted Sound Reduction Index (R_w)
This is a weighted single figure descriptor of the sound insulation performance of a partition measured under laboratory conditions. The procedure used to quantify the R_w is to compare the sound reduction index (SRI) in each of the one-third octave bands from 100Hz to 3150Hz against a set of standard reference curves.

Appendix B – Noise Survey Data

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
11:15:00	1	00:05:00	69.6	54.9	57.9	52.7	49.1
11:20:00	1	00:05:00	63.6	53.4	54.9	52.7	51.3
11:25:00	1	00:05:00	67.4	53.6	54.7	53	51
11:30:00	1	00:05:00	71.4	55.5	57.6	54.1	52.3
11:35:00	1	00:05:00	68.6	53.8	55.3	52.9	50.7
11:40:00	1	00:05:00	62.5	52.1	53.6	51.5	49.7
11:45:00	1	00:05:00	77.3	53.1	53.5	51.4	49.7
11:50:00	1	00:05:00	62.9	53.1	54.9	52.2	50.5
11:55:00	1	00:05:00	61.3	53	54.7	52.3	50.6
12:00:00	1	00:05:00	63.3	53	54.7	52.4	50.7
12:05:00	1	00:05:00	62.2	52.5	54	51.9	50.2
12:10:00	1	00:05:00	65.2	55	56.7	54.3	51.6
12:15:00	1	00:05:00	67.4	54.5	56.1	53.6	52
12:20:00	1	00:05:00	66.8	55.1	56.3	54.6	53.2
12:25:00	1	00:05:00	66.1	53.1	54.9	52.5	50.4
12:30:00	1	00:05:00	69.1	53	54.4	51.8	50.3
12:35:00	1	00:05:00	62.4	52.3	53.8	51.9	50
12:40:00	1	00:05:00	62.7	52.7	53.9	52.3	50.8
12:45:00	1	00:05:00	56.5	52.7	54.2	52.5	51
12:50:00	1	00:05:00	61.5	52.7	54.7	51.9	50.2
12:55:00	1	00:05:00	60.2	52.3	53.6	51.8	50.4
13:00:00	1	00:05:00	58.7	51.4	53.2	51.1	48.7
13:05:00	1	00:05:00	71.1	53.8	55.8	52.6	49.7
13:10:00	1	00:05:00	73.4	55.2	57.6	53.6	52
13:15:00	1	00:05:00	70.4	52.3	53.4	51.7	50.1
13:20:00	1	00:05:00	65.1	53	55.2	51.7	49.8
13:25:00	1	00:05:00	80.2	61.9	63.7	61.1	53.5
13:30:00	1	00:05:00	75.4	60.4	63.6	54.7	50.7
13:35:00	1	00:05:00	69.4	55.2	56.5	53.8	51.4
13:40:00	1	00:05:00	76.7	57.4	58.5	55.9	54.2
13:45:00	1	00:05:00	72.8	58	59.7	55.8	53.6
13:50:00	1	00:05:00	63.1	54.9	56.5	54.4	52.6
13:55:00	1	00:05:00	70.1	56	57.7	54.7	52.8
14:00:00	1	00:05:00	70.7	56.4	57.7	55	53
14:05:00	1	00:05:00	73.8	57.3	58.6	55.7	53.7
14:10:00	1	00:05:00	69.5	57.9	59.9	57	54.5
14:15:00	1	00:05:00	72.1	56.8	58.4	55.4	53.4

Figure B1: Results of baseline noise survey

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
11:30:00	2	00:00:30	85.2	71.5	74	62.6	60.2
11:30:00	2	00:00:30	86.8	69.5	68.7	63.5	61.2
11:31:00	2	00:00:30	88.8	75.2	78.5	69.8	60.6
11:31:00	2	00:00:30	91.5	76.9	80.8	62.7	59.4
11:32:00	2	00:00:30	88	75.3	79.2	63.6	59.7

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
11:32:00	2	00:00:30	83	69.5	71.5	62.3	59.3
11:33:00	2	00:00:30	97.5	87.2	95.3	69.2	61.2
11:33:00	2	00:00:30	92.3	83.6	88.8	78.4	62.3
11:34:00	2	00:00:30	76	64.2	65.5	62.5	60.6
11:34:00	2	00:00:30	92.4	78	75.5	64.7	60.9
11:35:00	2	00:00:30	96.3	87.5	92.8	77.7	69.7
11:35:00	2	00:00:30	98.2	87.7	92.9	76	69
11:36:00	2	00:00:30	91.5	77.1	78.8	67	62.2
11:36:00	2	00:00:30	83	69.1	71.4	64.2	61.1
11:37:00	2	00:00:30	76.4	65.6	68.1	63.1	60.2
11:37:00	2	00:00:30	96.1	78.1	78.2	68.8	61.5
11:38:00	2	00:00:30	98	87.5	95.1	67.3	62.1
11:38:00	2	00:00:30	97.5	83.9	81.6	71.3	63.2
11:39:00	2	00:00:30	104.3	87.8	83.3	71	63.3
11:39:00	2	00:00:30	99.1	89.8	96.5	70.8	61.7
11:41:00	3	00:00:30	92.8	85.6	90.6	76.8	66.8
11:41:00	3	00:00:30	92.9	81.5	84.7	74	63.8
11:42:00	3	00:00:30	86.3	75.7	80.1	70.4	64.8
11:42:00	3	00:00:30	87.3	77.3	81	73.4	63.3
11:43:00	3	00:00:30	94.3	81.3	84.2	75.5	64.4
11:43:00	3	00:00:30	93.8	80.5	80.3	72.6	67
11:44:00	3	00:00:30	96.2	85.2	87	74.1	68.9
11:44:00	3	00:00:30	90.3	76.6	78	70.9	63.1
11:46:00	4	00:00:30	89.6	74.5	77.5	69.5	59.3
11:46:00	4	00:00:30	84.8	72.8	74.6	71	59.7
11:47:00	4	00:00:30	86.1	73.3	75.7	71.5	62.6
11:47:00	4	00:00:30	86.9	74.1	75.6	71.1	62.2
11:48:00	4	00:00:30	85.5	72	74.6	65.9	58.6
11:48:00	4	00:00:30	89.4	75.8	77.8	72.4	66.8
11:49:00	4	00:00:30	84.8	73.6	77.4	69.8	64.5
11:49:00	4	00:00:30	82.3	68.8	69.5	66.6	62.4
11:53:00	4	00:00:30	84.1	74	79.4	69.2	62.2
11:53:00	4	00:00:30	83.3	73.7	77.2	70.8	66.4
11:54:00	4	00:00:30	80.4	72.8	77.9	66.5	63.8
11:54:00	4	00:00:30	80.6	70	73.1	67	59.5

Figure B2: Results of internal noise measurements

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
11:57:00	5	00:00:30	85.7	75.3	80	68.6	59.2
11:57:00	5	00:00:30	88.2	73.5	77	66.1	61.1
11:58:00	5	00:00:30	87.7	76.4	80.6	65.3	59.4
11:58:00	5	00:00:30	73.1	63.1	66	61	59.2
11:59:00	5	00:00:30	81.3	70.3	74	65.2	61.4
11:59:00	5	00:00:30	88.5	74.1	76.1	67.6	59
12:00:00	5	00:00:30	91.5	76.5	79.5	66.7	58.7

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
12:00:00	5	00:00:30	87.4	74.8	77	63.7	59.6
12:01:00	5	00:01:00	94.4	83.4	88.7	69.7	60.2
12:02:00	5	00:01:00	94.8	81.8	85.1	68.6	60.4
12:03:00	5	00:01:00	94.8	83.2	89.3	69.7	61.8
12:04:00	5	00:01:00	93.5	80.3	82.6	67.5	61
12:05:00	5	00:01:00	93	83.3	90.1	71.1	61.2
12:06:00	5	00:01:00	94	82.1	87.2	69.1	61.6
12:07:00	5	00:01:00	93.3	82.9	88.2	69.6	61.8
12:08:00	5	00:01:00	91.7	77.4	77.3	64.1	59.4

Figure B3: Results of shutter door 1m inside noise measurements

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
12:10:00	6	00:01:00	87.1	73.4	71.3	61	58
12:11:00	6	00:01:00	87.9	70.4	69.6	63	58.8
12:12:00	6	00:01:00	77	65	67	62.1	58.8
12:13:00	6	00:01:00	87.1	77.1	84.2	63.4	59.8
12:14:00	6	00:01:00	91.7	75.5	76.1	63.7	59.7
12:15:00	6	00:01:00	84.9	71.6	75.7	64.1	59.3
12:16:00	6	00:01:00	91.9	73.8	73.6	63.7	59.6
12:17:00	6	00:01:00	88.7	72.4	73.6	64.5	59.7

Figure B4: Results of shutter door 1m outside noise measurements

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
12:18:00	7	00:01:00	81.2	68.2	72.5	59.5	56.3
12:19:00	7	00:01:00	80.5	66.8	70.3	59.2	56.2
12:20:00	7	00:01:00	76.9	65.5	70.5	58.8	55.5
12:21:00	7	00:01:00	75.5	63.6	65.2	59.6	57.6
12:22:00	7	00:01:00	81.6	66.8	71	60.9	57.5
12:23:00	7	00:01:00	78.5	66.9	71.3	60.7	57.4
12:24:00	7	00:01:00	76.7	65.4	70.3	59.8	56.3
12:25:00	7	00:01:00	78.7	66.2	70.8	60.5	57.5

Figure B5: Results of closed shutter noise measurements

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
Shutter Open							
13:15:00	8	00:01:00	75.2	68.6	73.2	65.6	59.2
13:16:00	8	00:01:00	78.1	69.2	73.8	65.2	57.4
13:17:00	8	00:01:00	83.3	71.2	73.5	69	58.3
13:18:00	8	00:01:00	77	69.2	72.3	68.5	61.2
13:19:00	8	00:01:00	81	69.3	72.5	67	60.8
13:20:00	8	00:01:00	76.5	65.7	70.6	61.4	56.5
13:21:00	8	00:01:00	83.4	70	72.5	67	63
13:22:00	8	00:01:00	79	68.6	72.3	66.2	60.5
13:23:00	8	00:01:00	77.3	69.5	73.3	67.2	61.4
13:24:00	8	00:01:00	75.8	66.5	71.5	61.3	57

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
13:25:00	8	00:01:00	77.4	67.2	71	63.7	58.1
13:26:00	8	00:01:00	76.8	68.9	72.7	66.8	61.4
Shutter Closed							
13:27:00	8	00:01:00	77.6	69.4	72.6	68.5	60
13:28:00	8	00:01:00	77.2	66.9	70.8	63.7	58.9
13:29:00	8	00:01:00	73.6	63.8	68.4	58.8	56
13:30:00	8	00:01:00	75.2	68	72.1	65.3	61.3
13:31:00	8	00:01:00	77.3	67.2	71.2	64.2	56.4
13:31:00	8	00:01:00	77	65.3	69.2	59.7	57.2
13:32:00	8	00:01:00	78.3	70.1	73.7	68.2	60.5
13:32:00	8	00:01:00	87.7	70.1	72.5	67.9	58
13:33:00	8	00:01:00	79.5	69.8	73.6	67.3	57.3
13:33:00	8	00:01:00	83	70.5	73.5	65.9	59.3
13:34:00	8	00:01:00	76.7	68.1	72.3	64.3	58
13:34:00	8	00:01:00	79.8	70.9	74.2	68.8	63.3

Figure B6: Results of Crown Lane noise measurements

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
13:41:00	9	00:02:00	78	68.3	71.7	65.9	60
13:43:00	9	00:02:00	78.6	69.2	73.9	66.3	56.5
13:45:00	9	00:02:00	79.9	69	72	66.8	62.6
13:47:00	9	00:02:00	80.6	69.9	74.4	66	59.4

Figure B7: Results of Crown Lane noise measurements

Start	Position	Time	L_{Amax}	L_{Aeq}	L_{A10}	L_{A50}	L_{A90}
13:58:00	10	00:02:00	60.7	53	55.7	51.7	50
14:00:00	10	00:02:00	60.3	52.2	53.8	51.5	49.7
14:02:00	10	00:02:00	65.3	53	53.4	50.8	49
14:04:00	10	00:02:00	69.4	55.3	56.4	51.8	50.3
14:06:00	10	00:02:00	55.5	52.1	53.2	52	50.7
14:08:00	10	00:02:00	61.2	52.8	54.8	51.5	50
14:10:00	10	00:02:00	65	54.2	57.4	51.6	50.1
14:12:00	10	00:02:00	62.6	54	55.9	52.8	51.3
14:14:00	10	00:02:00	62.2	53.4	55.8	52.1	50.4
14:16:00	10	00:02:00	58.8	51.4	52.7	51.1	49.5

Figure B8: Results of Avonhead Close noise measurements