



Project: J 04187
Mechanical Noise Impact Assessment:
GDK 136 High Street, Ruislip

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A handwritten signature in blue ink, appearing to read 'D. M. Thomas'.

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Dated: Thursday 24th September, 2020



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1.0 BACKGROUND

- 1.1 The planning application at 136 High Street, Ruislip is for a restaurant including the introduction of new mechanical plant i.e. supply/extract fans, heat pumps (AC) and refrigeration condenser units (external).
- 1.2 The restaurant's proposed operational times are 11:00 – 23:00 hours.
- 1.3 Localised Environment

136 High Street, Ruislip is located in a mixed commercial and residential environment; the rear of 136 High Street has existing mechanical and AC plant from neighbouring commercial premises and McDonalds located at 144 High Street.

The flat at 136a High Street is directly above the front of 136 High Street (proposed restaurant seating area).

The nearest noise sensitive receivers to the proposed mechanical plant are shown in APPENDIX 3 & 4.

- 1.4 Proposed Mechanical Plant:

Equipment/System	Serving
Supply Air System	Kitchen/Store/Office/Toilets
Extract Air System	Kitchen
Heat Pumps/Condensers	(AC)
External Condensers	Cold Rooms

- 1.5 Sound Planning has been retained to evaluate potential noise impact on the nearest noise sensitive receivers using appropriate methodologies and assessment criteria.

1.5.1 Participating Acoustic Consultant

Dan Thomas is a Member of the Institute of Acoustics (M.I.O.A) having attained appropriate qualifications in acoustics and experience within the workplace.



1.5.2 Qualifications

Dan has been working within the noise and vibration industry for fourteen years and has attained the following qualifications within the field of acoustics:

- Institute of Acoustics (IOA) Diploma
- Post Graduate Diploma in Applied Acoustics and Noise Control (University of Surrey)
- Masters Degree in Applied Acoustics and Noise Control (University of Surrey)

2.0 ASSESSMENT CRITERIA

2.1 Noise emissions from mechanical plant should be assessed in accordance with the requirements of British Standard 4142: 2014^{1,2}; with any internal noise transmission evaluated against the requirements of British Standard 8233: 2014.³

2.2 BS 4142: 2014 – Scope

- 2.2.1 This British Standard 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; and
 - 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.

¹ British Standard 4142: 2014 – Methods for rating and assessing industrial and commercial sound.

² BS 4142: 1997 superseded by BS 4142: 2014.

³ BS 8233: 2014 is the *Guidance on sound insulation and noise reduction for buildings – Code of practice*.



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.

2.2.2 This standard is applicable to the determination of the following levels at outdoor locations:

a) rating levels for sources of sound of an industrial and/or commercial nature and

b) ambient, background and residual sound levels, for the purposes of:

- investigating complaints;
- assessing sound from proposed, new, modified or additional source(s) of sound of an industrial and/or commercial nature; and
- assessing sound at proposed new dwellings or premises used for residential purposes.

2.3 BS 4142: 2014 – Assessment of Impacts

2.3.1 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.

2.3.2 Evaluation of Adverse Impact

- Typically, the greater this difference, the greater the magnitude of the impact.
- 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.
- 2.3.3 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.
- 2.3.4 Objective method for assessing the audibility of tones in sound: One-third octave method

The test for the presence of a prominent, discrete-frequency spectral component (tone) typically compares the $L_{Zeq,T}$ sound pressure level averaged over the time when the tone is present in a one-third-octave band with the time-average linear sound pressure levels in the adjacent one-third-octave bands.

For a prominent, discrete tone to be identified as present, the time-averaged sound pressure level in the one-third-octave band of interest is required to exceed the time-averaged sound pressure levels of both adjacent one-third-octave bands by some constant level difference. The level differences between adjacent one-third-octave bands that identify a tone are:

- 15 dB in the low-frequency one-third-octave bands (25 Hz to 125 Hz);
- 8 dB in the middle-frequency one-third-octave bands (160 Hz to 400 Hz);
- 5 dB in the high-frequency one-third-octave bands (500 Hz to 10 000 Hz).

2.3.5 Rating Level

Subjective Method:

Tonality

For sound ranging from not tonal to prominently tonal the Joint Nordic Method gives a correction of between 0 dB and +6 dB for tonality. Subjectively, this can be converted to a penalty of 2 dB for a tone which is just perceptible at the noise receptor, 4 dB where it is clearly perceptible, and 6 dB where it is highly perceptible.



Impulsivity

A correction of up to +9 dB can be applied for sound that is highly impulsive, considering both the rapidity of the change in sound level and the overall change in sound level. Subjectively, this can be converted to a penalty of 3 dB for impulsivity which is just perceptible at the noise receptor, 6 dB where it is clearly perceptible, and 9 dB where it is highly perceptible.

One-third octave method:

Identify tones using the method given in Annex C, then add a correction of 6 dB if a tone is present.

Reference methods

When the one-third octave method is not sufficient, use the reference method for assessing the audibility of tones given in Annex D, which produces a penalty on a sliding scale from 0 dB to 6 dB.

Use the reference method given in Annex E for measuring the prominence of impulsive sounds, which produces penalties in the range 0.0 dB to 9.0 dB.

Other Sound Characteristics

Where the specific sound features characteristics that are neither tonal nor impulsive, though otherwise are readily distinctive against the residual acoustic environment, a penalty of 3 dB can be applied.

Intermittency

When the specific sound has identifiable on/off conditions a penalty of 3 dB can be applied.

2.4 Guidance on the Control of Odour and Noise from Commercial Kitchen Exhaust Systems (DEFRA January 2005).

2.4.1 Minimum Requirements for Noise Control

For new premises or premises covered by planning conditions restricting the impact of noise the system shall be designed to prevent an acoustic impact on the external environment and therefore harm to the amenity.



For existing premises not covered by planning conditions restricting the impact of noise, the system shall be designed to avoid statutory nuisance and shall comply with the principles of Best Practicable Means.

To achieve these objectives the noise control system shall include:

- Control of noise at source to the greatest extent possible, and
- Control of noise to the environment by taking acoustic considerations into account within duct, grille and termination design.

The control system should meet the requirements laid down in BS 4142: 1997 *“Method for rating industrial noise affecting mixed residential and industrial areas”*.

2.4.2 Types of noise in industrial kitchens

Factors that influence magnitude of noise in a commercial kitchen are:

Size and format of the exhaust: The bulk flow leaving the exhaust diffuser generates broadband aero-acoustic noise. The sound level increases with increase in air speed and decreases with increase in area. The presence of grilles will generate tonal components. The sound levels are inversely proportional to the increase in area and increase with the eighth power of the flow speed.

- Heat release from kitchen: this influences the size of the exhaust system required and the flow rate of air to be handled by the system. Increase in flow rates can increase the pressure perturbations that can generate noise or can excite other parts of the system leading to noise.
- Type of cooking appliances used: this dictates the overall noise level as each individual appliance might contribute significantly to the total noise.
- Position of exhaust fan in the system: this may influence the noise radiated by the fan to the interior or exterior of the building and the transmission of sound energy into the exhaust duct system.



- Fitting and dimensions of the exhaust flow ducts: exhaust duct dimensions, fixings and insulation can all influence the amount of noise these structures will transmit and propagate. Selection of appropriate noise attenuating materials, avoidance of flow restrictions, and vibration isolators between the ducts and the fan are some of the aspects to be considered.
- Fan type and speed: Type of fan used (e.g. centrifugal fan with blades that are backward curved, forward curved or radial, or axial fan) will influence the level and nature of noise emitted. The fan characteristic needs to be chosen so that it is operating at its most efficient duty point as this tends to be the region of minimum noise.

If fan speed is too high it will be operating away from that point which can lead to increases in level of up to 10 dB, as well as inefficient air management. It is often also desirable acoustically to use larger fans operating at low speeds rather than smaller fans operating at higher speeds

2.4.3 Extract System Design

The following points should be taken into account when designing a ventilation system to minimise noise emissions:

- The fan and its installation should be designed as a complete package for a specific task. Fans generally produce less noise if operated at the optimum efficiency relative to their characteristics;
- Fans should be located within buildings at low level, that is, on side walls, rather than in the roofs of buildings, as ground effect and the local topography will far more readily reduce the noise transmission;
- Correct selection of duct size and type;
- Lined or lagged ducts, including bends, elbows or spigots, may be required if additional noise reduction is necessary; and
- The recommended maximum supply and return velocities for grilles and terminals should be applied.

- Silencers may be required where additional attenuation is necessary. A range of silencers is available and it may be necessary to insert in-duct silencers both upstream and downstream to prevent radiation of fan noise through ductwork. These should be fitted as close to the fan as possible (but not so close as to lead to a non-uniform air flow velocity across the face of the silencer). Where this is not possible, the intervening ductwork should be acoustically lagged. It may also be necessary to enclose or lag the fan. Where fans are used to push gases up a stack, silencers containing absorbent material can sometimes be mounted directly on top of the stack. However, where gases are hot, wet or dirty, the infill may need to be protected.
- Acoustic louvres on exhausts and inlets can greatly reduce environmental noise. However, their performance can sometimes increase back-pressure or the velocity of the air flow leading to increased noise.

2.5 British Standard 8233: 2014⁴

2.5.1 BS 8233: 2014 is the *Guidance on sound insulation and noise reduction for buildings – Code of practice*.

2.5.2 Indoor Ambient Noise Levels for Dwellings

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, 16hour}	30 dB L _{Aeq, 16hour}

2.5.3 WHO Guidelines suggest a 45 dB L_{AFmax} criterion for preventing sleep disturbance in bedrooms at night time.

⁴ Supersedes BS 8233: 1999.



3.0 METHODOLOGY

3.1 Background Noise Assessment

- 3.1.1 Background noise measurements were undertaken towards the rear of the 1st floor flat roof; as close as possible to the worst affected noise sensitive receivers (residential apartments) nearest to the proposed mechanical plant area.

See APPENDIX 2 – Site Location (including background monitoring positions)

- 3.1.2 Background noise levels were measured during a 24 hour period from 15:15 hours Thursday 3rd September – 12:00 hours Friday 4th September, 2020.
- 3.1.3 The measurement periods incorporated a time period which is thought to have the quietest existing background noise levels within the proposed operational times of the proposed mechanical plant.
- 3.1.4 Measurements were undertaken in accordance with BS 7445⁵ and BS 4142⁶. The sound level meter was Type 1 – details provided in 3.1.8.
- 3.1.5 The microphone was fixed at 1.5m above the flat roof close to where the proposed mechanical equipment is to be located; this should be deemed representative of the worst affected noise sensitive receivers (proposed mechanical plant). There is currently no mechanical plant located on this roof.
- 3.1.6 The A-weighted L₉₀ parameter was measured using the Fast (F) setting, and logged periodically every 15 minutes.
- 3.1.7 Meteoric conditions were dry with calm winds, and generally acceptable in accordance with BS 7445.

See paragraph 4.3 – Meteorological Conditions

⁵ British Standard 7445-1: 2003 – *Description and measurement of environmental noise*. © BSI 1997. ISBN 0 580 19736 0.

⁶ British Standard 4142 – *Method for rating industrial noise affecting mixed residential and industrial areas*. © BSI 1997. ISBN 0 580 28300 3.



3.1.8 Equipment:

Equipment	Make	Model	Type	Serial Number	UKAS Calibration
SLM	Casella	CEL 490	1	128950	U31976 (4/6/19)
Field Calibrator	Casella	CEL 110/1	1	077948	U34831 (27/5/20)
Environmental Tripod					
Wind/Weather Shield					
Laser Measurer	Leica	Disto A5		1073750838	
Digital Camera	Samsung				

The Sound Level Meters (SLM) are Type 1 and have real time one third octave capability; compliant to IEC 61672⁷.

The sound level meter was field calibrated before and after measurements with no noticeably deviation. The sound level meter and field calibrator are UKAS calibrated (certificates available on request).

3.2 Equipment Noise Level Calculations (General)

- 3.2.1 All calculations will utilise the manufacturers' sound power level (SWL) or sound pressure level (SPL) data.
- 3.2.2 Noise calculations will subtract system losses, distance corrections and propagation corrections to the nearest noise sensitive receivers (NSR) based on spherical divergence:

$$SPL_2 = SPL_1 - 20\log_r - 11 + DI^8 +/ - MISC$$

Where 'r' = radius; SPL = Sound Pressure Level.

⁷ International Standard IEC 61672-1: 2002. Electroacoustics – Sound level meters – Part 1: Specifications.

⁸ DI = Directivity Index.



- 3.2.3 The resultant sound pressure level (SPL) will be compared to the measured background noise level in accordance with the requirements of BS 4142.

3.3 Extraction Noise Level Calculations

- 3.3.1 All calculations will utilise the manufacturers' sound power level (SWL) data or calculated SWL based on the fan type, pressure and air volume⁹.

- 3.3.2 The fan sound power level (SWL) will be attenuated by internal system (duct) losses and end reflection on reaching the exhaust termination¹⁰.

- 3.3.3 Duct Break-Out¹¹ calculations will utilise the formula:

$$\text{SWL}_{\text{break-out}} = \text{SWL}_{\text{duct}} - R + 10\log(S/A)^{12}$$

Where	SWL	Sound Power Level
S		Surface Area (Visible Duct)
A		Cross Section
R		Sound Reduction Index

The term 'R' cannot give a greater break-out level than there is inside the duct. Therefore at low frequency the effective reduction is taken as 3dB.

- 3.3.4 The noise level at the nearest external noise sensitive receivers (NSR's) will be calculated using the formula:

$$\text{SPL}_2 = \text{SPL}_1 - 20\log_r - 11 + \text{DI}^{13} \text{ [point source]} \text{ and } \text{SPL}_2 = \text{SPL}_1 - 10\log_r - 11 + \text{DI} \text{ [line source].}$$

Where 'r' = radius; SPL = Sound Pressure Level.

⁹ Sound Research Laboratories: *Noise Control in Building Services*. Pergamon Press 1988.

¹⁰ Sound Research Laboratories: *Noise Control in Building Services*. Pergamon Press 1988.

¹¹ See APPENDIX 7 – Plant Noise Calculations.

¹² Sound Research Laboratories: *Noise Control in Building Services*. Pergamon Press 1988.

¹³ DI = Directivity Index.



3.3.5 The directionality of the duct opening¹⁴ relative to the receiver should also be considered; the approximate directivity attenuation can be found by comparing fd/c with the angle to the receiver¹⁵.

3.3.6 Screening attenuation is based on Maekawa's formula (if required), where the expected insertion loss the barrier is the function of the Fresnel number ($2.8/\lambda$)¹⁶.

'Line of sight' screening achieves a 5 dB reduction through frequencies.

3.3.7 The resultant (combined) sound pressure level (SPL) will be compared to the measured background noise level in accordance with BS 4142.

3.3.8 Noise mitigation calculations will utilise sound reduction indices or insertion loss data from the manufacturer's specification data sheets.

3.4 Noise Level Evaluation

3.4.1 Extract Duct - Acoustic Features

Kitchen extract fans (attenuated) sound emissions contain minimal *tonality* (+2 dB penalty) and should not display '*impulsive*' sound characteristics; however they do emit 'other sound characteristics (+3 dB penalty) in operation.

Total sound characteristic penalties are 5 dB.

3.4.2 Target Noise Level

Due to the total sound penalties of 5 dB (for both noise sources), it would seem reasonable to target 10 dB below the lowest background level as required in BS 4142: 1997 (this equates to a Rating level of 5dB below background in the context of BS 4142: 2014).

This target level equates to an evaluation of '*complaints unlikely*' [BS 4142: 1997] and the sound source having '*low impact*' [BS 4142: 2014].

¹⁴ The configuration of the duct termination is currently unknown e.g. cowl etc.

¹⁵ f = frequency; d = duct opening (m); and c = speed of sound 344m/s. Reference: Watson et al. *The Little Red Book of Acoustics*. BTA 2007.

¹⁶ Attenborough, K. et al. *Predicting Outdoor Sound*. Copyright Taylor & Francis Group 2007.



3.5 Sound Insulation Testing – Separating Floor 136 High Street – 136a High Street

3.5.1 Observations

Following an evaluation of proposal plans and floor above (on site dimensions/distance measurements) it can be seen that the main kitchen plant (internal) is located towards the rear of 136 High Street and will be directly below the flat roof terrace area (approximately 5 metres away from the footprint of flat 136a High Street).

Flat 136a High Street will potentially be exposed to general restaurant noise from the seating area which would be directly below the flat.

3.5.2 Floor Construction:

The existing floor construction is unknown however there are acoustic tiles to the ceiling below with ceiling void to the sub floor above.

3.5.3 Test Procedure

The separating floor was tested for airborne sound insulation generally in accordance with the methodology detailed within ISO 140-4: 1998. All procedures described in Annex B of the Building Regulations 2000 (Part E) have been adhered to.

The room to room insulation measurements have been carried out in one third octaves from 100 Hz – 3150 Hz and single number values for $D_{nT_w} + C_{tr}$ have been calculated using methodology detailed in ISO 717-1: 1997.

All airborne source and receiver room measurements were taken using 5 manual moving microphone techniques with a sample time of at least 30 seconds.

The pink noise generator (loud speaker) was positioned centrally within the proposed restaurant area directly below 136a High Street.

Sound levels within 136a High Street were measured within 3 rooms: kitchen, living room and bedroom.



3.5.4 Equipment

Equipment	Make	Model	Type	Serial Number	UKAS Calibration
SLM	Casella	CEL 490	1	128950	U31976 (4/6/19)
Field Calibrator	Casella	CEL 110/1	1	077948	U34831 (27/5/20)
Loud Speaker	Norsonic	Nor 276			
Power Amplifier	Norsonic	Nor 280			
Wind/Weather Shield					
Laser Measurer	Leica	Disto A5		1073750838	
Digital Camera	Samsung				

3.6 Empirical Restaurant Noise Level Assessment

- 3.6.1 Restaurant noise measurements were carried out at an existing Côte restaurant in Farnham, Surrey.
- 3.6.2 The noise assessment was conducted on a Friday evening between 21:10 – 21:40 hours (2nd November 2012) in order to assess the restaurant within a busy period (worst case).
- 3.6.3 Noise levels were measured in one third octave bands for comparison to separating floor sound insulation performance.
- 3.6.4 Other empirical data sets

Please see paragraph 4.3



4.0 RESULTS

4.1 Sound Planning Background Noise Level¹⁷:

4.1.1 Time Period Results

Time Period (hours)	Background Level (dB L _{A90})	Time Occurred (Time Period)
Up to 23:00	47	Consistent
Up to 00:00	47	Consistent
24 hours	42	00:15 – 05:00 hours

- 4.1.2 The quietest background level during the proposed operational period of the supply/extract system/AC is 47 dB L_{A90}; the refrigeration condensers can operate any time in 24 hour period with a quietest background level of 42 dB L_{A90}.
- 4.1.3 The background levels for the proposed operational hours (11:00 – 23:00 hours) are 47 dB L_{A90}; the background level remains at 47 dB L_{A90} until after 00:00 hours.

See APPENDIX 6 – Background Noise Levels

4.2 Separating Floor Test

Test	Source Room	Receiver Room	D _{nTw} + C _{tr}
1	Proposed Restaurant Area	Kitchen	57 dB
2	Proposed Restaurant Area	Living Room	52 dB
3	Proposed Restaurant Area	Bedroom	55 dB

¹⁷ See APPENDIX 6 for full results.



4.3 Noise Sensitive Receivers

External Mechanical Plant	Nearest NSR Distance (m)
Extract System - Outlet Duct (external)	5
Extract System - Termination Cowl	5
Supply System - Atmosphere Intake	6
Freezer Condenser	5
Chiller Condenser	5
Heat Pump (AC1)	5
Heat Pump (AC2)	5

See APPENDIX 2 – Site Location and APPENDIX 3 – Site Plans/Elevations

4.4 Restaurant Noise

Empirical Data - Internal Restaurant Noise Levels¹⁸

Data Source	Restaurant Noise Level	
	dB L _{Aeq}	dB L _{Amax}
Côte Farnham	72.5	95
Lebo et al.	80	87
Chicken Coop	72	89

¹⁸ Reference sources: APPENDIX 9.

4.5 Meteorological Conditions

Weather Conditions	Period		
	Day 1	Night 1	Day 2
Wind Speed/Direction¹⁹	1 m/s NNE	1 m/s SE	1 m/s NE
Likelihood of Temperature Inversion²⁰	No	No	No
Precipitation	No	No	No
Fog	No	No	No
Wet Ground	No	No	No
Frozen Ground/Snow Coverage	No	No	No
Av. Temperature	22°C	12°C	19°C
Cloud Cover	Clear	Clear	Clear

¹⁹ Propagation assistance – No.

²⁰ i.e. Calm night with little cloud cover.

4.6 Levels of Uncertainty

Category	Notes
Complexity of Sound Source	Extract Duct Break-Out. Supply/Extract Air to Atmosphere Heat Pumps (fan/compressor) Condensers (fan/compressor)
Complexity of Acoustic Environment (Residual)	Site positioned to the rear of busy high street with commercial buildings including restaurants.
Level of Residual Sound (including Specific)	n/a
Measurement Locations	Representative
Distance Between Sound Source & Measurement Position	n/a
Number of Measurements Taken	24 hours
Measurement Time Intervals	n/a
Range of Times	Includes quietest likely times of proposed operation
Range of Suitable Weather Conditions	1 measurement period – Suitable weather conditions
Measurement Method/Practitioners	1 measurement period (Dan Thomas)
Level of Rounding	Rounded to nearest DP; 0.5 rounded up
Instrumentation	Type 1 SLM (suitable)

5.0 NOISE LEVEL CALCULATIONS

5.1 Combined Sound Pressure Level at Nearest Noise Sensitive Façade (before attenuation)

5.1.1 NSR Window²¹ (rear of 136 High Street) – Restaurant Opening Hours

System Area	Level @ NSR
(Opening Times)	dB(A)
Extract System - Outlet Duct	52
Extract System - Termination Cowl	59
Supply System - Atmosphere Intake	57
Freezer Condenser	51
Chiller Condenser	50
Heat Pump (AC1)	44
Heat Pump (AC2)	44
Combined	63
Background	47
Excess	16

5.1.2 NSR Window (rear of 136 High Street) – 24 Hours (refrigeration condensers)

System Area	Level @ NSR
(24 hours)	dB(A)
Freezer Condenser	51
Chiller Condenser	50
Combined	54
Background	42
Excess	12

²¹ See APPENDIX 2 – Site Location, APPENDIX 3 – Site Plans and APPENDIX 4 – Site Photographs for NSR position.

5.2 Internal Sound Levels – Restaurant Noise Transmission

5.2.1 Empirical Data – Average Noise Levels in Flat 136a High Street

Data Source	Restaurant Noise Level	Floor Sound Reduction²²	Flat 136a Internal Level
	dB L_{Aeq}	dB D_{nTw} + C_{tr}	dB L_{Aeq}
Côte Farnham	72.5	52	21
Lebo et al.	80	52	28
Chicken Coop	72	50	22

5.2.2 Empirical Data – Maximum Noise Levels in Flat 136a High Street

Data Source	Restaurant Noise Level	Floor Sound Reduction	Flat 136a Internal Level
	dB L_{Amax}	dB D_{nTw} + C_{tr}	dB L_{Amax}
Côte Farnham	95	52	43
Lebo et al.	87	52	35
Chicken Coop	89	50	39

5.2.3 British Standard 8233: 2014 - Indoor Ambient Noise Levels for Dwellings

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, 16hour}	30 dB L _{Aeq, 16hour}

5.2.4 WHO Guidelines suggest a 45 dB L_{AFmax} criterion for preventing sleep disturbance in bedrooms at night time.

²² Worst case paragraph 4.2.



6.0 NOISE MITIGATION

6.1 NSR Window (rear of 136 High Street, Ruislip) – Restaurant Opening Hours

System Area	Attenuation	Level @ NSR
(Opening Times)		dB(A)
Extract System - Outlet Duct	Silencer 100mm Air Way x 1200mm (L)	31
Extract System - Termination Cowl	Silencer 100mm Air Way x 1200mm (L)	29
Supply System - Atmosphere Intake	Silencer 100mm Air Way x 1200mm (L)	28
Freezer Condenser	Environ Enclosure	25
Chiller Condenser	Environ Enclosure	24
Heat Pump (AC1)	Acoustic Louvre Enclosure	28
Heat Pump (AC2)	Acoustic Louvre Enclosure	28
Combined		37
Background		47
Excess		-10

See APPENDIX 7 - Plant Noise Calculations for further calculation detail

6.2 NSR Window (rear of 136 High Street, Ruislip) – 24 Hours (refrigeration condensers)

System Area		Level @ NSR
(24 hours)		dB(A)
Freezer Condenser	Environ Enclosure	25
Chiller Condenser	Environ Enclosure	24
Combined		28
Background		42
Excess		-14

See APPENDIX 7 - Plant Noise Calculations for further calculation detail



6.3 Noise Mitigation Notes

- 6.3.1 Flakt Woods Splitter Attenuators should be fitted as close as possible to the fan (inlet and outlet side) as specified.
- 6.3.2 The cross-sectional area of the attenuator may have to be larger than the duct in order to restrict pressure drop to permissible levels²³; if this is the case duct transitions may be required before and after the attenuator.
- 6.3.3 The acoustic enclosures should be separated to allow for air flow in and out of enclosures (please seek advice from enclosure suppliers).

6.4 Separating Floor

- 6.4.1 Predicted Average Noise Levels in Flat 136a High Street - Daytime

Data Source	Flat 136a Internal Level	BS 8233: 2014 Target Level 07:00 – 23:00 hrs	Meets Target
	dB L _{Aeq}	dB L _{Aeq}	Yes/No
Côte Farnham	21	≤ 35	Yes
Lebo et al.	28	≤ 35	Yes
Chicken Coop	22	≤ 35	Yes

- 6.4.2 Predicted Average Noise Levels in Flat 136a High Street – Night Time

Data Source	Flat 136a Internal Level	BS 8233: 2014 Target Level 23:00 – 07:00 hrs	Meets Target
	dB L _{Aeq}	dB L _{Aeq}	Yes/No
Côte Farnham	21	≤ 30	Yes
Lebo et al.	28	≤ 30	Yes
Chicken Coop	22	≤ 30	Yes

²³ The contractor should verify pressure drop with Flakt Woods.



6.4.3 Predicted Maximum Noise Levels in Flat 136a High Street – Night Time

Data Source	Flat 136a Internal Level	BS 8233: 2014 Target Level 23:00 – 07:00 hrs	Meets Target (worst case)
	dB L _{Amax}	dB L _{Amax}	Yes/No
Côte Farnham	43	≤ 45	Yes
Lebo et al.	35	≤ 45	Yes
Chicken Coop	39	≤ 45	Yes

6.4.4 Noise Mitigation Requirements

The existing separating floor system meets BS 8233: 2014 / WHO 2000 internal requirements within Flat 136a High Street – No further noise mitigation measures are required.

6.5 Suppliers

7.0 CONCLUSIONS

7.1 Sound Planning has carried out a noise impact assessment in accordance with BS 7445 and BS 4142, and a separating floor assessment in accordance with ISO 140-4: 1998 and ISO 717-1: 1997.

See section 3.0 - METHODOLOGY

7.2 The lowest background noise levels measured to the rear of 136 High Street, Ruislip during the assessment period were:

Time Period (hours)	Background Level (dB L _{A90})
Up to 23:00	47
Up to 00:00	47
24 hours	42

See section 4.0 - RESULTS



7.3 Predicted Sound Levels at Nearest Noise Sensitive Receivers

The predicted combined plant noise at the nearest noise sensitive receiver (nearest apartments to the rear of 136 High Street, Ruislip) exceeds background noise levels by 16 dB(A) during the operational hours of the restaurant (11:00 – 23:00 hours) and 12 dB(A) during the night time when refrigeration plant (Chiller & Freezer) will need to be operational.

See paragraph 5.1

7.4 The introduction of noise mitigation measures (noise control products) results in a combined external mechanical plant noise level at the worst affected noise sensitive window which meets target levels during restaurant opening hours and overnight (refrigeration plant) i.e. 10 dB below background.

The proposed noise mitigation measures result in a *low impact* at the worst affected noise sensitive receiver and meet the requirements of BS 4142: 2014.

See paragraph 6.1 – 6.3

7.5 Noise Mitigation Products (mechanical equipment)

7.5.1 Supply Air Fan

Inlet (atmosphere): 100mm Air x 1200mm (L) Flakt Woods Splitter Silencer

7.5.2 Extract Fan

Outlet (atmosphere): 100mm Air x 1200mm (L) Flakt Woods Splitter Silencer

7.6 Levels of Uncertainty

7.6.1 Mechanical Plant Noise

The complexity and screening of the sound sources would lead to the greatest uncertainty. Sound Planning has evaluated each source in detail, its position relative to the nearest noise sensitive receivers and used appropriate calculation methodology in order to accurately predict specific noise (and noise rating level) at the nearest noise sensitive receiver.



Sound Planning has designed to 10 dB below background, this should allow for any penalties which could be applied for '*Tonality*', '*Impulsivity*', '*Intermittency*' and '*Other Sound Characteristics*'.

See section 2.0

7.6.2 Internal Noise Levels – Flat 136a High Street, Ruislip

The existing separating floor system meets BS 8233: 2014 / WHO 2000 internal requirements within Flat 136a High Street – No further noise mitigation measures are required.



APPENDIX 1

Terms & Definitions

The Decibel, dB

The unit used to describe the magnitude of sound is the decibel (dB) and the quantity measured is the sound pressure level. The decibel scale is logarithmic and it ascribes equal values to proportional changes in sound pressure, which is a characteristic of the ear. Use of a logarithmic scale has the added advantage that it compresses the very wide range of sound pressures to which the ear may typically be exposed to a more manageable range of numbers. The threshold of hearing occurs at approximately 0 dB (which corresponds to a reference sound pressure of 2×10^{-5} pascals) and the threshold of pain is around 120 dB. The sound energy radiated by a source can also be expressed in decibels. The sound power is a measure of the total sound energy radiated by a source per second, in watts. The sound power level, L_w is expressed in decibels, referenced to 10^{-12} watts.

Frequency, Hz

Frequency is analogous to musical pitch. It depends upon the rate of vibration of the air molecules that transmit the sound and is measured as the number of cycles per second or Hertz (Hz). The human ear is sensitive to sound in the range 20 Hz to 20,000 Hz (20 kHz). For acoustic engineering purposes, the frequency range is normally divided up into discrete bands. The most commonly used bands are octave bands, in which the upper limiting frequency for any band is twice the lower limiting frequency, and one-third octave bands, in which each octave band is divided into three. The bands are described by their centre frequency value and the ranges which are typically used for building acoustics purposes are 63 Hz to 4 kHz (octave bands) and 100 Hz to 3150 Hz (one-third octave bands).

A-weighting

The sensitivity of the ear is frequency dependent. Sound level meters are fitted with a weighting network which approximates to this response and allows sound levels to be expressed as an overall single figure value, in dB(A).



BS 4142 - Noise Descriptors

For the purposes of this British Standard, the following terms and definitions apply.

NOTE All the measurements and values used throughout this standard are “A”-weighted. Where “A” weighting is not explicit in the descriptor, it is to be assumed in all cases, except where it is clearly stated that it is not applicable, as in the case of tones.

Acoustic Environment

Sound from all sound sources as modified by the environment [BS ISO 12913-1:2013].

Ambient Sound

Totally encompassing sound in a given situation at a given time, usually composed of sound from many sources near and far .

NOTE The ambient sound comprises the residual sound and the specific sound when present.

Ambient Sound Level, $L_a = L_{Aeq,T}$

Equivalent continuous A-weighted sound pressure level of the totally encompassing sound in a given situation at a given time, usually from many sources near and far, at the assessment location over a given time interval, T .

NOTE The ambient sound level is a measure of the residual sound and the specific sound when present.

Background Sound Level, $L_{A90,T}$

A-weighted sound pressure level that is exceeded by the residual sound at the assessment location for 90% of a given time interval, T , measured using time weighting F and quoted to the nearest whole number of decibels.

Equivalent Continuous A-weighted Sound Pressure Level, $L_{Aeq,T}$

Value of the A-weighted sound pressure level in decibels of continuous steady sound that, within a specified time interval, $T = t2 - t1$, has the same mean-squared sound pressure as a sound that varies with time, and is given by the following equation:



$$L_{Aeq,T} = 10 \lg_{10} \left\{ (1/T) \int_{t_1}^{t_2} [p_A(t)^2/p_0^2] dt \right\}$$

where:

- p_0 is the reference sound pressure (20 μPa); and
 $p_A(t)$ is the instantaneous A-weighted sound pressure (Pa) at time t .

NOTE The equivalent continuous A-weighted sound pressure level is quoted to the nearest whole number of decibels.

Measurement Time Interval, T_m

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, $L_{Ar,Tr}$

Specific sound level plus any adjustment for the characteristic features of the sound.

Reference Time Interval, T_r

Specified interval over which the specific sound level is determined.

NOTE This is 1 h during the day from 07:00 h to 23:00 h and a shorter period of 15 min at night from 23:00 h to 07:00 h.

Residual Sound

Ambient sound remaining at the assessment location when the specific sound source is suppressed to such a degree that it does not contribute to the ambient sound.

Residual Sound Level, $L_r = L_{Aeq,T}$

Equivalent continuous A-weighted sound pressure level of the residual sound at the assessment location over a given time interval, T .



Specific Sound Level, $L_s = L_{Aeq,Tr}$

Equivalent continuous A-weighted sound pressure level produced by the specific sound source at the assessment location over a given reference time interval, Tr .

Specific Sound Source

Sound source being assessed.

Frequency Analysis

Octave Band *A band of frequencies the upper limit of which is twice the lower limit. They are known by their centre frequency, e.g., 63, 125, 250, 500, 1000, 2000 Hz...*

One Third Octave *The logarithmic frequency interval between a lower frequency f_2 , when f_2/f_1 equals $2^{1/3}$ apart. Frequencies include: 100, 125, 160, 200, 250, 315, 400, 500, 630, 800, 1000Hz.*

Sound Transmission in the Open Air

Most sources of sound can be characterised as a single point in space. The sound energy radiated is proportional to the surface area of a sphere centred on the point. The area of a sphere is proportional to the square of the radius, so the sound energy is inversely proportional to the square of the radius. This is the inverse square law.

In decibel terms, every time the distance from a point source is doubled, the sound pressure level is reduced by 6 dB. Road traffic noise is a notable exception to this rule, as it approximates to a line source, which is represented by the line of the road. The sound energy radiated is inversely proportional to the area of a cylinder centred on the line. In decibel terms, every time the distance from a line source is doubled, the sound pressure level is reduced by 3 dB.



Factors Affecting Sound Transmission in the Open Air

Reflection

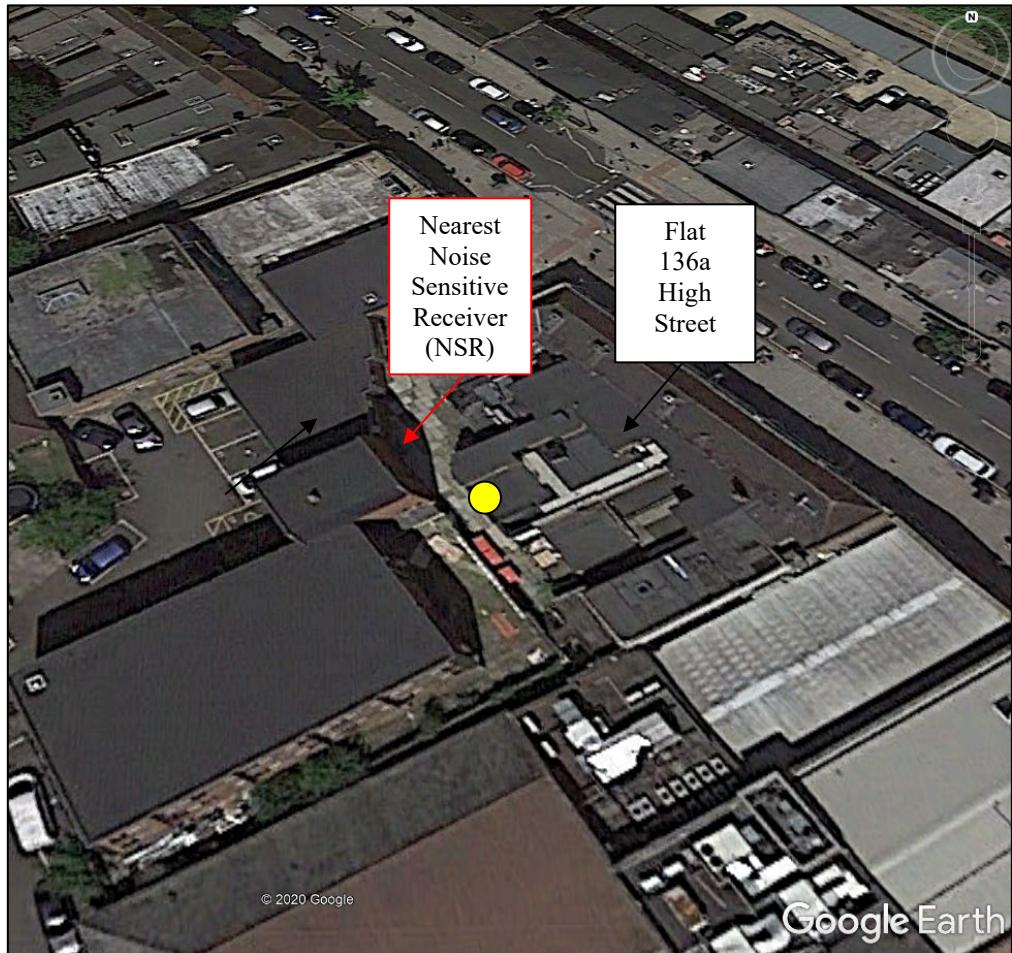
When sound waves encounter a hard surface, such as concrete, brickwork, glass, timber or plasterboard, it is reflected from it. As a result, the sound pressure level measured immediately in front of a building façade is approximately 3 dB higher than it would be in the absence of the façade.

Screening and Diffraction

If a solid screen is introduced between a source and receiver, interrupting the sound path, a reduction in sound level is experienced. This reduction is limited, however, by diffraction of the sound energy at the edges of the screen. Screens can provide valuable noise attenuation however. For example, a timber boarded fence built next to a motorway can reduce noise levels on the land beyond, typically by around 10 dB(A). The best results are obtained when a screen is situated close to the source or close to the receiver.

APPENDIX 2

Site Location



Key:

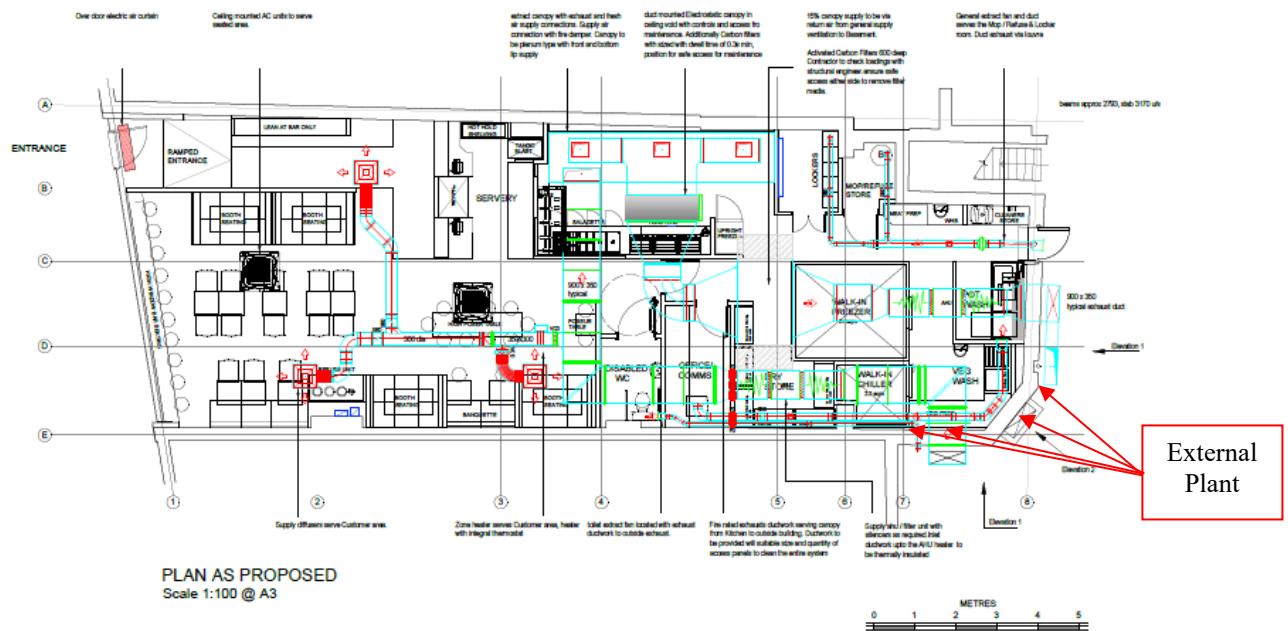
- Microphone Position (background noise measurements)²⁴

²⁴ Positioned close to where new mechanical plant (extract duct, AC condensers & refrigeration condensers) will be located.

APPENDIX 3

Site Plans/Elevations (proposed)

Mechanical Plant Layout

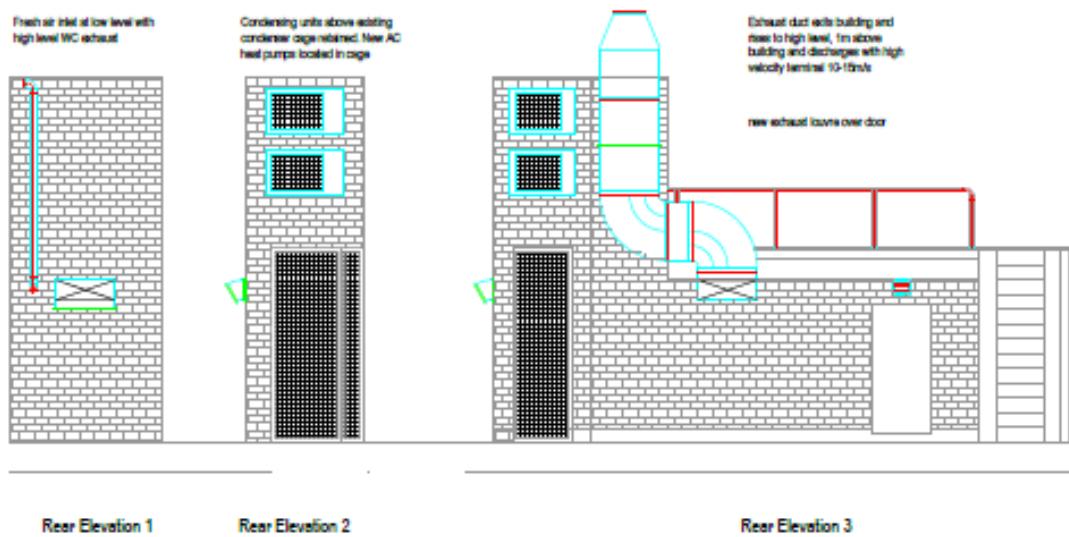




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Site Plans/Elevations (proposed)

Mechanical Plant Elevations



APPENDIX 4

Site Photographs



Background Monitoring - Microphone Position



Background Monitoring - Microphone Position

Site Photographs



Existing Mechanical Plant



Existing Mechanical Plant (not belonging to 136 High St)

Site Photographs



Existing Mechanical Plant

APPENDIX 5

Equipment Noise Data

Extract Fan

Flakt Wood MaXfan



MAXFAN COMPAC - THE NEXT GENERATION IN KITCHEN FANS

FEATURES

- 400 - 630 mm diameter
- Volumes up to 4.9m³/s
- Static Pressures up to 900 Pa (Non-stalling characteristic)
- Fans tested to ISO5801 and BS848
- High efficiency energy saving IE2 motor
- Low breakout noise levels
- Motor protection and terminal block IP55 (DW172 & Defra Compliant)
- Ambient temperatures up to 80°C (Dependant on size)
- Overheat protection as standard
- Compact robust light weight construction
- Galvanised casing for high corrosion resistance
- Full inverter control and flexibility

ELECTRICAL SUPPLY

230V/50Hz/1 Ph (3 Ph Motor) - L Type

TEMPERATURE RANGE

Suitable for temperatures up to 80°C*

*dependent on the fan size, please refer to the specific fan technical page

SIZES

400, 450, 500, 560 and 630 mm

Smaller 315 & 355 mm available on request

IMPELLERS

A unique high efficiency aerofoil section blade with a smoothed hub and clamp plate offers a high efficiency solution.

The Flakt Woods impellers are all high pressure die cast to offer thin aerofoil sections for low generation of noise. Every cast aluminium component is X-ray examined using Real Time Radiography inspection prior to assembly. The maximum pitch angles shown allow for speed control by frequency inverter.

MOTORS

All motors are totally enclosed air stream rated with class F insulation. Constructed from aluminium or cast iron as standard with special pad mounted fixings. Although this product incorporates a three phase electric motor, by using a matched inverter solution it is suitable for use with a single phase electrical supply on site. In addition, using a frequency inverter allows the speed to be turned down to 20% of maximum speed. Suitable for horizontal or vertical shaft operation. Supplied IP55, with removable drain plugs.

Sealed for life bearings lubricated with wide temperature range grease. The complete range of motors are fitted with Thermistor DIP as standard. Motors are IE2 efficiency class as standard.



CASINGS

The MaXfan Compac is available with a galvanised casing, complete with an externally mounted pre-wired electrical terminal box. Casings are spun from sheet steel with integral pre-drilled and radiused inlet flanges. The galvanised finish gives a high resistance to corrosion and is ideal for external as well as internal use.

PRODUCT CODE

40 MaXfan Compac

- 40 - denotes the fan impeller diameter in centimetres

ACCESSORIES





Equipment Noise Data

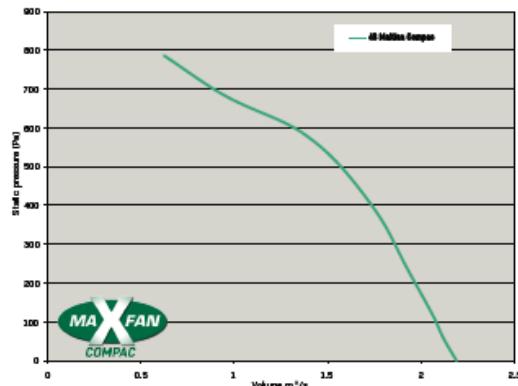
Extract Fan

Flakt Wood 45 MaXfan Compac



MAXFAN COMPAC 230 V/50HZ/1 PH - L TYPE

PERFORMANCE CHART - 45 MaXfan Compac (EJ463266)



ADDITIONAL ACCESSORIES



PRODUCT AND ELECTRICAL TABLE - 45 MaXfan Compac

Part Number	Part Description	Temperature (°C)	Frame	h/W	FLD (A)	SC (A)	Phase	Voltage	Inverter Model	Wiring Diagram	Ambient Sound Level (dB) @ 1m	Fan Weight (kg)	Casing Length (mm)
EJ463266	45 MaXfan Compac	55	88	1.32	53	25.5	1	230	0.0	CD1842	48	37	375

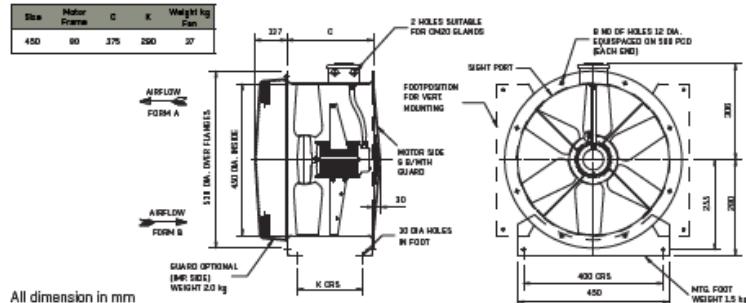
SOUND DATA - 45 MaXfan Compac

Freq (Hz)	Sound Spectrum (Hz)								Dwelling	
	53	125	250	500	1k	2k	4k	8k		
Inlet*	79	61	68	62	60	60	79	75	61	66
Outlet*	79	61	68	62	60	60	79	77	61	67
Breakout*	69	61	68	58	56	52	57	53	72	42

*dB A re 10⁻²² W
Pa Sound data at 1.98m³/s @ 200Pa (static)

**dB A re 2x10⁻² Pa

DRAWING - 45 MaXfan Compac





Equipment Noise Data

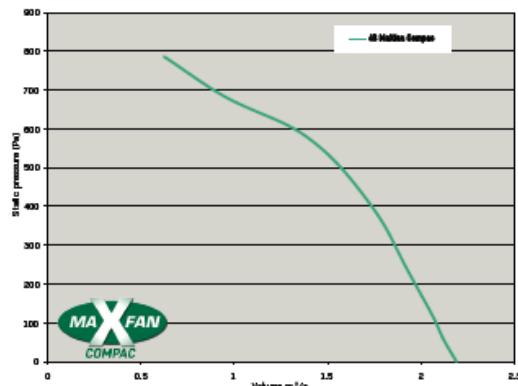
Supply Fan

Flakt Wood 45 MaXfan Compac



MAXFAN COMPAC 230 V/50HZ/1 PH - L TYPE

PERFORMANCE CHART - 45 MaXfan Compac (EJ463266)



ADDITIONAL ACCESSORIES



PRODUCT AND ELECTRICAL TABLE - 45 MaXfan Compac

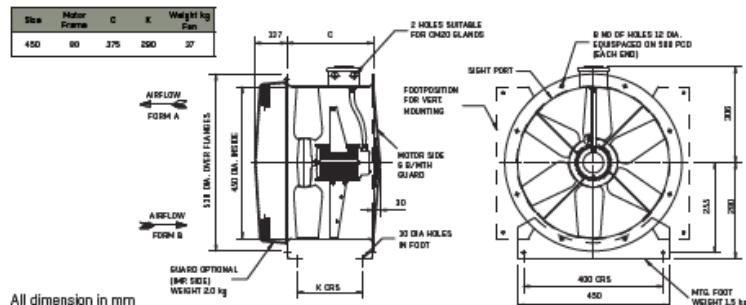
Part Number	Part Description	Temperature (°C)	Frame	kW	PLC (A)	SC (A)	Phase	Voltage	Inverter Model	Wiring Diagram	Breakout Sound Level (dB(A) @ 1m)	Per Weight (kg)	Electrical Length (mm)
EJ463266	45 MaXfan Compac	55	88	1.12	53	25.5	1	230	0.8	CD1842	42	37	375

SOUND DATA - 45 MaXfan Compac

Freq	Sound Spectrum (Hz)							Overall
	50	125	250	500	1k	2k	4k	
Inlet*	79	61	68	62	60	60	70	75
Outlet*	79	61	68	62	60	60	70	77
Breakout*	59	61	68	58	56	52	57	59

*dB A re 20⁻²² W
**Sound data at 1.0m/s @ 200Pa (static)

DRAWING - 45 MaXfan Compac





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Equipment Noise Data

Coldroom Condensers²⁵

Type	Winsys outdoor	Wintsys outdoor
Model	WINAJ4519Z	WINFH2511ZFZ
Dimensions	W 942mm D 574mm H 690mm	W 1174 mm D 531 mm H 710mm
Weight	65 kg	83kg
Compressor Model	CAJ4519Z	CAJ4531Z HR
Pipe sizes	Gas 5/8 liquid 3/8"	Gas 7/8" Liquid 1/2"
Power supply S/Phase	20amp	30amp
Refrigerant	16amp per phase	16amp per phase
Gas	R404a	R404a
Noise Level	41 dBA	42 dBA

²⁵ 'Noise Level' measured at 10m - Conversion to SPL@ 1m. + 20 log (10/1).

Equipment Noise Data

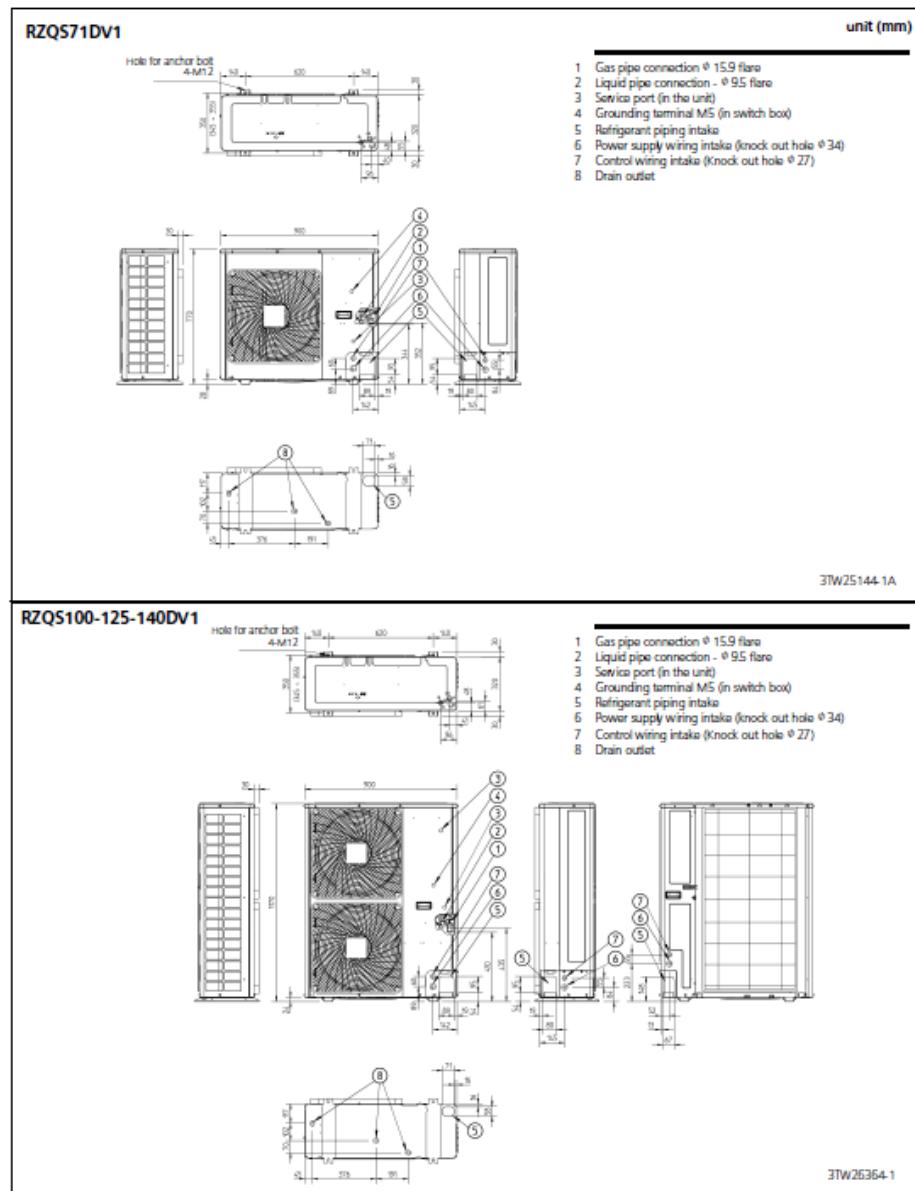
External Condenser Units

Daikin RZQS100

DAIKIN • Outdoor Units • R-410A • RZQS-DV1

6 Dimensional drawing & centre of gravity

6 - 1 Dimensional drawing





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Equipment Noise Data

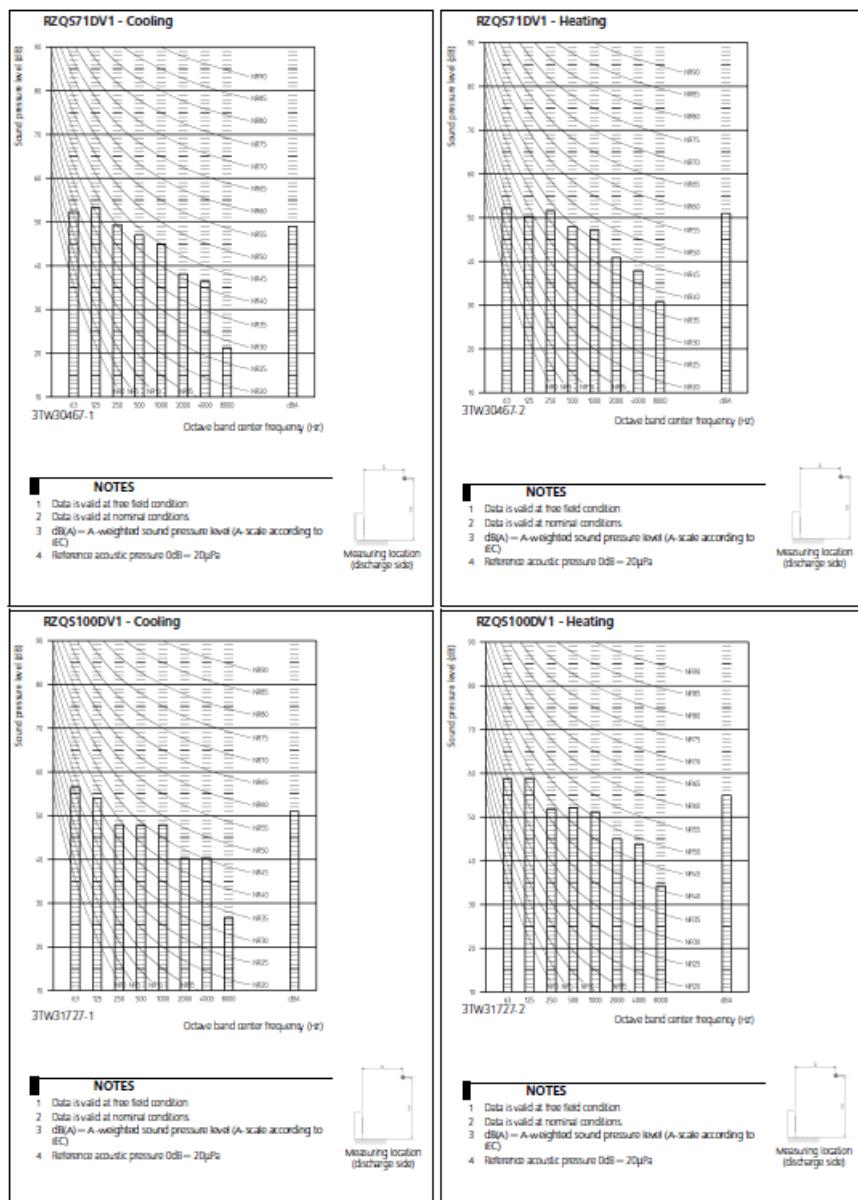
External Condenser Units

Daikin RZQS100

DAIKIN • Outdoor Units • R-410A • RZQS-DV1

9 Sound data

9 - 1 Sound pressure spectrum



DAIKIN • Split Sky Air • Outdoor Units



APPENDIX 6

Background Noise Measurements

Table

Period	Date	Time	L _{Fmax}	L _{Fmin}	L _{eq}	L _{F50}	L _{F90}
		(hrs:mins)	dB, (A)	dB, (A)	dB, (A)	dB, (A)	dB, (A)
1	9/3/2020	15:15:00	78.8	49.1	52.9	51.5	50
2	9/3/2020	15:30:00	64.4	48.4	51.3	50.5	50
3	9/3/2020	15:45:00	75.8	48.5	56.7	53.5	50.5
4	9/3/2020	16:00:00	72.5	49.4	57.5	55.5	52.5
5	9/3/2020	16:15:00	64.1	48.8	52.5	52	50.5
6	9/3/2020	16:30:00	66.3	47.2	51.1	50.5	49
7	9/3/2020	16:45:00	61.3	46.9	49.9	49.5	48.5
8	9/3/2020	17:00:00	64.2	46.2	49.7	49.5	48
9	9/3/2020	17:15:00	64.2	46.7	49.4	49	48
10	9/3/2020	17:30:00	63.8	46.5	50.3	49.5	48
11	9/3/2020	17:45:00	67	46.9	50.4	49.5	48.5
12	9/3/2020	18:00:00	58.8	46.6	49.7	49	48
13	9/3/2020	18:15:00	63.9	46.7	49.6	49	48
14	9/3/2020	18:30:00	61.2	46.6	49.6	49	48
15	9/3/2020	18:45:00	61.5	46.7	49.7	49.5	48
16	9/3/2020	19:00:00	65.5	46.7	49.7	49	48
17	9/3/2020	19:15:00	61.2	46.5	50.2	49.5	48
18	9/3/2020	19:30:00	64.2	46.3	49.4	48.5	48
19	9/3/2020	19:45:00	65.4	46.3	49.2	49	47.5
20	9/3/2020	20:00:00	63.1	46.4	49	48.5	47.5
21	9/3/2020	20:15:00	58	46.5	49	48.5	47.5
22	9/3/2020	20:30:00	59.2	46.2	48.9	48.5	47.5
23	9/3/2020	20:45:00	60.2	46	48.6	48.5	47.5
24	9/3/2020	21:00:00	68.1	46.4	49.4	48.5	47.5
25	9/3/2020	21:15:00	55.9	46.4	48.6	48.5	47.5
26	9/3/2020	21:30:00	67.7	46.4	48.9	48	47.5
27	9/3/2020	21:45:00	55.1	46.2	48.7	48.5	47.5
28	9/3/2020	22:00:00	62.2	46.3	48.8	48	47.5
29	9/3/2020	22:15:00	58	45.9	48.3	48	47
30	9/3/2020	22:30:00	62.1	46.1	48.9	48	47.5
31	9/3/2020	22:45:00	59.8	46.3	48.5	48	47.5
32	9/3/2020	23:00:00	57.2	46.1	48.4	48	47.5



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33	9/3/2020	23:15:00	60.2	46.2	48.5	48	47
34	9/3/2020	23:30:00	60.3	46.1	48.5	48	47
35	9/3/2020	23:45:00	55.2	46.3	48.3	48	47
36	9/3/2020	0:00:00	56.9	46.1	48.4	48	47
37	9/4/2020	0:15:00	54.3	40.9	46	44.5	42
38	9/4/2020	0:30:00	54.5	40.9	44.7	43.5	42
39	9/4/2020	0:45:00	55.1	40.8	44.2	43	42
40	9/4/2020	1:00:00	56.6	41.3	44.6	43.5	42.5
41	9/4/2020	1:15:00	74.3	41.5	44.7	43.5	42.5
42	9/4/2020	1:30:00	58.8	41.9	44.8	43.5	43
43	9/4/2020	1:45:00	52.5	41.2	43.8	43.5	42.5
44	9/4/2020	2:00:00	58.4	41.2	43.9	43	42
45	9/4/2020	2:15:00	53.7	41.2	43.4	43	42
46	9/4/2020	2:30:00	55.7	40.9	43.8	43	42
47	9/4/2020	2:45:00	55.2	41	44	43	42
48	9/4/2020	3:00:00	56.8	41.2	43.9	43	42.5
49	9/4/2020	3:15:00	59.4	41.1	43.8	43	42
50	9/4/2020	3:30:00	51.7	40.9	43.1	43	42
51	9/4/2020	3:45:00	55.8	41.1	44.3	43	42.5
52	9/4/2020	4:00:00	54.7	41	43.6	43	42
53	9/4/2020	4:15:00	57	40.9	44.1	43	42
54	9/4/2020	4:30:00	65.2	41.2	48.2	48.5	42.5
55	9/4/2020	4:45:00	60.3	41.4	46.8	44.5	42.5
56	9/4/2020	5:00:00	54.5	41.1	44.3	43.5	42.5
57	9/4/2020	5:15:00	61.5	41.7	49.5	46.5	43
58	9/4/2020	5:30:00	68.9	41.8	46.8	44	43
59	9/4/2020	5:45:00	61.7	42.8	49.7	48.5	45
60	9/4/2020	6:00:00	61.1	43.1	49.2	48.5	45.5
61	9/4/2020	6:15:00	60.9	46.5	49.8	49	48
62	9/4/2020	6:30:00	56.9	46.1	49.3	48.5	47.5
63	9/4/2020	6:45:00	59	46.6	50	49.5	48
64	9/4/2020	7:00:00	61.1	46.8	49.9	49	48
65	9/4/2020	7:15:00	58.7	46.9	50.6	50	48
66	9/4/2020	7:30:00	60.7	47.4	50.4	50	48.5
67	9/4/2020	7:45:00	67	47.2	50.7	50	48.5
68	9/4/2020	8:00:00	67.7	47.9	51.3	50.5	49.5
69	9/4/2020	8:15:00	72.9	48.8	51.7	51	50
70	9/4/2020	8:30:00	65.1	47	50.2	50	48.5
71	9/4/2020	8:45:00	69.3	47.2	51.7	51	48.5
72	9/4/2020	9:00:00	62.5	47.2	49.8	49.5	48.5
73	9/4/2020	9:15:00	59.7	47.5	49.8	49.5	48.5
74	9/4/2020	9:30:00	63.1	46.8	49.7	49.5	48.5



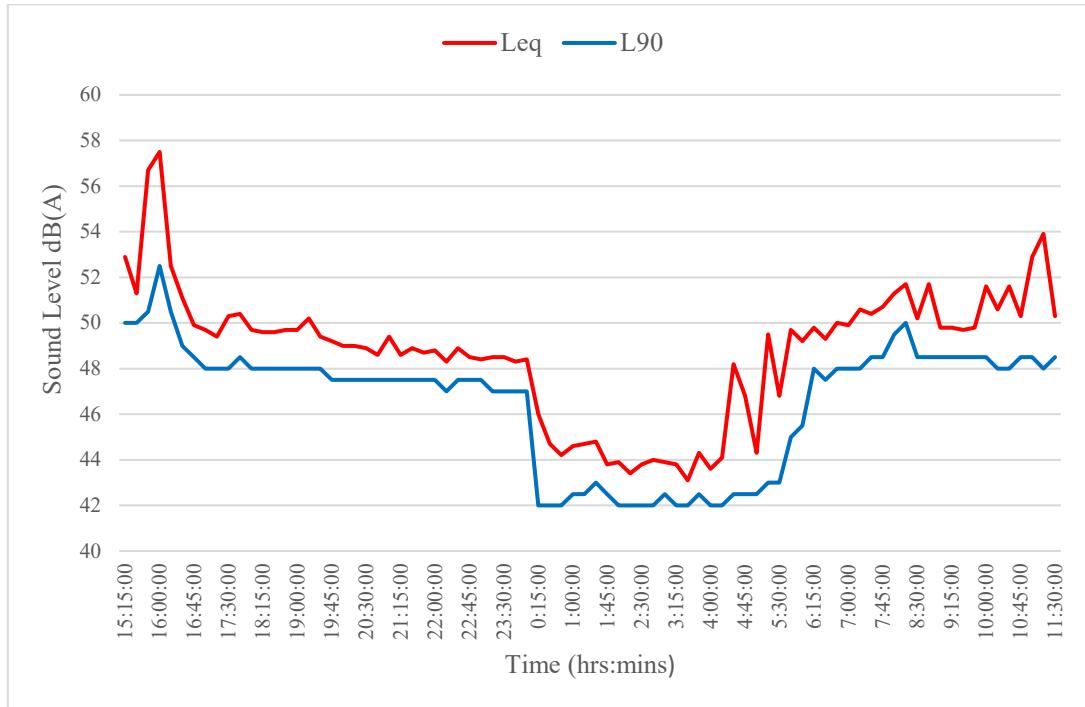
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75	9/4/2020	9:45:00	64.6	47.1	49.8	49.5	48.5
76	9/4/2020	10:00:00	79.9	46.8	51.6	49.5	48.5
77	9/4/2020	10:15:00	60.3	46.7	50.6	49.5	48
78	9/4/2020	10:30:00	75.4	46.9	51.6	49	48
79	9/4/2020	10:45:00	70.9	46.9	50.3	49.5	48.5
80	9/4/2020	11:00:00	78.5	47.1	52.9	49.5	48.5
81	9/4/2020	11:15:00	76	46.8	53.9	49	48
82	9/4/2020	11:30:00	66.9	46.9	50.3	49.5	48.5



Background Noise Measurements

Graph



APPENDIX 7

Plant Noise Calculations

Extract Outlet Duct

Duct Break-Out	Frequency (Hz)								Overall	dB
	63	125	250	500	1k	2k	4k	8k		
45 MaXfan	79	81	88	82	81	80	79	77	91	dB
A-Weighted	52.8	64.9	79.4	78.8	81	81.2	80	75.9	88	dB(A)
Flakt Woods 100 x 1200mm	-6	-12	-23	-40	-51	-51	-41	-29		
Duct Length (m)	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0		
Duct Loss per m	0.07	0.07	0.07	0.10	0.16	0.16	0.16	0.16		
Duct Attenuation	-0.1	-0.1	-0.1	-0.2	-0.3	-0.3	-0.3	-0.3		
90° Duct Bend				-1.0	-2.0	-3.0	-3.0	-3.0		
Corrected L _{WA}	72.9	68.9	64.9	40.8	27.7	25.7	34.7	44.7		
Duct Skin (22g)	-3	-8	-14	-20	-23	-26	-27	-35		
ALLEN Formula										
Visible Perimeter (m)	0.45	0.45	0.45	0.45	0.45	0.45	0.45	0.45		
Length (m)	2	2	2	2	2	2	2	2		
Perimeter x Length (S)	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9		
Duct Cross Section (m ²) (A)	0.16	0.16	0.16	0.16	0.16	0.16	0.16	0.16		
10log(S/A)	7.5	7.5	7.5	7.5	7.5	7.5	7.5	7.5		
Losses	4.5	-0.5	-6.5	-12.5	-15.5	-18.5	-19.5	-27.5		
Minimum -3	-3.0	-3.0	-6.5	-12.5	-15.5	-18.5	-19.5	-27.5		
L _{W(radiated)}	69.9	65.9	58.4	28.3	12.2	7.2	15.2	17.2	72	dB(A)
Distance (m)	5	5	5	5	5	5	5	5		
DI	3	3	3	3	3	3	3	3		
Point Source Attenuation	-25	-25	-25	-25	-25	-25	-25	-25		
Screening	0	0	0	0	0	0	0	0		
Attenuated Level	47.9	43.9	36.4	6.3	-9.8	-14.8	-6.8	-4.8	50	dB
A-Weighted	21.7	27.8	27.8	3.1	-9.8	-13.6	-5.8	-5.9	31	dB(A)



Plant Noise Calculations

Extract Termination to Atmosphere

TERMINATION	Frequency (Hz)								Overall	
	63	125	250	500	1000	2000	4000	8000		
45 MaXfan	79	81	88	82	81	80	79	77	91	dB
A-Weighted	52.8	64.9	79.4	78.8	81	81.2	80	75.9	88	dB(A)
Flakt Woods 100 x 1200mm	-6	-12	-23	-40	-51	-51	-41	-29		
Corrected L _{WA}	73.0	69.0	65.0	42.0	30.0	29.0	38.0	48.0		dB
Duct Length (m)	3.5	3.5	3.5	3.5	3.5	3.5	3.5	3.5		
Duct Loss per m	0.07	0.07	0.07	0.10	0.16	0.16	0.16	0.16		
Duct Attenuation	-0.2	-0.2	-0.2	-0.4	-0.6	-0.6	-0.6	-0.6		Ref SRL
90° Duct Bend				-1.0	-2.0	-3.0	-3.0	-3.0		
End Reflection 0.4mØ	-11	-7	-3	-1	0	0	0	0.0		
Screening	0	0	0	0	0	0	0	0		
Distance (m)	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0		DI
Point Source Attenuation	-25	-25	-25	-25	-25	-25	-25	-25		
Attenuated Level	36.8	36.8	36.8	14.7	2.5	0.5	9.5	19.5	42	dB
A-Weighted	10.6	20.7	28.2	11.5	2.5	1.7	10.5	18.4	29	dB(A)



Plant Noise Calculations

Supply Inlet (Atmosphere)

TERMINATION	Frequency (Hz)								Overall	
	63	125	250	500	1000	2000	4000	8000		
45 MaXfan	78	81	88	82	80	80	78	75	91	dB
A-Weighted	51.8	64.9	79.4	78.8	80	81.2	79	73.9	87	dB(A)
Flakt Woods 100 x 1200mm	-6	-12	-23	-40	-51	-51	-41	-29		
Corrected L _{WA}	72.0	69.0	65.0	42.0	29.0	29.0	37.0	46.0	74	dB
Duct Length (m)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5		
Duct Loss per m	0.07	0.07	0.07	0.10	0.16	0.16	0.16	0.16		
Duct Attenuation	-0.2	-0.2	-0.2	-0.3	-0.4	-0.4	-0.4	-0.4		Ref SRL
90° Duct Bend				-1.0	-2.0	-3.0	-3.0	-3.0		
End Reflection 0.4mØ	-11	-7	-3	-1	0	0	0	0		
Screening	0	0	0	0	0	0	0	0		
Distance (m)	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0		DI
Point Source Attenuation	-27	-27	-27	-27	-27	-27	-27	-27		
Attenuated Level	34.3	35.3	35.3	13.2	0.0	-1.0	7.0	16.0	40	dB
A-Weighted	8.1	19.2	26.7	10.0	0.0	0.2	8.0	14.9	28	dB(A)



Plant Noise Calculations

Condenser Units

Serving	Equipment			
	Freezer	Chiller	AC1	AC2
Manufacturer	/	/	Daikin	Daikin
Model	WINFH2511ZFZ	WINAJ4519Z	RZQS100	RZQS100
SPL @ 1m dB(A)	62	61	55	55
Environ/Acoustic Louvre	-26	-26	-16	-16
DI	3	3	3	3
NSR Distance (m)	5	5	5	5
NSR SPL @ 1m dB(A)	25.0	24.0	28.0	28.0
Background	52	52	52	52
Excess	-27.0	-28.0	-24.0	-24.0

APPENDIX 8

Noise Mitigation Products

Flakt Wood Attenuators

Splitter Silencers

Coding: Type WS/WSE Silencers

Code	
WS	Drilled Flanges (with Side Liners)
WSY	Cleat Flanges (with Side Liners)
M	Moisture Resistant Lining
L	Low Pressure Loss
P	High System Pressure
K	Fume Resistant
C	Perforated Linings
CC	Stainless Perforated Linings

Example

WSY LM/75-X-X-X

Type WSY

Variants LM

Airway 75

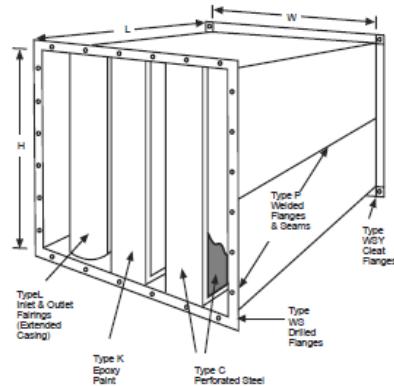
Width mm X

Silencer Length mm X

Width mm X

Height mm X

Figure 1



Coding: Type WBS Silencers

CODE WBS (H or V)
Plus Variants
as for type WS

H or V = Bend in Horizontal or Vertical Plane

Example

WBS (H) or (V) M/75-X-X-X-X

Type WBS (H) or (V)

Variants M

Airways 75

Width mm X

Air Entry leg Dimension L₁ mm X

Air exit leg Dimension L₂ mm X

Silencer Width mm X

Height mm X

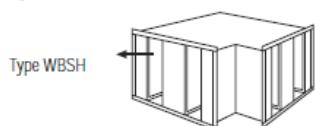
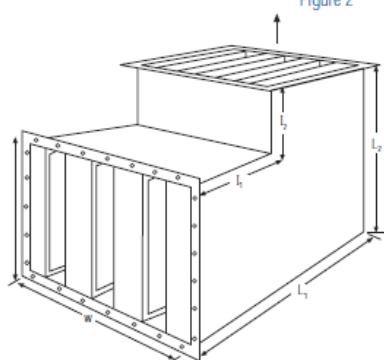


Figure 2

Type WBSV



$L_1 + L_2$ Minimum Dimension 100mm
(300mm fairings Type WBSH)



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Noise Mitigation Products

Flakt Wood Attenuators

Splitter Silencers

Performance

Type WS/WSY

Intermediate airway widths can be provided to suit individual requirements. Please enquire.

Care should be taken in use of 50mm Airway Silencer. Perforated Linings are required on airways of 75mm or less. Please enquire.

The following airway velocities should not be exceeded for the ventilation space noise levels tabulated, in order to avoid possible noise regeneration in the silencer.

Airway Velocity=

Volume Flow Rate m^3/s
Number of Airways x Airway Width x Height (metres)

TABLE C

Velocity m/s	NC/NR Level
15	45-50
13	35-40
10	30

For special applications please enquire.

Table A

Airways mm	Length mm	Octave Band Mid Frequencies							
		63	125	250	500	1K	2K	4K	8K
50	600	6	12	22	31	40	40	40	30
	900	8	16	27	45	55	55	55	50
	1200	10	20	36	55	55	55	55	55
	1500	13	24	42	55	55	55	55	55
	1800	15	30	51	55	55	55	55	55
	2100	17	34	55	55	55	55	55	55
	2400	19	38	55	55	55	55	55	55
75	600	5	8	11	24	31	32	24	20
	900	6	11	19	34	45	45	39	28
	1200	7	14	26	46	55	55	52	38
	1500	9	17	30	48	55	55	55	42
	1800	10	20	34	50	55	55	55	46
	2100	12	23	40	55	55	55	55	55
	2400	13	24	45	55	55	55	55	55
100	600	4	7	11	21	31	29	21	20
	900	5	9	16	30	39	39	31	26
	1200	6	12	23	40	51	51	41	29
	1500	8	15	26	43	53	53	45	32
	1800	9	17	30	47	55	55	49	36
	2100	11	20	35	55	55	55	55	43
	2400	12	23	40	55	55	55	55	47
150	600	2	5	8	12	15	15	11	7
	900	3	6	11	20	25	25	15	8
	1200	4	7	15	26	33	33	19	11
	1500	5	9	18	33	41	41	24	13
	1800	6	11	22	39	49	49	29	16
	2100	7	13	26	45	55	55	34	19
	2400	8	15	30	52	55	55	39	21

Type WBS

The value of additional attenuation due to the mitred bend should be deducted from the attenuation required.

To obtain the attenuation, dimensions $L_2 + I_2$ must be equal or greater than 2.5 x height for Type WBSV or 2.5 width for Type WBSH.

Table B

Silencer Height for WBSV or width for WBSH	Additional Attenuation in Octave Bands Hz							
	63	125	250	500	1K	2K	4K	8K
300	0	0	2	8	6	3	3	3
450	0	1	5	7	4	3	3	3
600	0	2	8	6	0	3	3	3
750	0	3	8	5	0	3	3	3
900	0	5	7	4	0	3	3	3
1050	0	7	7	4	0	3	3	3
1200	1	8	6	4	0	3	3	3
1350	2	8	6	3	0	3	3	3
1500	3	8	5	3	0	3	3	3

Noise Mitigation Products

Environ Environlite ELV1.1.25AC



Acoustic Enclosure Systems for Air Conditioning and Refrigeration Plant

environlite 1.2.25AC SPLIT

Versatile yet cost effective noise control solutions for small and medium sized Split Air Conditioning and Heat Pump systems that have horizontal air flow characteristics.

This attractive range of units combines superior noise reduction characteristics and application versatility with a user friendly design for ease of assembly.

An introduction:

environlite is not only physically compact and discrete; its flexibility allows for a wide range of AC applications and is particularly suited to 'difficult to access' locations. Available as a new build or retrofit solution, environlite is supplied to the user palletised as a simple on-site self build kit.

All Environ products are a proven solution for the elimination of noise where commercial establishments coexist with domestic neighbours and environlite is especially suited to the ever growing domestic AC market.

By design, environlite applies its patented noise control features to best advantage, ensuring maximum acoustic performance.

With advanced noise control technology underpinned by quality engineering and manufacturing standards, environlite solutions help alleviate local authority approval issues, whilst eliminating the air conditioning noise problem for the user.

With almost infinite plant application compatibility and deriving its name from its design, environlite is matched to provide unparalleled acoustic performance to light commercial and domestic AC applications. The range is available in a variety of sizes, allowing it to be tailored to meet specific applications for new build or retrofit noise abatement.

The integrated airways are sized to suit the requirements of the enclosed plant and full service and maintenance access is provided by the provision of removable and hinged access panels.

environlite is secure and gives greater flexibility regarding the positioning of plant and machinery, especially where space is at a premium. Being 'Visually Quiet', no moving parts are visible - so the enclosed plant remains out of sight and out of mind.....

STEP 1-4 - Structure

STEP 5-6 - Air in Grilles

STEP 7 - Locate AC unit

STEP 8 - Fit RH Airway

STEP 9 - Fit LH Airway

STEP 10-12 - Complete Assembly

The Environ Integra, Modula and Lite acoustic designs are protected under patent



Noise Mitigation Products

Environ Environlite ELV1.1.25AC



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Cambourne, Cambridgeshire, UK, CB23 6DP
Tel: +44 (0)870 383 3344
Fax: +44 (0)1223 598001
www.environ.co.uk

environlite ELV1.1.25AC Acoustic Performance Data (March 2010)

Noise Measurement Information:

Test: Environ Lite Acoustic Enclosure — W 1700mm x D 1000mm x H 1550mm

Test Standard:

BS EN ISO 140-3 Acoustics - Measurement of Sound Insulation in Buildings and of Building Elements - Part 1: Airborne Sound Insulation

Sound Level Measuring Equipment:

Norsonic 830 RTA Precision Sound Analyser Type 1
CEL 284/2 Acoustic Calibrator Type 1
JBL Loudspeaker driven by CEL Loudspeaker driven by 830 White Noise Source

Transmission Loss Data:

Transmission Loss — Environ ELV1.1.25AC Acoustic Enclosure							
Octave Frequency in Hertz (dB ref 2×10^{-5} Pascal's)							
63	125	250	500	1K	2K	4K	8K
14	16	23	30	37	39	38	39
<u>Summary</u>							
Transmission Loss Equates to an Overall Reduction of 26 dB(A)							

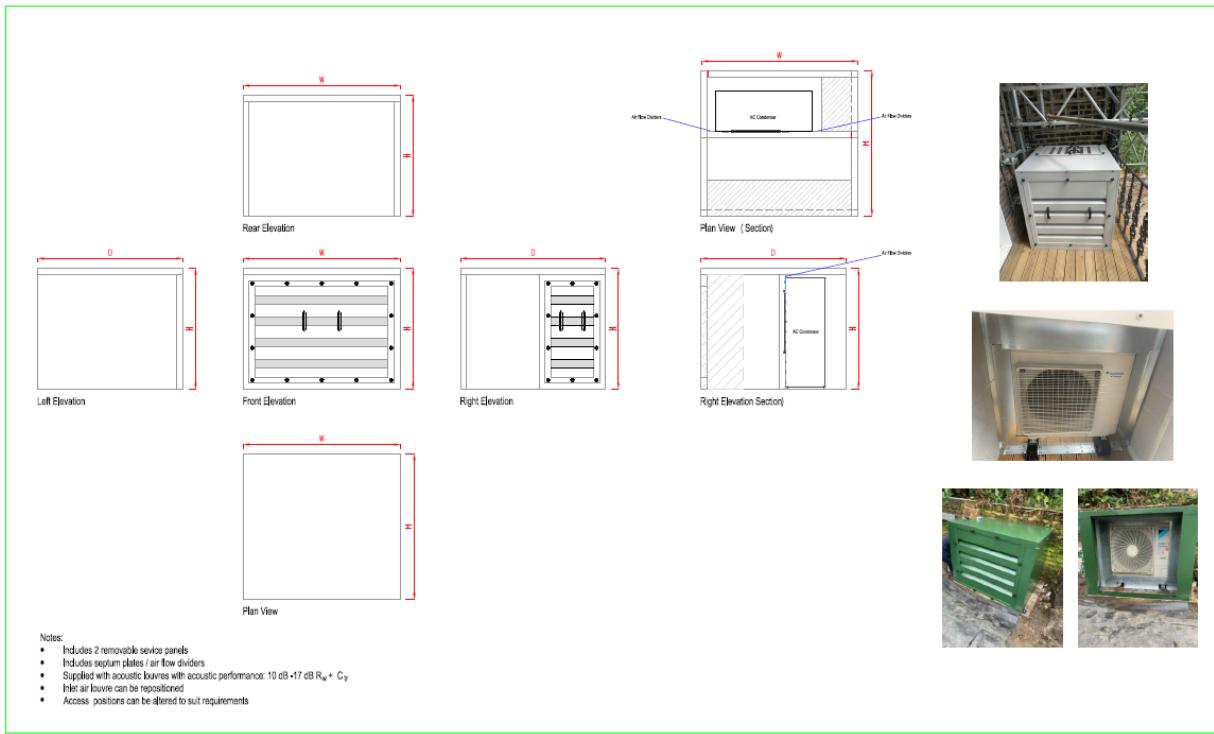
Support Information:

Monitoring was carried out using the BS3740 technique, insofar as measurements were taken in each quadrant and the results averaged. Internal Test Room: W 6m x D 16m x H 5m. Background noise in the semi-reverberant test room was such as not to interfere with the practical measurements

Environ acoustic enclosure designs are protected under patent

Noise Mitigation Products

Acoustic Louvre Enclosures



Rev	Amendment	Date	Project	Scale:	NTS @A3	Date:	15/07/20	soundplanning	Sound Planning Limited Farnham Surrey Phone: 01223 711972 Fax: 01223 631983 Email: enquiries@soundplanning.co.uk
Notes	No scaling permitted from this drawing. All dimensions shown to be verified prior to construction / manufacture.		Title: Sound Enclosure QuietBox 2	Drawn:	B.Walker				
				Drawing No:	QuietBox 2				

APPENDIX 9

Empirical Data – Restaurant Noise

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Articles

Restaurant Noise, Hearing Loss, and Hearing Aids

CHARLES P. LEBO, MD; MANSFIELD F. W. SMITH, MD; ELLEN R. MOSHER, MS, *San Jose*; SUSAN J. JELONEK, MBA, *Fairfield*; DAVID R. SCHWIND; KAREN E. DECKER; HARLAN J. KRUSEMARK; and PAMELA L. KURZ, *San Francisco, California*

Our multidisciplinary team obtained noise data in 27 San Francisco Bay Area restaurants. These data included typical minimum, peak, and average sound pressure levels; digital tape recordings; subjective noise ratings; and on-site unaided and aided speech discrimination tests. We report the details and implications of these noise measurements and provide basic information on selecting hearing aids and suggestions for coping with restaurant noise.

(Lebo CP, Smith MFW, Mosher ER, et al: Restaurant noise, hearing loss, and hearing aids. *West J Med* 1994; 161:45-49)

Restaurants are not merely eating and drinking sites; they are also popular settings for important social and business conversations. For the more than 27 million Americans with impaired hearing, restaurant noise can be debilitating. Hearing loss is ranked fourth among chronic medical conditions affecting Americans aged 65 and older. More than 3 million Americans wear hearing aids. Hearing impairment affects one in ten Americans. By age 50, 20% of Americans have a hearing loss.^{1,2}

Existing disability statutes in the United States do not yet require noise control in restaurants, but it has been reported that the US Department of Justice, under the Americans With Disabilities Act of 1990, has taken the position that compliance with this legislation entails providing quiet listening areas in restaurants and other places in which hearing-impaired persons may convene. A report on this subject by the US Department of Justice is scheduled for early release.

Although persons with normal hearing do experience hearing difficulties in restaurants, the inability to understand speech in noisy restaurants may be a symptom of undiagnosed hearing loss. Poor speech discrimination in social groupings or in restaurants can become so frustrating that many otherwise active and healthy hearing-impaired adults tend to avoid outside dining and social activities.

Several years ago, two of us (E.R.M. and S.J.J.) initiated the use of a questionnaire for hearing-impaired adults to identify difficult listening environments and important listening situations ("Patient Satisfaction Survey," unpublished data, February 1993).³ The results of this ongoing survey indicate that more than 80% of this group is dissatisfied with its ability to hear and understand conversation in restaurants, both with and without hearing aids.

Restaurants are also listed as one of the four most important listening situations by more than 60% of those surveyed.

The most common type of acquired hearing impairment is sensorineural hearing loss, the principal causes of which are aging and noise-induced inner ear damage. Persons so affected hear better in quiet settings than in noisy ones. To address patients' speech intelligibility requirements in noise, audiologic procedures were modified to include quantitative measurements of unaided and aided sound-field speech discrimination in varied noise conditions with different speech stimuli and "real-ear" measurements (taken with a probe microphone placed in the external auditory canal). These test data were integrated into decisions regarding hearing aid selection and earmold configurations. Evaluation of an extensive patient database revealed that speech discrimination problems in noise are not adequately ameliorated by the types of hearing aids most commonly provided for them: linear circuitry and an in-the-ear or in-the-canal configuration. Currently, such hearing aids are routinely dispensed without testing their performance in background noise.

The US Food and Drug Administration has recently charged six major hearing aid companies with excessive or unsubstantiated advertising claims regarding the extent to which their products help users hear amid noise ("Technology and Health," *Wall Street Journal*, April 27, 1993, p 6; Associated Press (on-line), April 26, 1993, 1629 EDT, V0122).⁴ Restaurants, sports events, and theaters were mentioned as areas where hearing aids do not perform in accordance with advertising claims.

Objectives

This study was designed to measure specific noise and

From the Hearing Institute for Children and Adults Medical Group, San Jose (Drs Lebo and Smith and Ms Mosher); Microsound Products, Fairfield (Ms Jelonek); and Charles M. Salter and Associates (Mr Schwind and Ms Decker), and Reid and Tarics Associates (Mr Krusemark and Ms Kurz), San Francisco, California.

Reprint requests to Hearing Institute for Children and Adults, 2120 Forest Ave, San Jose, CA 95128.



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relevant interior design features in restaurants of various types, evaluate hearing-aid performance in the presence of restaurant noise, and make digital tape and compact disc recordings of restaurant noise for clinical use.

Patients and Methods

A multidisciplinary research team consisting of two otologists, one audiologist, two architects, two acoustical engineers, and one communication scientist was assembled. We selected 27 San Francisco Bay Area restaurants to include all major restaurant types. A multiparametric measurement protocol was developed to describe the acoustic characteristics of restaurants.

Restaurant acoustic evaluations, sound pressure level measurements, subjective noise evaluations, digital tape recordings, and both aided and unaided speech discrimination tests were conducted by this team during peak eating times (with management consent) on Friday and Saturday nights. In addition to the calibrated measuring and recording hardware used by our acoustical engineers, an inexpensive type 3 sound-level meter (calibrated before use) was used for comparable measurements (decibels on the A and C slow scale) by another member of the team.

The measurements included A- and C-weighted maximum, minimum, and integrated (average) noise in various areas of each restaurant. The minimum noise sampling time was five continuous minutes. Each team member subjectively rated the intensity of restaurant noise using a scaled evaluation form. All measurements, observations, and tests were conducted almost simultaneously. Data were either recorded on site and saved by computerized measuring equipment or entered into a portable computer database immediately after exiting each restaurant.

A male subject with age-related hearing loss (it was not feasible to bring a statistically representative group of hearing-impaired subjects into these restaurants) was used to evaluate the performance of certain hearing aids in restaurants. This subject was fitted binaurally with behind-the-ear hearing aids equipped with both linear and nonlinear multiband compression circuitry. A user-operated switch controlled the type of amplification in use. Aided and unaided speech discrimination testing was conducted in each restaurant, using a supplemented Harvey Gardner three- to four-syllable high-frequency word list.²⁴ Two subjects with normal hearing were used periodically to establish speech discrimination baselines.

The single-subject on-site evaluation of hearing aid performance in restaurant noise was expanded with more extensive sound-booth studies and real-ear measurements involving 57 subjects, using the same nonlinear, multiband compression, behind-the-ear hearing aids, standard noise tapes, restaurant noise recordings on compact discs, and other audio material recorded during the restaurant visits.

Spectral analyses of digital audio recordings and real-ear measurements of the hearing aids used were completed later using a FONIX 6500 (Frye Electronics) test set.

Results

This study generated a massive amount of multiparametric data. Because this article focuses on otologic and audiologic aspects of those measurements, only data germane to these concerns are included.

Noise Profiles of Restaurants

The range of A-scale-decibel (dBA) sound-pressure levels in our restaurant samples was wide. The average loudness ranged from 59 to 80 dBA sound-pressure levels (Table 1). The mean loudness level in all restaurants surveyed was 71 dBA sound-pressure levels, and the median was 72 dBA sound-pressure levels.

The average loudness level of 71 dBA sound-pressure levels is particularly important because it exceeds the average intensity of conversational speech (65 dB). Because speech intelligibility varies directly with the signal-to-noise ratio, the latter measurement is useful in evaluating the suitability of these restaurants for personal communication. Speech intelligibility requires a signal-to-noise ratio of +6 for persons with normal hearing and +12 for persons whose hearing is impaired.²⁵

We classified the evaluated restaurants in terms of average noise level and signal-to-noise ratios as follows:

- *Type 1.* Less than 65 dBA; signal-to-noise ratio = 0: 6 restaurants. Quiet atmosphere with (designed or unplanned) acoustical serenity.
- *Type 2.* 65 to 74 dBA; signal-to-noise ratio = ≤ 10 : 15 restaurants. High variability of speech intelligibility in both normal and hearing-impaired subjects.
- *Type 3.* 75 or more dBA; signal-to-noise ratio = > 10 : 6 restaurants. High ambient noise levels with or without music; conversation difficult for patrons with normal hearing and poor to impossible for persons with hearing losses.

Noise crested (peaked) as high as 87 dBA in some of the restaurants studied. It is important to note that the crest factor (the peak sound-pressure level minus the root-mean-square sound-pressure level during a stated time period) in restaurant noise is as critical as the average sound-pressure level because these noise peaks disrupt the ability of a listener to concentrate and to process speech effectively.²⁶ High crest factors tend to overload hearing aid amplifiers, with resultant signal distortion. They tend to cancel key speech consonant sounds, there-

TABLE 1.—Ranges of Background Noise Levels in Restaurants Included in This Study

Restaurant Types	Decibels (dBA) on the A Scale
Bistro	65-80
California cuisine	74-80
Elegant	60-66
Ethnic	70-76
Family	59-70
Fast food	75-77
Steak	66-70



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by reducing speech intelligibility. Restaurants with dramatically fluctuating noise levels present serious difficulties for patrons whose hearing aids require manual (local or remote) volume adjustments.

Independent Subjective Noise Evaluations

To establish how accurately diners might appraise loudness levels without the benefit of electronic measuring equipment, each member of the team rated each restaurant for loudness, using a five-point scale. These subjective appraisals correlated well with electronic acoustic measurements ($r = .88$).

Noise and Restaurant Types

Although the Zagat restaurant surveys list 32 restaurant types,⁹ we deemed seven classifications to be adequate for our purposes: bistro, California cuisine, elegant, ethnic, family, fast food, and steak.

We found that restaurant classifications do not reliably predict loudness levels (Table 1). Elegant restaurants tended to be quiet, and bistros tended to be noisy, but there were exceptions. Such classifications, ours included, do not generally include ambient noise levels in their definitions. We found no correlation between price or food ratings and noise levels.

Acoustic and Architectural Design Factors

Restaurant profiles were compiled using the following variables: location (street type and traffic), building site access (distance to street, proximity to parking), occupancy (maximum seating, percentage of occupancy, actual numerical occupancy), environment (dining, reception, and bar areas, music and ancillary rooms) and dining room configuration (size, volume, walls, percentage of glass, ceiling material and height, flooring material, chair and table type and covering, booth type and covering). Although certain materials and architectural design features help control ambient noise, it is difficult to predict the interior ambient noise conditions accurately by means of these architectural features alone ("Best Meals, Best Deals," *Consumer Reports* 1992; 57:356-372).

Hearing Aid Performance

Our hearing-impaired subject (moderately severe, binaural, high-frequency hearing losses) was tested in all studied restaurants with Audiotone MSP-90C (Bausch & Lomb) behind-the-ear hearing aids, which are equipped with a switch that permits the user to select either the linear or the multiband compression circuitry. These aids were fitted with special nonoccluding Micro Ear ear molds, which are fabricated from Polysheer II, a polymerized vinyl compound made specifically for Pacific Coast Laboratory, San Leandro, California. These open ear molds have long, thin-walled ear canal tubes (usually 4 mm in external diameter) to avoid feedback (Figure 1). They permit the entry of nonamplified low-frequency sound into the ear canal in a normal manner and free the wearer from occlusion effects (the sensations caused by

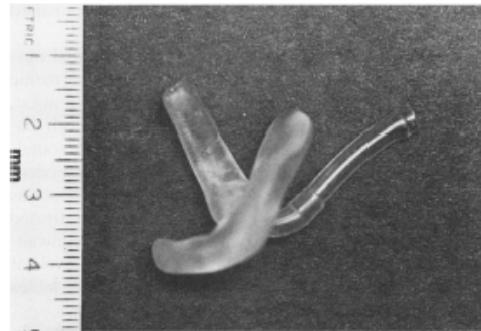


Figure 1.—A typical Micro Ear behind-the-ear ear mold is shown. Note the length of the ear canal tube.

occluding the external auditory canal), including amplification of the user's voice by a hearing aid, foreign body awareness, acoustic effects, and attenuation. Amplification of the user's voice by hearing aids causes the user to reduce, rather than increase, vocal loudness in noise, causing hearing problems for the user's companions.^{2,3,11}

The three- to four-syllable high-frequency words described previously were presented by the same speaker to the hearing-impaired subject to assess speech discrimination unaided and using both linear and multiband compression amplification. To evaluate the communication difficulties further, two team members with normal hearing also underwent the speech discrimination tests under identical conditions (in 11 restaurants only). The hearing-impaired subject's aided and unaided performances were compared in 11 restaurants. Surprisingly, the subject's unaided discrimination scores were higher than aided scores with linear amplification in 9 (45%) and equal in 1 (9%) of the studied restaurants. Unaided scores were never higher than those obtained when multiband compression amplification was used.

The performance of the multiband compression mode in the restaurant environment was substantially better than that obtained with linear amplification. The linear scores were poorer than those recorded with multiband compression in 18 of 27 restaurants (67%), equal to the multiband compression scores in 9 of the latter (33%), and better in none.

Discussion

The ambient noise levels in the restaurants studied varied greatly. There was an 18-dBA range in average loudness among the restaurants studied. Noise levels variably interfered with conversation, ranging from no interference to almost total masking. Speech discrimination testing of subjects with normal hearing and one hearing-impaired person indicated these masking effects can confound persons with normal hearing as well as those with impaired hearing. The critical background noise level for speech discrimination occurs between 65 and 70 dBA and corresponds with a signal-to-noise ratio of 0 dB.^{12,13} When background noise levels exceed this level, it becomes in-



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creasingly difficult for both normal and hearing-impaired persons to communicate.¹⁴

Our restaurant measurements showed substantial variability in loudness characterized by continual dynamic shifts that, whether caused by music, voices, floor noise, food service, or combinations thereof, erode speech discrimination. Within a given restaurant, the dBA sound-pressure level can vary with seating location and occupancy level; communication is easier in certain locations and is enhanced by low occupancy. Small, crowded rooms, however, can intensify noise levels. The waiters (or seating hosts) we encountered had mixed levels of awareness of the locations of the quietest areas or tables in their establishments.

Both our field test data and laboratory test data obtained with our restaurant recordings indicate environmentally that, for speech discrimination in restaurant noise, linear amplification is inferior to nonlinear amplification combined with adaptive multiband compression. This conclusion is supported by the aforementioned 57-subject study, which used the same hearing aid technology and employed both sound field and real-ear measurements of aided performance in noise.³

We encountered differences in hearing aid and subjects' performance with changes in background noise levels. The compression spectrum of the hearing aid (and the functional limitations thereof) and the specific settings of the circuitry are critical to any person's aided performance in noise. Ear-mold configuration is another variable that can greatly affect performance in noise. For the single subject in this study, some of the aided discrimination scores recorded in the noisiest establishments were better than others obtained in less noisy restaurants; this difference appears to be related to the compression and multiband characteristics of the hearing aids tested. In the 57-patient group study, many subjects showed drops in aided performance when the signal-to-noise ratio remained at -10, but the loudness levels increased by 10 dBA. Aided performance at higher noise levels was sometimes improved by changes in the compression settings or ear-mold configuration.

Recommendations

Ear examinations, including audiologic tests, are indicated in persons who admit to or are reported to have difficulty understanding conversations in restaurants. Untreatable hearing losses, of which the most common are the sensorineural type, can be mitigated with the appropriate hearing aids.

The following suggestions will be helpful to all persons wishing to converse effectively in restaurants:

- Ask for a quiet table;
- Do not sit near the kitchen or the walls, bar, or bus or waiter stations;
- Think "soft"—that is, patronize restaurants with plush environments (rugs, wall coverings, tablecloths, plants);
- Avoid restaurants providing live or recorded music;

- Avoid crowded places, especially small rooms, and periods of peak occupancy.

Fitting protocols for hearing aids and evaluations of their performance should better reflect the context of hearing-aid use. Speech testing, not just pure-tone testing, is essential. Unaided and aided sound-field speech discrimination tests in both quiet and noise should be used routinely in selecting and dispensing hearing aids to verify their appropriateness and effectiveness. Because the spectral characteristics of noise vary, hearing-aid performance should be evaluated using compact disc recordings of the environments in which a person routinely functions.

Binaural behind-the-ear hearing aids that are nonlinear, adaptive, and are equipped with multiband compression circuitry and soft, deep, nonoccluding or maximally vented continuous flow amplification ear molds are currently the hearing-aid system of choice for patients with high-frequency sensorineural hearing losses who need to understand speech, not just in quiet, but also in noise.

Equivalent hearing aid performance in noise cannot be expected for all patients with any given hearing aid technology. Patient expectations must be realistic; counseling by a physician and the support of family members are essential. Judgments of any improvements in speech discrimination must be relative to the medical and audiologic nature of the hearing loss as well as the age, lifestyle, motivation, and cognitive capacity of the patient.

The hearing aid industry, driven by intrinsic economics rather than social responsibility, is generally not (despite advertising claims) marketing hearing aids that incorporate the more important currently available technologic advances. Because physicians must assume ultimate responsibility for maximizing the benefits of hearing aids provided for their patients, it is incumbent on them to be aware of and demand state-of-the-art technology from the hearing aid industry and optimal evaluation, fitting, and follow-up services by audiologists and dispensers. The hearing aid industry should be urged to tailor compression spectra to real-world environments (perhaps to the restaurant noise models) and to develop both internal electronic adaptability and user-controllable variability in compression features. Until the major limitations and defects of the linear in-the-ear configuration can be eliminated, the industry would better serve the public by improving, promoting, and creating demand for high-technology behind-the-ear aids.

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Empirical Data – Restaurant Noise

Côte - Farnham

Hz	dB	dB	dB	dB	dB	dB
Band	LFmax	LFmin	Leq	LF10	LF50	LF90
Z	102.9	67.6	79.2	80.5	75	72
C	97	66	75.4	77.5	73.5	71
A	95	60.8	72.5	75	70.5	67
12	81.3	34.1	59.7	63	53	46
16	88.5	40.1	61.9	63.5	56.5	51
20	92.1	38.8	62.4	60	54	49
25	89.1	37.4	58.7	57.5	51.5	47.5
32	84.5	33.1	59.3	57	47.5	42.5
40	90.2	39	60.3	59	53	48
50	86.4	43.8	60.3	61	58.5	54.5
63	85.7	35.4	56.5	57.5	48	42
80	83.1	36.3	57.5	60.5	51	44.5
100	77	39.8	57.3	61	53.5	47.5
125	74.5	40.8	56.3	59	54.5	50
160	82.9	45.9	63.3	66.5	61.5	56.5
200	77.7	49.2	60.8	63.5	59.5	55.5
250	84.6	50.2	62.3	64.5	60	56.5
315	86.2	47.3	62.8	65.5	60.5	56.5
400	90.7	50.3	64.8	67.5	62.5	58
500	89.3	52.5	66.1	68.5	64	59.5
630	96.8	50	67.4	69.5	64	60
800	85.1	50	63.9	66.5	61.5	57
1k	82.9	49.3	62	64.5	60	56.5
1k25	82.3	44.3	61.3	64	58.5	53.5
1k6	81.5	45.8	61.4	64.5	58.5	53.5
2k	79.7	44.5	59.3	61.5	56.5	52
2k5	83.7	42.7	58.6	60.5	55	50.5
3k15	80.7	40.3	55.7	58.5	52	48
4k	78.9	38.6	55.7	58.5	50.5	46
5k	81.5	35.7	52.2	54.5	46.5	42.5
6k3	77.9	32.4	50.6	51.5	44	39.5
8k	72.1	31.3	48.6	50.5	42.5	38
10k	74.5	26.7	46.1	47	39	34
12k5	71.6	24	42.7	43	34	29.5
16k	66.2	19.6	39	38	29	24
20k	60.8	14.4	32.2	31.5	22	17.5



Empirical Data – Restaurant Noise

Chicken Coop - Camberwell Church Street, London²⁶

Frequency (Hz)								Tot	dB
63	125	250	500	1k	2k	4k	8k		
69.5	78.3	70.3	70.5	64.9	64.3	59.39	54.3	80.2	dB
43.3	62.2	61.7	67.3	64.9	65.5	60.39	53.2	72.2	dB(A)

²⁶ Sound Planning Noise Impact Assessment 2011.

Empirical Data – Restaurant Noise

Chicken Coop - Camberwell Church Street, London²⁷

Service Area Noise Measurements

Hz	dB	dB	dB	dB
Band	L _{Fmax}	L _{Fmin}	L _{eq}	L _{F90}
Z	91.8	70.3	79.9	75
A	89.1	56.7	69	62
12	76.9	33.3	59.7	47.5
16	82.4	35.3	60	48
20	82.1	41.4	63.5	54
25	82.1	44.6	65.2	56
32	83.8	49.7	68	60
40	84.9	48.5	70.1	61
50	90.5	57.4	74.4	66
63	88.3	51.6	72.2	62.5
80	84.4	49.4	64.3	56.5
100	84.7	45.4	61.7	53.5
125	80.1	45.2	59.6	51.5
160	79.3	48.9	61.1	55
200	83	47.9	64.2	53.5
250	81.5	49.6	61.1	54.5
315	84.4	48.5	61.4	54.5
400	81.1	48.6	61.7	54
500	82	48.4	62.4	54.5
630	81.8	47.9	61.9	54
800	80.8	47.9	59.9	52.5
1k	80	46	58.8	51
1k25	81.4	44.3	58.6	50.5
1k6	79.9	43	57.8	50
2k	80.8	41.9	56.2	48
2k5	74.5	39.8	54.3	46
3k15	78.5	37.6	53.1	43.5
4k	73.3	36.9	50.7	41.5
5k	66.9	33.4	48.1	38
6k3	73.9	30.7	46.8	35.5
8k	64.6	28	45.1	33
10k	65.3	25.3	41.7	30
12k5	71.7	20.1	42	26
16k	74.9	17.9	41.1	22.5
20k	68.2	12.5	37.2	16

²⁷ Sound Planning Noise Impact Assessment 2011.



APPENDIX 10

Separating Floor Tests

ISO 717 Calculation Sheets

Kitchen

Kitchen	L1	L2	Diff				9		D	L		
Hz	dB	dB		D _{nT}	Ref Values	Diff	Shifted Ref	Revised Dif	D _{nT}	Ctr' Spectrum	Diff	10 ^{(L-D/10) x 10⁵}
Band	Leq	Leq										
100	97.2	49.3	48.0	48.0	33	-15.0	42	-6.0	48.0	20	-68.0	0.016
125	101.9	52.6	49.3	49.3	36	-13.3	45	-4.3	49.3	20	-69.3	0.012
160	101.6	51.9	49.8	49.8	39	-10.8	48	-1.8	49.8	18	-67.8	0.017
200	102.3	50.5	51.8	51.8	42	-9.8	51	-0.8	51.8	16	-67.8	0.017
250	100.4	49.1	51.3	51.3	45	-6.3	54	2.7	51.3	15	-66.3	0.023
315	99.3	43.4	55.8	55.8	48	-7.8	57	1.2	55.8	14	-69.8	0.010
400	96.0	40.9	55.1	55.1	51	-4.1	60	4.9	55.1	13	-68.1	0.016
500	93.6	37.2	56.4	56.4	52	-4.4	61	4.6	56.4	12	-68.4	0.014
630	92.6	34.2	58.5	58.5	53	-5.5	62	3.5	58.5	11	-69.5	0.011
800	92.2	34.2	58.0	58.0	54	-4.0	63	5.0	58.0	9	-67.0	0.020
1k	92.8	32.5	60.3	60.3	55	-5.3	64	3.7	60.3	8	-68.3	0.015
1k25	94.1	31.0	63.1	63.1	56	-7.1	65	1.9	63.1	9	-72.1	0.006
1k6	93.2	30.1	63.1	63.1	56	-7.1	65	1.9	63.1	10	-73.1	0.005
2k	91.7	27.7	64.0	64.0	56	-8.0	65	1.0	64.0	11	-75.0	0.003
2k5	91.7	27.2	64.5	64.5	56	-8.5	65	0.5	64.5	13	-77.5	0.002
3k15	90.4	24.2	66.3	66.3	56	-10.3	65	-1.3	66.3	15	-81.3	0.001
				≤32	TOTAL	-61.4		30.9			TOTAL	0.187
						(tot +'s)		(tot +'s)			D _{nTw}	61
											C _{tr}	-3.7
											D _{nTw} + C _{tr}	57.3



Separating Floor Tests

ISO 717 Calculation Sheets

Living Room

Living	L1	L2	Diff				6		D	L		
Hz	dB	dB		D _{nT}	Ref Values	Diff	Shifted Ref	Revised Dif	D _{nT}	Ctr' Spectrum	Diff	10 ^{(L-D)/10 x 10⁵}
Band	Leq	Leq										
100	97.2	58.2	39.0	39.0	33	-6.0	39	0.0	39.0	20	-59.0	0.126
125	101.9	63.0	38.9	38.9	36	-2.9	42	3.1	38.9	20	-58.9	0.128
160	101.6	59.5	42.2	42.2	39	-3.2	45	2.8	42.2	18	-60.2	0.097
200	102.3	56.2	46.1	46.1	42	-4.1	48	1.9	46.1	16	-62.1	0.062
250	100.4	51.1	49.3	49.3	45	-4.3	51	1.7	49.3	15	-64.3	0.037
315	99.3	49.1	50.2	50.2	48	-2.2	54	3.8	50.2	14	-64.2	0.038
400	96.0	47.1	48.9	48.9	51	2.1	57	8.1	48.9	13	-61.9	0.065
500	93.6	40.8	52.9	52.9	52	-0.9	58	5.1	52.9	12	-64.9	0.033
630	92.6	34.2	58.4	58.4	53	-5.4	59	0.6	58.4	11	-69.4	0.011
800	92.2	33.2	59.1	59.1	54	-5.1	60	0.9	59.1	9	-68.1	0.016
1k	92.8	31.1	61.7	61.7	55	-6.7	61	-0.7	61.7	8	-69.7	0.011
1k25	94.1	28.1	65.9	65.9	56	-9.9	62	-3.9	65.9	9	-74.9	0.003
1k6	93.2	27.9	65.3	65.3	56	-9.3	62	-3.3	65.3	10	-75.3	0.003
2k	91.7	26.1	65.6	65.6	56	-9.6	62	-3.6	65.6	11	-76.6	0.002
2k5	91.7	25.0	66.6	66.6	56	-10.6	62	-4.6	66.6	13	-79.6	0.001
3k15	90.4	22.4	68.0	68.0	56	-12.0	62	-6.0	68.0	15	-83.0	0.000
			≤32	TOTAL	-45.9		28.1			TOTAL	0.632	
					(tot +'s)		(tot +'s)			D _{nTw}	58	
										C _{tr}	-6.0	
										D _{nTw} + C _{tr}	52.0	



Separating Floor Tests

ISO 717 Calculation Sheets

Bedroom

Bedroom	L1	L2	Diff				7		D	L		
Hz	dB	dB		D _{nT}	Ref Values	Diff	Shifted Ref	Revised Dif	D _{nT}	Ctr' Spectrum	Diff	10 ^{(L-D)/10 x 10⁵}
Band	Leq	Leq										
100	97.2	53.5	43.7	43.7	33	-10.7	40	-3.7	43.7	20	-63.7	0.043
125	101.9	54.3	47.7	47.7	36	-11.7	43	-4.7	47.7	20	-67.7	0.017
160	101.6	58.1	43.6	43.6	39	-4.6	46	2.4	43.6	18	-61.6	0.070
200	102.3	53.9	48.4	48.4	42	-6.4	49	0.6	48.4	16	-64.4	0.036
250	100.4	51.0	49.4	49.4	45	-4.4	52	2.6	49.4	15	-64.4	0.036
315	99.3	47.9	51.4	51.4	48	-3.4	55	3.6	51.4	14	-65.4	0.029
400	96.0	44.1	51.9	51.9	51	-0.9	58	6.1	51.9	13	-64.9	0.032
500	93.6	42.0	51.7	51.7	52	0.3	59	7.3	51.7	12	-63.7	0.043
630	92.6	32.7	59.9	59.9	53	-6.9	60	0.1	59.9	11	-70.9	0.008
800	92.2	32.5	59.7	59.7	54	-5.7	61	1.3	59.7	9	-68.7	0.013
1k	92.8	31.8	61.0	61.0	55	-6.0	62	1.0	61.0	8	-69.0	0.013
1k25	94.1	28.7	65.4	65.4	56	-9.4	63	-2.4	65.4	9	-74.4	0.004
1k6	93.2	28.7	64.6	64.6	56	-8.6	63	-1.6	64.6	10	-74.6	0.003
2k	91.7	27.8	63.9	63.9	56	-7.9	63	-0.9	63.9	11	-74.9	0.003
2k5	91.7	27.2	64.4	64.4	56	-8.4	63	-1.4	64.4	13	-77.4	0.002
3k15	90.4	23.3	67.1	67.1	56	-11.1	63	-4.1	67.1	15	-82.1	0.001
			≤32	TOTAL	-51.4		25.0			TOTAL	0.353	
					(tot +'s)		(tot +'s)			D _{nTw}	59	
										C _{tr}	-4.5	
										D _{nTw} + C _{tr}	54.5	