Acoustic Associates Sussex Ltd

Measurement of Existing Noise Levels & Assessment of New Plant Machinery Noise

Site: **7 Rowlands Road, Worthing**
Client: **Greg Davey**

Report by: George Orton BEng(Hons) MIOA
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Institute of Acoustics

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1.0 Introduction and Executive Summary

1.1 Acoustics Associates Sussex has been appointed by Greg Davey to:

- Measure existing noise levels at 7 Rowlands Road, Worthing
- Predict Noise Levels of proposed new plant machinery
- Compare noise level predictions with relevant standards/criteria

1.2 New plant machinery is to be installed in the kitchen area of the Fresh Cut Café at 7 Rowlands Road. The proposed plant machinery consists of one kitchen extract fan. The fan connects to ductwork which runs through an existing chimney flue and discharges at the top of the building.

1.3 This report provides the results summary of measurements of existing noise levels at one location taken on the rear façade of the development.

1.4 The measurement survey shows that the representative background noise level is 35dB(A) during the opening hours.

1.5 The noise assessment calculated that the "Noise Rating Level" of the extract system is approximately 19 dB(A) at the nearest residential window.

1.6 The calculated "Noise Rating Level" is 16 dB(A) below the measured background noise level.

1.7 At 16 dB(A) below the background noise level complaints will be unlikely and the Local Authority's external noise criterion is satisfied.

1.8 The assessment calculated that the noise breakout level from the extract system would be less than NR 15

1.9 NR 15 corresponds to a sound pressure level of approximately 20 dB(A) within the residential room.

1.10 This breakout noise level is well below the WHO target internal noise level for a lounge or a bedroom.

2.0 Terminology

Terminology and extracts from BS4142 (Method for rating industrial noise affecting mixed residential and industrial areas (1997)) have been used in this report. For clarity a definition of certain terms can be found below:

- **Specific noise level,** *L*Aeq,*Tr*
  The equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval.

- **Measurement time interval,** *T*m
  The total time over which measurements are taken. NOTE. This may consist of the sum of a number of non-contiguous, short term measurement time intervals.

- **Rating level,** *L*Ar,*Tr*
  The specific noise level plus any adjustment for the characteristic features of the noise.

- **Ambient noise**
  Totally encompassing sound in a given situation at a given time usually composed of sound from many sources near and far.

- **Residual noise**
  The ambient noise remaining at a given position in a given situation when the specific noise source is suppressed to a degree such that it does not contribute to the ambient noise.

- **Residual noise level,** *L*Aeq,*T*
  The equivalent continuous A-weighted sound pressure level of the residual noise.

- **Background noise level,** *L*A90,*T*
  The A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 % of a given time interval, *T*, measured using time weighting, *F*, and quoted to the nearest whole number of decibels

- **Noise Rating,** *NR*
  Noise rating (NR) is a graphical method for assigning a single number rating to a noise spectrum. It can be used to specify the maximum acceptable level in each octave band of a frequency spectrum, or to assess the acceptability of a noise spectrum for a particular application. The method was originally proposed for use in assessing environmental noise, but it is now used in the UK mainly for describing noise from mechanical ventilation systems in buildings".

3.0 Background Noise Survey Details

2.1 Site

- 7 Rowlands Road, Worthing.

2.2 Survey Engineer

- George Orton BEng (Hons) MIOA

2.3 Survey Date

- 29th June – 5th July 2009

2.4 Equipment used:

- RION NL18 Class 1 Real Time Noise Analyser
- Weatherproof microphone housing
- Castle GA607 Class 1 Acoustic Calibrator
- Microphone Mounting Poles

The meter was calibrated before commencing the noise measurements (@94dB). The calibration was re-checked at the end of the measurements to ensure that no calibration drift had occurred. After survey the calibration showed no significant drift (94dB)

2.5 Weather condition

- Dry,
- Wind speed average less than $5ms^{-1}$,

2.6 Free field Adjustment

- All measurements were taken with the microphone 3m from the rear façade of 7 Rowlands Road. Taking in to account the microphone location it follows that all measurements at this location are free-field measurements and therefore require no correction.

2.7 Microphone Positions

- Measurements were taken at 3rd floor level.

4.0 Background Noise Measurement Results

4.1 Summary of Noise Measurements

The graph below shows the continuous noise level survey results:

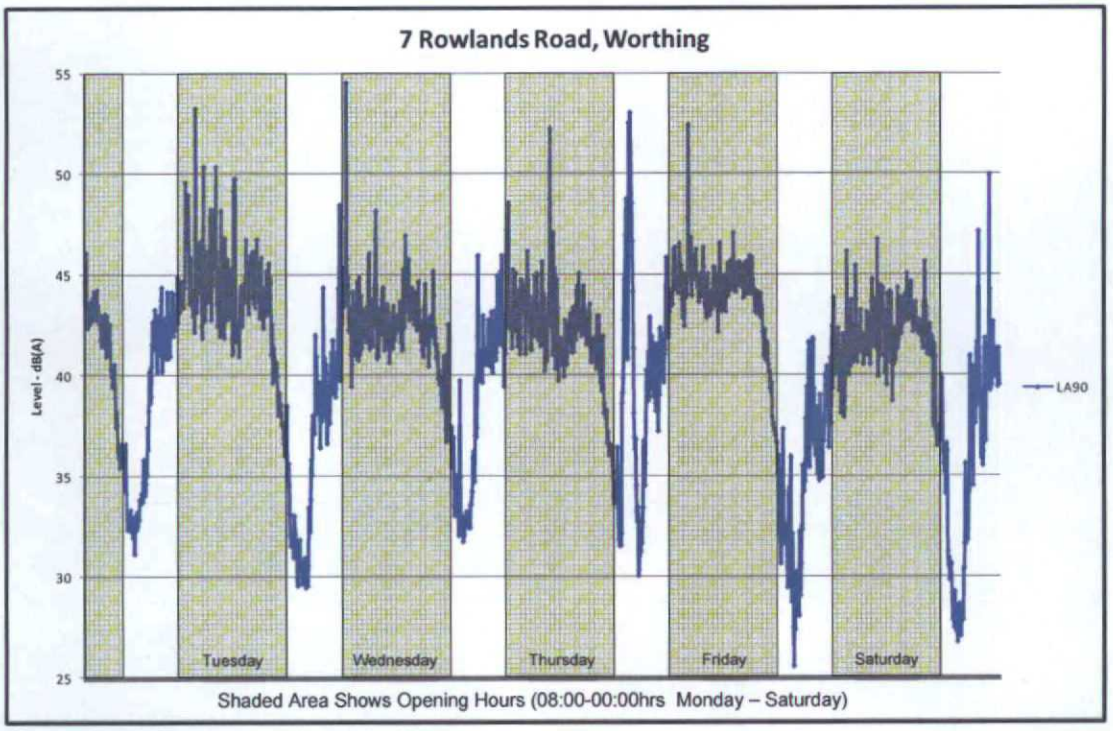


Figure 1– Noise Survey Graphical Data

4.2 Representative Background Noise Level (During Opening Hours)

Background noise level, $L(A)_{90,T}$ is the A-weighted sound pressure level of the residual noise at the assessment position that is exceeded for 90 % of a given time interval, T.

The results above show that the representative background noise level would be approximately 35dB(A).

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5.0 Extract System Specification

5.1 New Plant Machinery Layout

As part of the refurbishment of the Fresh Cut Café a new extract fan is to be installed into the ground floor kitchen area. The fan extracts via rectangular ducting through the kitchen to an existing chimney stack. A silencer is also to be fitted between the fan and the point where the duct work enters the chimney. The ductwork at this point changes to a circular duct which travels up the existing chimney before discharging above the roof apex.

5.2 New Extract Fan (Nicotra – "dd 9/9 550 watt 4 pole")

Noise data regarding the Nicotra fan is given as sound power levels in the table below:

	Octave Band Centre Frequency (Hz)							
	63	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Sound Power (dB)	63.6	80.3	77.1	68.5	69.9	67.8	63.9	58.7

Figure 2 – Extract Fan Sound Power Levels

5.3 Duct Silencer

A bespoke silencer unit is going to be installed in order to reduce the noise levels within the duct–work that travels through the chimney stack. The insertion loss or attenuation provided by the silencer is shown in the table below:

	Octave Band Centre Frequency (Hz)							
	63	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Attenuation	12	23	36	30	26	32	35	30

Figure 3 – Silencer Specification

5.3 Insertion Loss Due to Duct Bend

It is assumed that the rectangular ductwork in the kitchen will have at least one bend in it in order to route the ductwork from the fan to the chimney stack. The insertion loss or attenuation provided by bend is shown in the table below:

	Octave Band Centre Frequency (Hz)							
	63	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Attenuation	0	0	1.2	7.8	6	3.2	3	3

Figure 4 – Bend Attenuation

6.0 Indoor Noise Predictions

6.1 Noise Breakout from Duct System

As mentioned in the previous section the kitchen fan extracts through ductwork which travels up through an existing chimney stack. Circular ductwork is to be inserted in to the chimney and is to be connected at ground floor level within the kitchen and within the loft of the building. The chimney stack travels all the way up the building and also travels through residential dwelling areas. If not installed correctly, noise and vibration generated by the extract system may breakout into the dwelling areas.

The fan noise will have to be silenced sufficiently so that noise breaking out of the duct/chimney will be inaudible within the dwelling areas.

To reduce vibration transfer from the duct-work to the chimney structure the duct should be supported with anti-vibration connectors. The duct should not be allowed to touch the walls of the chimney as it travels up the chimney stack.

6.2 Sound Power Duct after Silencer

The in duct sound power level after the silencer (Lw_{duct}) will be used in the next section to predict the noise breakout levels in the residential areas. The sound power level will be calculated using the data in section 5. The sound power in the duct will be the sound power created by the fan after it has been attenuated by the silencer and the duct bend:

	Octave Band Centre Frequency (Hz)							
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Fan - Sound Power (dB)	63.6	80.3	77.1	68.5	69.9	67.8	63.9	58.7
Silencer Attenuation	12	23	36	30	26	32	35	30
Bend Attenuation	0	0	1.2	7.8	6	3.2	3	3
Duct Sound Power Lw_{duct} *(dB)*	51.6	57.3	39.9	30.7	37.9	32.6	25.9	25.7

Figure 5 – In-Duct Sound Power Calculations

6.3 Noise Breakout Level within Residential Areas

The duct-bourne fan noise will travel up the ductwork within the chimney and will also "breakout" through the duct wall and chimney.

To simplify the situation and to give a "worst case" scenario noise breakout level, the noise attenuation of the semi flexible duct has been ignored. In this simplified situation the chimney stack is acting as the duct.

6.3.1 Duct Breakout Sound Power Equation

The total sound power level passing through the duct walls into the receiving room ($Lw_{breakout}$) is given approximately by:

$$Lw_{breakout} = Lw_{duct} - R + 10 \text{ Log } (S_W/S_D) \quad dB$$

- Lw_{duct} - Derived in 7.2 and is average sound power level within duct, over the length contained in the receiving room
- R – Sound reduction index of the duct wall
- S_W – Surface area of duct (chimney) radiating into the receiving room = $3.6m^2$
- S_D – Cross sectional area of duct = $0.1m^2$

6.3.2 Sound reduction index of the duct wall (R)

Brick chimneys of this type are likely to be 4.5-9 inches thick and constructed from brick. To represent the worst case scenario the sound reduction index of a 4.5 inch brick wall will be used. The sound reduction index (R) is shown in the table below:

	Octave Band Centre Frequency (Hz)							
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Sound reduction index (R)	29	36	37	40	46	54	56	58

Figure 6 – Chimney SRI

6.3.3 Duct Breakout Sound Power ($Lw_{breakout}$)

The table below shows the duct breakout as calculated by the equation in 7.3.1:

	Octave Band Centre Frequency (Hz)							
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Lw_{duct} *(dB)*	51.6	57.3	39.9	30.7	37.9	32.6	25.9	25.7
Sound reduction index (R)	29	36	37	40	46	54	56	58
10 Log (S_W/S_D)	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6
$Lw_{breakout}$ *(dB)*	38.2	36.9	18.5	6.3	7.5	0	0	0

Figure 7 – Sound Power Breakout Calculations

6.3.4 Equation for Calculating Sound Pressure Level in Residential Area

The duct breakout sound power can be used to calculate the sound pressure level within a room which the chimney stack travels through. The equation below shows how the calculation will be made:

$$SPL = Lw_{breakout} + 10\ Log\left[\frac{Q_\theta}{4\pi\ r^2} + \frac{4}{R_c}\right]\ dB$$

6.3.5 Room constant (R_c)

Rc was calculated using the Sabine formula and assuming the reverberation time within the room is 0.5seconds. This assumption has been made based on the fact that Approved document "E" of the Building regulations states that a furnished residential room will have a reverberation time of approximately 0.5 seconds. It is assumed that the chimney will travel through a bedroom that has a volume of $29m^3$.

6.3.6 Distance from Chimney to Person in Room (r)

It is assumed that the reception point within the room is 1m from the chimney.

6.3.7 Directivity Factor (Q_θ)

As the chimney is likely to run along the middle of wall it is assumed that $Q_\theta = 2$

6.3.8 Sound Pressure Level in Residential Area (SPL)

The sound pressure level calculated is shown in the table below:

	Octave Band Centre Frequency (Hz)								
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*	*Broad Band*
SPL (dB)	35	34	16	3	5	0	0	0	
A-Weighted SPL - dB(A)	9	18	7	0	5	0	0	0	**19.2 dB(A)**

Figure 8 – SPL in Residential

7.0 External Noise Level Predictions

7.1 Assumptions

As mentioned in previous section the kitchen fan extracts through ductwork which travels up through an existing chimney stack. The duct will then discharge at the top of the chimney. A simplified calculation can be made to predict the noise level outside a residential window. Assumptions will be made to represent a worst case scenario situation:

- No attenuation due to length of duct has been calculated
- It is assumed that the nearest residential window is 6m from the discharge point
- It is assumed that the nearest residential window is in direct line of sight

7.2 Duct Termination

Due to acoustic impedance differences between the air in the duct and the atmosphere not all of the energy in the duct will be radiated into the atmosphere. Some of the energy is actually reflected back due to the impedance difference. Therefore:
$Lw_{ductdischarge} = Lw_{duct}$ – Discharge Attenuation

Assuming the duct has a diameter of 300mm the attenuation due to reflection at the discharge point is shown in the table below:

	Octave Band Centre Frequency (Hz)							
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*
Discharge Attenuation	14	9	4.6	1.5	0	0	0	0

Figure 9 – Duct Termination Attenuation

7.3 Equation to Calculate Noise level Outside Residential Window

As the duct is discharging into the atmosphere rather than into an enclosed space the direct sound pressure level will be calculated using the equation below:

$SPL = Lw_{ductdischarge} - 20 \text{ Log } r - 11$ dB

(r=6m as stated in 8.1)

7.4 Noise level Outside Residential Window SPL

The table below shows how the noise level (SPL) outside the nearest residential window is calculated using information in the above sub-sections:

	Octave Band Centre Frequency (Hz)								
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*	*Broad Band*
Lw_{duct} ***(dB)***	51.6	57.3	39.9	30.7	37.9	32.6	25.9	25.7	
Discharge Attenuation	14	9	4.6	1.5	0	0	0	0	
20 Log R	15.6	15.6	15.6	15.6	15.6	15.6	15.6	15.6	
Propagation Factor	11	11	11	11	11	11	11	11	
Residential Window SPL (dB)	11	21.7	8.7	2.6	11.3	6	0	0	**14 dB(A)**

Figure 10 – External SPL

8.0 Noise Criteria

8.1 Local Environmental Health Indoor Noise Criterion

Local Environmental Health requires that any noise generated by the extract system should be inaudible within 7 Rowlands Road dwelling areas.

8.2 WHO Noise Criteria

The target internal levels are based on guidelines laid out by the World Health Organisation (WHO) and are as follows:

Room Type	Target Internal Level - Leq dB (A)
Living rooms	35 (Daytime only)
Bedrooms	30 (Night)

The target internal noise level for a bedroom during the night time corresponds to the threshold of sleep disturbance. Internal noise levels of 30dB (A) and above are likely to cause sleep disturbance.

8.1 Local Environmental Health External Noise Criterion

The Local Environmental Health Criterion is that the rating level of noise produced by an industrial source must be at least 5dB below the background noise (LA90) just outside the nearest residential dwelling.

With regard to rating level BS4142 states the following:

"Before the measured and calculated noise can be compared to the Local Environmental Health Criterion for Noise the rating level will need to be established. Certain acoustic features can increase the likelihood of complaint. The BS 4142 standard states that 5dB should be added to the specific noise to obtain the rating level if:

a) The noise contains a distinguishable, discrete continuous note (tonal)
b) The noise contains distinct impulses.
c) The noise is irregular enough to attract attention.

BS7445 describes how to detect for tonality in the following way:
"In some practical cases, a prominent tonal may be detected in one third octave spectra if the level of a one third octave band exceeds the level of the adjacent bands by 5dB or more."

Taking into account the noise data in 7 it is assumed that the specific noise source is "tonal and will require a character correction as detailed above.

Therefore noise rating level will be 5dB higher than the predicted level outside the nearest window.

The night time representative background level has been stated in section 4.2 and is 35dB(A)

9.0 Conclusion

9.1 Indoor noise level

- Section 6 calculated the duct noise breakout level within a residential room. The table of results has been copied below:

	Octave Band Centre Frequency (Hz)								
Information	*63*	*125*	*250*	*500*	*1k*	*2k*	*4k*	*8k*	*Broad Band*
SPL (dB)	35	34	16	3	5	0	0	0	
A-Weighted SPL - dB(A)	9	18	7	0	5	0	0	0	**19.2 dB(A)**

Figure 8 – SPL in Residential

- BS8233[3] (Sound insulation and noise reduction for buildings Code of practice) Introduces the Noise Rating Number NR. The extract, below, taken from BS8233 describes the noise rating number:

  "Noise rating (NR) is a graphical method for assigning a single number rating to a noise spectrum. It can be used to specify the maximum acceptable level in each octave band of a frequency spectrum, or to assess the acceptability of a noise spectrum for a particular application. The method was originally proposed for use in assessing environmental noise, but it is now used in the UK mainly for describing noise from mechanical ventilation systems in buildings".

  To obtain an NR number the octave band sound pressure levels are plotted onto the set of reference curves detailed in BS8233. The NR of the spectrum corresponds to the value of the first NR contour that is entirely above the spectrum.

  The noise levels calculated in figure 8 and the reference curves within BS8233 show that the duct noise breakout will be NR15.

- Noise rating curves were defined from Kosten and van Os, "Community reaction criteria for external noises" 1962. The document also recommends that the criterion for a sleeping area should be NR25. It also recommends that corrections should be applied for character (-5dB as in BS4142) and also if the sleeping area is in a very quiet suburban area (-5dB).

  This implies that the criterion for Rowlands Road is that the noise breakout level is NR1. The above shows that this criterion is achieved.

- In a suburban area the noise level of NR15 should not be audible.

- The predicted internal noise level is well below the WHO target internal noise level for a bedroom or lounge.

9.2 Exterior Noise Level

- In order to satisfy the internal noise criteria it was necessary for a silencer to be incorporated into the kitchen extract system. The silencer will also reduce the level of noise which escapes from the duct termination at roof level.

- Section 7 calculated that the specific noise level at the nearest residential window will be approximately 14dB(A). Section 8 demonstrated that the specific noise source was tonal and therefore would require a character correction. Therefore the "Noise Rating Level" (as described in BS4142) will be 19 dB(A) at the nearest residential window.

- The "Noise Rating Level at the nearest residential window is 16 dB(A) below the representative background noise level which was derived in section 4.

- Therefore the Local Authority's external noise criterion is easily satisfied.

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