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10th May 2023

Ormskirk Market

Assessment of Extract Fan Noise at the
former Ormskirk Market, L39 3BH.

Prepared for :-

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1.0 SUMMARY

The assessment is based on a very cautious interpretation of previous measurements of the background levels. It is also based on very cautious interpretations of the fan manufacturer's source data.

Assuming all fans running at normal speed the modelled levels would appear to support the current complaints. The fans are already fitted with silencers, but these are on the kitchen-side of the fans and have no effect on the external noise. However, with relatively straight forward silencers fitted to the discharge side of the fans, the impact is likely to be negligible, even if fans are inadvertently left running into the early hours of the night.

A R Raymond

P J Durell

2.0 INTRODUCTION

ADC was asked to carry out an independent assessment of the above site with regards to the existing extract fans, but it the form of an assessment for planning.

This report begins by summarising assessment standards and, where appropriate, discusses alternative interpretations.

After a brief statement of survey details we discuss basic results and the resulting assessment. The impact is discussed along with any recommendations for mitigation.

3.0 ASSESSMENT STANDARDS

3.1 NPPF, NPSE and NPPG

The National Planning Policy Framework (NPPF), the Noise Policy Statement for England (NPSE) and the National Planning Practice Guidance (NPPG) provide nothing in the way of quantitative criteria but instead provide general policy aims and statements and some guidance on how certain situations can be interpreted.

The NPPF's main statement on noise is to be found in paragraph 185:-

> 185. Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:
>
> a) mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life[65];
>
> b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason; and
>
> c) limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation.

Paragraph 187 is also relevant:-

187. Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or 'agent of change') should be required to provide suitable mitigation before the development has been completed.

The NPPF refers to the NPSE which sets out the following aims:-

1. *avoid significant adverse impacts on health and quality of life;*
2. *mitigate and minimise adverse impacts on health and quality of life;*

   and

3. *where possible, contribute to the improvement of health and quality of life.*

It also introduces the concepts of:

- *NOEL – No Observed Effect Level. In simple terms, below this level, there is no detectable effect on health and quality of life due to the noise.*
- *LOAEL – Lowest Observed Adverse Effect Level. This is the level above which adverse effects on health and quality of life can be detected.*
- *SOAEL – Significant Observed Adverse Effect Level. This is the level above which significant adverse effects on health and quality of life occur.*

SOAEL is clearly something the policy seeks to avoid in aim 1. Aim 2 represents situations between SOAEL and LOAEL, and seeks to minimise and mitigate the effects.

The NPPG section on noise adds some further detail, much of it reproducing the NPPF and NPSE, but some useful qualitative guidance is provided Noise Exposure Hierarchy, as follows:-

Response	***Examples of outcomes***	***Increasing effect level***	***Action***
No Observed Effect Level			
Not present	No Effect	No Observed Effect	No specific measures required
No Observed Adverse Effect Level			
Present and not intrusive	Noise can be heard, but does not cause any change in behaviour, attitude or other physiological response. Can slightly affect the acoustic character of the area but not such that there is a change in the quality of life.	No Observed Adverse Effect	No specific measures required
Lowest Observed Adverse Effect Level			
Present and intrusive	Noise can be heard and causes small changes in behaviour, attitude or other physiological response, e.g. turning up volume of television; speaking more loudly; where there is no alternative ventilation, having to close windows for some of the time because of the noise. Potential for some reported sleep disturbance. Affects the acoustic character of the area such that there is a small actual or perceived change in the quality of life.	Observed Adverse Effect	Mitigate and reduce to a minimum
Significant Observed Adverse Effect Level			
Present and disruptive	The noise causes a material change in behaviour, attitude or other physiological response, e.g. avoiding certain activities during periods of intrusion; where there is no alternative ventilation, having to keep windows closed most of the time because of the noise. Potential for sleep disturbance resulting in difficulty in getting to sleep, premature awakening and difficulty in getting back to sleep. Quality of life diminished due to change in acoustic character of the area.	Significant Observed Adverse Effect	Avoid
Present and very disruptive	Extensive and regular changes in behaviour, attitude or other physiological response and/or an inability to mitigate effect of noise leading to psychological stress, e.g. regular sleep deprivation/awakening; loss of appetite, significant, medically definable harm, e.g. auditory and non-auditory.	Unacceptable Adverse Effect	Prevent

It also makes the point that the subjective nature of noise means that there is not a simple relationship between noise levels and the impact on those affected. This will depend on how various factors combine in any particular situation, including the level of the noise in absolute terms and how it might compare with the underlying background noise, the impulsiveness or intermittence pattern of the noise, its spectral content, and the time of day. It discusses in very general terms the issues to consider when introducing noise sources to existing noise sensitive area, new residential development in areas affected by existing noise sources (most of which have their own specific guidance, such as BS 4142, BS 8233, etc.) and the potential impact on wildlife.

3.2 BS8233 and WHO

BS 8233 was updated in March 2014. Quantitatively, however, the design criteria are little changed – just expressed differently to reduce ambiguity in certain situations. Its guidance is primarily intended for new buildings, but the criteria are routinely referred to for putting general noise climates into context.

The criteria in Table 4 of BS 8233 are based on WHO guidance and give the desirable criteria for indoor ambient noise levels for dwellings as follows:-

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	35 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area	40 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	35 dB $L_{Aeq,8hour}$	30 dB $L_{Aeq,8hour}$

Note that the standard accepts the widely used rule of thumb that, for a partly open window, the levels just outside will be 15dB higher than those just inside. This brings us to an external equivalent of the above table, as follows:-

Activity	Location	07:00 to 23:00	23:00 to 07:00
Resting	Living room	50 dB $L_{Aeq,16hour}$	-
Dining	Dining room/area	55 dB $L_{Aeq,16hour}$	-
Sleeping (daytime resting)	Bedroom	50 dB $L_{Aeq,8hour}$	45 dB $L_{Aeq,8hour}$

It goes on to state that, where necessary, the criteria can be relaxed by up to 5 dB and still achieve reasonable conditions.

Note that the new version does not explicitly state criteria for bedroom noise in terms of dB L_{Amax} but the WHO Guidelines for Community Noise (or similar) are widely used with a recommendation that the noise inside bedrooms should not typically exceed 45 dB L_{Amax}, for instance no more than 10 to 15 times a night.

Garden area criteria are unchanged with 50 dB L_{Aeq} and 55 dB L_{Aeq} being considered desirable and reasonable respectively.

Note that the new version of BS8233 more explicitly specifies the assessment periods as 16 hour and 8 hour for daytime and night time respectively.

3.3 BS 4142

BS 4142 was updated in November 2014. The standard is very complicated but, basically, it describes methods for rating and assessing sound of an industrial and/or commercial nature, which includes:

a) sound from industrial and manufacturing processes

b) sound from fixed installations which comprise mechanical and electrical plant and equipment

c) sound from the loading and unloading of goods and materials at industrial and/or commercial premises

d) sound from mobile plant and vehicles that is an intrinsic part of the overall sound emanating from premises or processes, such as that from forklift trucks, or that from train or ship movements on or around an industrial and/or commercial site.

   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.

<u>Characteristics and Context</u>

Certain acoustic features can increase the significance of impact over that expected from a basic comparison between the specific sound level and the background sound level. Where such features are present at the assessment location, we need to add a character correction to the specific sound level to obtain the rating level.

These features can include tonality, impulsivity and intermittency with corrections typically ranging potentially from 0dB to 9 dB. Corrections at the higher end would represent characteristics which are highly perceptible in the context of the ambient noise as a whole. Corrections at the lower end would represent characteristics which are just perceptible in the presence of the ambient noise as a whole,

The significance of sound of an industrial and/or commercial nature depends upon both the margin by which the rating level of the specific sound source exceeds the background sound level and the context in which the sound occurs. An effective assessment cannot be conducted without an understanding of the reason(s) for the assessment and the context in which the sound occurs/will occur. When making assessments and arriving at decisions, therefore, it is essential to place the sound in context.

<u>Assessment</u>

We obtain an *initial estimate* of the impact of the specific sound by subtracting the measured background sound level from the rating level and considering the following.

a) Typically, the greater this difference, the greater the magnitude of the impact.

b) A difference of around +10 dB or more is likely to be an indication of a significant adverse impact, depending on the context.

c) A difference of around +5 dB is likely to be an indication of an adverse impact, depending on the context.

d) 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.

Where the initial estimate of the impact needs to be modified due to the context, pertinent factors need to be taken into consideration, including the following.

1) The absolute level of sound.

   For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low.

   Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.

   Where residual sound levels are very high, the residual sound might itself result in adverse impacts or significant adverse impacts, and the margin by which the rating level exceeds the background might simply be an indication of the extent to which the specific sound source is likely to make those impacts worse.

2) The character and level of the residual sound compared to the character and level of the specific sound.

   We need to consider whether it would be beneficial to compare the frequency spectrum and temporal variation of the specific sound with that of the ambient or residual sound, to assess the degree to which the specific sound source is likely to be distinguishable and will represent an incongruous sound by comparison to the acoustic environment that would occur in the absence of the specific sound. Any sound parameters, sampling periods and averaging time periods used to undertake character comparisons should reflect the way in which sound of an industrial and/or commercial nature is likely to be perceived and how people react to it.

3) The sensitivity of the receptor and whether dwellings or other premises used for residential purposes will already incorporate design measures that secure good internal and/or outdoor acoustic conditions.

4.0 GUIDE TO MODELLING

We have used the CadnaA model established for the original assessment report dated 10Th October 2023. The assumptions are the same and reiterated as follows:-

1. The ground is mainly reflective, with a coefficient of 0.11 assumed (note that this was originally set up for the surrounding residents close to the building. The there will be far more ground absorption between the fans and the house to the east).

2. Calculations are based on two orders of reflections.

3. The site building and the surrounding buildings are assumed to be mainly reflective (0.5 dB loss on reflection assumed).

4. The discharges of the 6 fans are enters as area sources (horizontal discs) at a height of 4.2 m. The sound power levels are entered in octave bands across the frequency range based on the fan data sheets.

5. The software then calculates the noise at nearby noise-sensitive properties. The predicted façade noise levels are calculated for all floors and the software automatically displays the noisiest floor level.

Appendix 2 shows the full calculations for the assessment and the figures which are input to the model.

5.0 SURVEY DETAILS

It was agreed that there would be no survey work specific to this assessment. Although there have since been delays, the reason was in order to save time, and also the fact that it was accepted by the operators that the fan noise needed to be controlled. It was agreed that the specification of silencers would be based on pessimistic assumptions to allow for the uncertainty.

We refer briefly to the survey work done for the main assessment as presented in our report dated 10th October 2023.

6.0 RESULTS AND DISCUSSIONS

6.1 Assumed Background Levels

As discussed in section 5 above, we refer to the survey results of the original assessment, a summary of which is reproduced below.

*Lowest 15 Minute Period**	*Index*	***dB(A)***
Up to 23:00	Leq	**49**
	Lmax	**68**
	L90	**41**
23:00 to 00:00	Leq	**46**
	Lmax	**62**
	L90	**37**
00:00 to 01:00	Leq	**47**
	Lmax	**67**
	L90	**37**
01:00 to 02:00	Leq	**41**
	Lmax	**62**
	L90	**35**

* Lowest in terms of the dB L_{A90} Index

Very importantly, BS 4142 does not require the lowest measurements to be used as the representative Background Sound Level. However, we have used the lowest 15 minute periods here as a means of assuming a worst case, and to mitigate for uncertainty.

Note, of course there that these measurements were made to the front of the development. For this part of the assessment we are only interested in the dB L_{A90} index which tend to vary far less than the other indices, but it is reasonable to assume that levels will be lower to the rear of the houses to the east. The fans should not normally run beyond the late evening, but it was agreed to assume that they may occasionally be left running into the early part of the night time. The lowest 15 minute period up to 02:00 is 35 dB L_{A90}. If we assume that the levels to the rear of the houses to the east are 30 dB L_{A90} then this should provide a very safe assumption. As discussed later, this can be considered to be a very low level where the basic numerical processes of BS 4142 loose relevance.

6.2 Discussion of Sources

There is a total of 6 extract fans. The fan furthest north is a Systemair AR 315E4 sileo Axial fan.

AR 315E4 sileo Axial fan

Article Number: 34463
Variant : 230V 1~ 50Hz

systemair

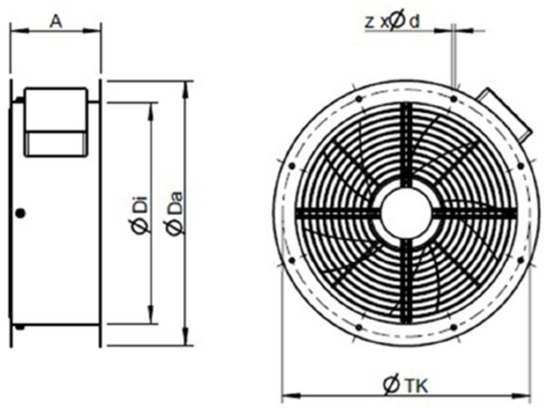
Description

speed controllable by voltage reduction
inlet protection guard
safe and maintenance free operation
can be installed in any mounting position
electric connection via terminal box mounted on the casing
supplied with capacitor
Axial fans of the AR sileo range do have a bionic shape of the fan blade, and are driven by external rotor motors. The AR range is mounted in a round casing according Eurovent 1/2, galvanized steel and powder coated in black (RAL9005). The protection guard at the inlet side is powder coated in black. The axial impeller is manufactured from black high efficiency composite material. The impeller is balanced dynamically in two levels...
Find more details in our online catalogue

Technical parameters

Nominal data		
Voltage (nominal)	230	V
Frequency	50	Hz
Phases	1~	
Input power	160	W
Input current	0.67	A
Impeller speed	1,300	rpm
Air flow	max 0.6767	m^3/s
Capacitance of capacitor	5	µF
Temperature of transported air	max 50	°C
Max temperature of transported air, when speed controlled	50	°C
Sound data		
Sound pressure level at 1m	59	dB(A)

Dimension



	A	B	C	ØDi	ØDa	z x Ød	ØTK
AR 315E4 sileo	135	12	120	316	382	8 x Ø9.5	355

Note that only sound pressure level at 1m is available for this fan, and only in dB(A) terms, ie. not octave band (frequency band) information. We describe how we deal with this later.

The other 5 are slightly larger Systemair AR 450E4 sileo Axial fans.

AR 450E4 sileo Axial fan

Article Number: 37385
Variant : 230V 1~ 50Hz

systemair

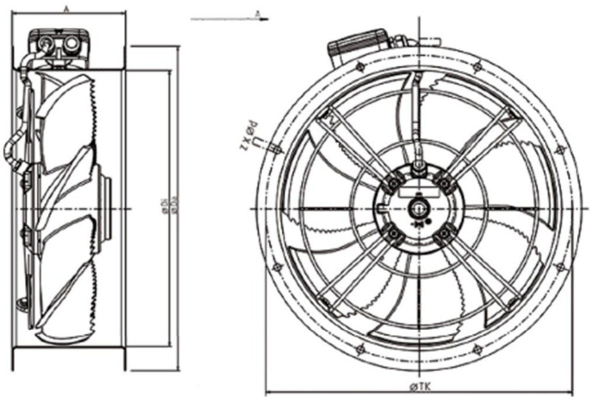
Description

speed controllable by voltage reduction, plus option of 2-step operation by D/Y switching for 400V versions
safe and maintenance free operation
can be installed in any mounting position
electric connection via terminal box mounted on the casing
Axial fans of the AR sileo range do have a bionic shape of the fan blade, and are driven by external rotor motors. The AR range is mounted in a round casing according Eurovent 1/2, galvanized steel and powder coated in black (RAL9005). The axial impeller is manufactured from black high efficiency composite material. The impeller is balanced dynamically in two levels in accordance with DIN ISO...
Find more details in our online catalogue

Technical parameters

Nominal data		
Voltage (nominal)	230	V
Frequency	50	Hz
Phases	1~	
Input power	600	W
Input current	2.9	A
Impeller speed	1,390	rpm
Air flow	max 2.028	m³/s
Air flow at max. efficiency	1.39	m³/s
Specific ratio	1	
Capacitance of capacitor	14	µF
Temperature of transported air	max 70	°C
Max temperature of transported air, when speed controlled	70	°C
Sound data		
Sound pressure level at 1m	66	dB(A)

Dimension



	A	ØDi	ØDa	ØTK	z x Ød
AR 450 sileo	185	451	530	500	8 x Ø12

Wiring

Linkslauf
Counter Clockwise rotation
Rotation à gauche

This data sheet also includes sound power levels in octave band (frequency bands).

Supply voltage										230 V
Sound power level		**63**	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	**Total**
Inlet	dB(A)	20	42	53	64	68	68	65	58	73
Outlet	dB(A)	20	42	53	65	68	68	65	60	73

Accessories

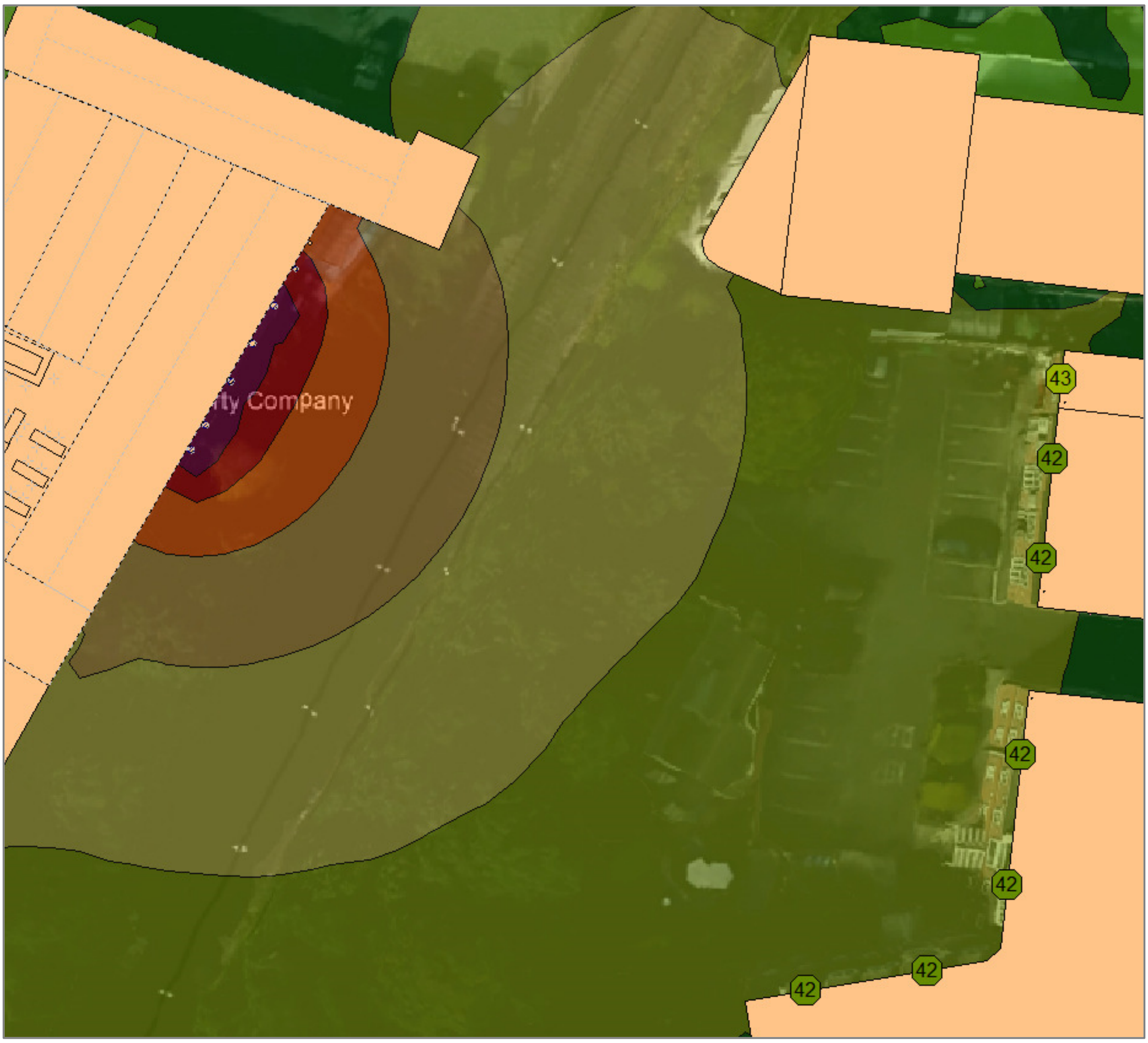
Based on the sound pressure levels at 1 m, the smaller fan is 6 dB lower than the larger fan. It is reasonable, therefore, to assume that the sound power level would be lower by 7 dB as well. Further, in the absence of any octave band data for the smaller fan, we have assumed that it is 7 dB quieter in all octave bands.

It is not clear from the data sheets whether the quoted sound power levels are "in-duct" or based on an open fan. If they were "in-duct" levels, and then an end correction would be applicable which would significantly reduce the lower frequencies. However, in order to present a worst case, we have assumed that the quoted levels are based on open fans.

The 6 fan discharges were entered into the CadnaA model as horizontal discs at the top of cylindrical ducts. We then tested the outcome by placing a receiver at 1 m directly above the discharges, and another at 1 m 90° horizontally from the discharges. It is not clear from the data sheets whether quoted figures apply but, in order to present a worst case, we have assumed that it applies at 90°. This involved adding 9 dB to the figures, which should be extremely robust.

6.3 Results of Modelling

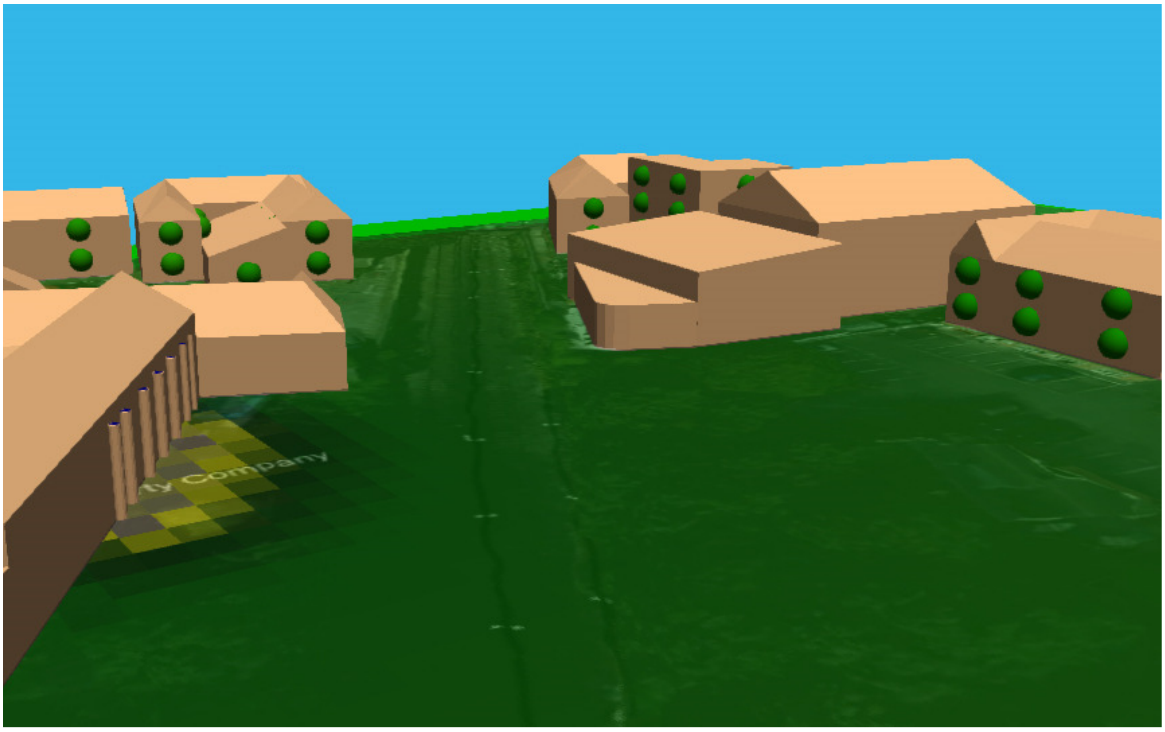
Full details of sources are stated in 6.2 and methods and assumptions described in Section 4.0. The result of the modelling of is shown below.



Note that:-

- The beige shapes are buildings.
- The sources on top of the cylinders are difficult to see in plan view but clearer in the 3 D image below.
- The coloured octagons are the noise levels at the residential facades.
- The contours are for guidance only to illustrate how the noise propagates. They are at a height of 4 m.

The following 3D view should help to visualise the model.



6.4 Mitigation

We can see that the modelling shows levels up to 43 dB L_{Aeq}. This is likely to be a very pessimistic prediction but it was agreed that we would do so as an actual site assessment has been completed.

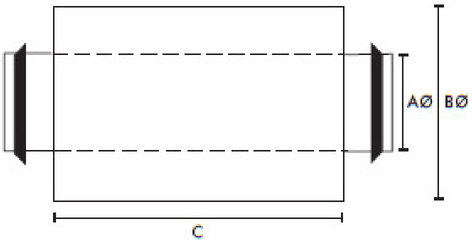
Notwithstanding this, the noise from the fans have received persistent complaints and the predicted levels would suggest at least an adverse impact.

Mitigation in the form of additional silencers fitted to the discharge side of the fans is recommended to reduce the modelled levels to well below 30 dB L_{Aeq}. We have recommended a design target of 25 dB L_{Aeq} which should provide a very significant safety margin to cover all uncertainty. It is an 18 dB reduction on the noisiest façade level shown above. Note that this is likely to be well below background levels and so will be impossible to measure and therefore verify, so it is referred to as a design target.

Silencer suppliers should be asked to provide an 18 dB reduction to the figures presented 6.2 above. There are numerous fan suppliers but, by way of illustration, the Sonex datasheet gives figures which reduce the overall levels by 18 dB with a Sonex 83040120 and by 20 dB with a Sonex 830501120. An extract from the datasheet is as follows.

Sonex Circular Sound Attenuators

Dimensions, Weights & Insertion Loss



	Dimensions (mm)				Attenuation dB mid Frequency Hz							
Stock Ref	AØ	BØ	C	kg.	63	125	250	500	1K	2K	4K	8k
83040120	400	606	1200	27	6	8	14	24	30	28	17	9
83050120	500	711	1200	38	5	7	13	18	26	23	15	9

The following image shows the mode with the Sonex 830101120 applied to the faller fan and the Sonex 830501120 applied to 5 larger fans.

6.5 Overall Assessment

The following is BS 4142 assessment at the noisiest residential position façade for the fans fitted with silencers as specified above.

Specific Sound Level:	23 to 25 dB L_{Aeq}
Feature Corrections[1]	
tonality:	0 dB L_{Aeq}
impulsivity:	0 dB L_{Aeq}
intermittency:	0 dB L_{Aeq}
other:	0 dB L_{Aeq}
Rating Level:	23 to 25 dB L_{Ar}
Background Sound Level:	30 dB L_{A90} (assumed. See 6.1 above)
Rating Level Excess re. Background	-5 to -7 dB

This is well below what BS 4142 rates as "low impact depending on the context".

One aspect of the context is especially crucial here, particularly when we move on to the discussion of uncertainty on 6.6 below, is the very low predicted noise levels. BS 4142 states:-

> Where the initial estimate of the impact needs to be modified due to the context, take all pertinent factors into consideration, including the following.
>
> 1) The absolute level of sound. For a given difference between the rating level and the background sound level, the magnitude of the overall impact might be greater for an acoustic environment where the residual sound level is high than for an acoustic environment where the residual sound level is low.
>
> Where background sound levels and rating levels are low, absolute levels might be as, or more, relevant than the margin by which the rating level exceeds the background. This is especially true at night.
>
> Where residual sound levels are very high, the residual sound might itself result in adverse impacts or significant adverse impacts, and the margin by which the rating level exceeds the background might simply be an indication of the extent to which the specific sound source is likely to make those impacts worse.

The current version of BS 4142 does not define what is "low", but previous versions defined it as a background level below 30 dB L_{A90} and a rating level below 35 dB L_{Aeq}. Here, levels are significantly below these figures and it is unlikely that the units will be audible at all.

[1] The units are extremely unlikely to be tonal, impulsive or intermittent even at source. In any case, with the silencers fitted, the noise is unlikely to be barely audible at the receiver positions and so no character corrections apply.

We also need to acknowledge that the development is a new one and has already attracted complaints. It may therefore be that residents have been sensitised to the impact. However, the predicted levels are so low that this s unlikely to make any difference to the overall assessment. We would suggest that the impact will be negligible.

6.6 Discussion of Uncertainty

BS 4142 requires us to

"Consider the level of uncertainty in the data and associated calculations. Where the level of uncertainty could affect the conclusion, take reasonably practicable steps to reduce the level of uncertainty".

The measurements of Background/Residual for to the front of the development rather than the rear. However, we discuss in 6.1 how our assumptions should more than mitigate for this.

Source data is assumed to be reliable – Systemair is a well-established and reputable company. However, we believe that there is uncertainty in the correct interpretation of the figures and so we have erred on the most pessimistic interpretation at all stages. See discussions in 6.2 above.

Calculations are based on the processes of *ISO 9613 : Acoustics – Attenuation of sound during propagation outdoors*. We know of no concerns within our industry as to the basic reliability of these methods and it is cited in BS 4142 as *"a validated method of calculating sound levels"*. The CadnaA software uses this standard and the input assumptions err on the side of caution and are stated in Section 4.

7.0 CONCLUSIONS/RECOMMENDATIONS

Assuming all fans running at normal speed the modelled levels would appear to support the current complaints. The fans are already fitted with silencers, but these are on the kitchen-side of the fans and have no effect on the external noise. However, with relatively straight forward silencers fitted to the discharge side of the fans, the impact is likely to be negligible, even if fans are inadvertently left running into the early hours of the night.

We recommend that you issue this report to Planners and seek urgent quotes for the fitting of silencers.

Appendix 1

Definition of Acoustic Terms

The Decibel

The decibel is the basic unit of noise measurement and is denoted dB. Technically, it is a means of expressing the difference in noise level between the measured noise and a standard level of noise. Most often the threshold of human hearing is used as the standard reference but is really should be stated. The threshold of human hearing is a sound pressure of 20μPa or a sound power of 1pW.

A sound pressure level or SPL should be expressed in dB(re. 20μPa). A sound power level or SWL should be expressed in dB(re. 1pW). If the reference levels are omitted, it will often (but not always) be safe to assume that they are referenced to the threshold of human hearing.

A-Weighting and dB(A)

The human hearing system responds differently to different frequencies. The A-weighting system takes account of this by emphasising mid and high frequencies more than low frequencies to give an overall level. An A-Weighted noise level, therefore, reflects the way normal, healthy hearing would perceive the overall level of the noise. The basic unit is dB(A), although other systems of expressing an A-weighted levels are discussed below.

Other weighting systems, such as C-Weighting, denoted dB(C), reflect the human hearing system’s response at higher noise levels.

NR and NC Levels

NR curves and NC curves are a series of curves representing noise levels across the frequency range. A given noise climate has an NR level or NC level if it equals a point on the curve at any frequency. They are particularly, although by no means exclusively, used as a means of specifying noise limits in an indoor environment, for instance from mechanical services or traffic noise break-in from the outside. They are typically expressed as NR or NC followed by a number, e.g. NR40, NC55, etc.

Equivalent Continuous Sound Level, L_{eq}

This can be simplistically described as a way of expressing the average noise level.

The unit is dB L_{eq}. For A-weighted levels the unit is dB(A) L_{eq} or, in more modern units, dB L_{Aeq}.

Maximum Level, L_{max}

This is the maximum level reached (usually for a fraction of a second) in the measurement period.

The unit is dB L_{max}. For A-weighted levels the unit is dB(A) L_{max} or, in more modern units, dB L_{Amax}.

Statistical (Percentile) Levels, L_n

During a measurement of fluctuating noise, it is often useful to establish the levels exceed for a percentage of the time. L_n is the index representing the level exceeded for n% of the measurement period.

The unit is dB L_n. For A-weighted levels, the unit is dB(A) L_n or, in more modern units, dB L_{An}.

Common examples are as follows :-

dB L_{A90} is the A-weighted level exceeded for 90% of the time and is often used to describe the underlying background noise.

dB L_{A50} is the A-weighted level exceed for 50% of the time. Mathematically, it is the median, another kind of average.

dB L_{A10} is the A-weighted level exceeded for 10% of the time and has traditionally been used to describe the intermittent highs in the noise climate such as passing cars or aircraft.

Frequency Analysis

Here the audible frequency range is divided up into bands and the noise level is expressed in each frequency band from low pitches to high pitches.

Octave Band analysis is where the frequency range is divided into 8 bands from 63 Hz to 8kHz, or sometimes into 10 bands from 31.5 Hz to 16kHz.

1/3 Octave Band analysis provides more detailed subdivision into 24 bands from 50 Hz to 10kHz, or sometimes into 30 bands from 20Hz to 20kHz.

Narrow Band analysis takes this further with the possibility of many thousands of bands, possibly only 1Hz wide, or even less.

In all types of frequency analysis, the level in each band can be expressed in terms of L_{eq}, L_{max}, L_n, etc. as defined above.

Sound Insulation

Sound insulation is best expressed across the frequency range in octave bands or third octave bands. Often, however, in known environments such as domestic sound insulation and speech privacy, it is simpler to express the sound insulation as a single figure. A higher value means better sound insulation.

The most common ways are dB D_{nTw}, dB R_w and $dB_{(mean\ 100\text{-}3150Hz)}$. The first two are ways of expressing average sound insulation, weighted to account for speech frequencies. The third is simply an un-weighted mean value.

The Building Regulations Approved Document E (ADE) routinely refer to D_{nTw} $+C_{tr}$ The C_{Tr} term is a negative number which is used to modify the D_{nTw} value for the insulation properties at lower frequencies.

ADE also uses the L_{nTw} index for impact sound transmission. It is a measure of the level of noise in the room below a room in which a standard tapping machine is being used. It represents the impact sound transfer such as footfall noise, scraping chairs, washing machines, etc. A lower value means better insulation.

Reverberation Time

The most common measure of Reverberation Time is, effectively the time taken for sound from a steady source to decay by 60 dB after it has been abruptly cut off. In practice it is often difficult to measure a 60 dB decay and so decays of 30 dB, 20 dB, or even 10 dB are often used and adjusted pro rata, although the exact measure is not quite the same.

Reverberation Time is generally expressed as RT in seconds. We may, if we are being precise, add subscripts 60, 30, etc to show whether the basis of the measure is 60 dB decay, 30 dB decay, etc. E.g. the RT_{60} = 0.52s, the RT_{30} = 0.49s, etc.

RT can be expressed in octave bands or 1/3 octave bands across the frequency range, or at central frequencies such as 500 Hz or 1kHz.