39-45 Gray's Inn Road
London

PLANT NOISE ASSESSMENT
REPORT 20447/PNA1 Revision 2

For:

The Lincolns Management Limited
Care of; Opai Developments Ltd
3rd Floor
33 Lowndes Street
London
SW1X 94X

15 July 2014

HANN TUCKER ASSOCIATES
Consultants in Acoustics
Noise and Vibration

Head Office
Duke House
1-2 Duke Street
WOKING
Surrey GU21 5BA

Tel : 01483 770595
Fax : 01483 729565

Northern Office
First Floor
346 Deansgate
MANCHESTER
M3 4LY

Tel : 0161 832 7041
Fax : 0161 832 8075

E-mail : Enquiries@hanntucker.co.uk
www.hanntucker.co.uk

REPORT 20447/PNA1 Revision 1

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Revision No.	Date	Description
1	11/07/2014	Inclusion of night set back mode following liaison with manufacturer.
2	15/07/2014	Update client's title

1.0 INTRODUCTION

39-45 Gray's Inn Road is currently vacant. It is proposed to redevelop the building into multiple residential dwellings with a retail outlet (Co-operative).

As part of the proposals, a number of new items of plant are to be installed that will service the residential dwellings and the retail outlet. These will need to be compliant with the Planning Conditions imposed by Camden Borough Council (Conditions 8 and 11).

Hann Tucker Associates have been commissioned to undertake a plant noise assessment based on the plant noise emissions criteria and previous noise survey data presented in Hawkins Environmental's Noise Repot dated 29 May 2013.

2.0 OBJECTIVES

To assess the noise emissions from the proposed plant based upon data with which we are provided, and comment upon the acceptability in accordance with Condition 8.

To assess the requirement of any attenuation measures associated with plant noise emissions from the A1 unit (Co-operative) in accordance with Condition 11.

To provide details of anti-vibration measures associated with the residential plant that is to be located at roof level.

The assessment will be based on the criteria and noise survey report provided by Opai Investments Ltd.

To present our results in a Report to support the planning application as far as reasonably possible.

3.0 PLANT NOISE EMISSION CRITERIA

39-45 Gray's Inn Road, London (referred to as "site" from here on) lies within the London Borough of Camden, who have issued the following Planning Condition relating to noise emissions from all mechanical plant:

<u>Condition 8</u>

"Noise levels at a point 1 metre external to sensitive facades shall be at least 5dBA less than the existing background measurement (LA90), expressed in dBA when all plant/equipment (or any part of it) is in operation unless the plant/equipment hereby permitted will have a noise that has distinguishable discrete continuous note (whine, hiss, screech, hum) and/or if there are distinct impulses (bangs, clicks, clatters, thumps)., then the noise levels from that piece of plant/equipment at any sensitive façade shall be at least 10dBA below the LA90, expressed in dBA."

Based on the results of the Hawkins Environmental's Noise Report and the advice above, the following plant noise emission levels are to be achieved with all plant running simultaneously at the nearest upper level residential window.

Plant Noise Emission Criteria (dBA re:2x10^{-5}Pa)			
Position	**Daytime 07:00 to 23:00**	**Night-Time 23:00 to 07:00**	**24 Hours**
Front Windows	62*	44	44
Rear Windows	38*	29	29

Values in table are 5dB below the measured night-time LA90 background levels reported.
* Day-time values are presented as $L_{Aeq\ (I\ Hour)}$ values in Hawkins Environmental Report.

It should be noted that the above criteria are subject to final approval by Camden Borough Council.

A second planning condition has been provided by Camden Borough Council which relates to ventilation of the A1 premises (Co-operative). The condition is set out below:

Planning Condition 11

"Prior to the first use of the premises for A1 use hereby permitted, full details of a scheme for ventilation, including manufacturers specifications, noise levels and attenuation shall be submitted to and approved by the Local Planning Authority in writing. The use shall not proceed other than in accordance with such scheme as has been approved. All such measures shall be retained and maintained in accordance with the manufacturers' recommendations."

We understand the fit-out will be completed by the tenant and we are therefore only able to provide data for items that our client has been briefed on and will provide as part of their scope of work; namely to supply the plant described in Section 4.1 (external plant).

4.0 PLANT NOISE ASSESSMENT

4.1 Proposed Plant

We understand that the following item of plant is to be installed at site.

Residential Plant

Plant Description	Location	Qty	Plant Make	Model Number
Condensing Unit	Roof-top Plant Enclosure	16	Daikin	RXYSQ4PV

A1 Unit Plant

Plant Description	Location	Qty	Plant Make	Model Number
Condensing Unit	First Floor Roof Plant Area	2	Daikin	LRYEQ16AY1

4.2 Plant Noise Emissions

We understand the manufacturer's noise data for the equipment to be as follows:

Plant Description	Sound Pressure Level (dB re $2x10^{-5}$ Pa) at 1 metre at Octave Band Centre Frequency (Hz)								dBA
	63	125	250	500	1k	2k	4k	8k	
RXYSQ4PV	62	54	54	52	48	41	34	26	53
LRYEQ16AY1	71	66	66	63	65	61	50	44	68

4.3 Location of Plant

4.3.1 Residential

The mechanical plant which will serve the residential dwellings is to be located on the roof of the building in a purpose designed enclosure which will house all 16No. units.

4.3.2 A1 Unit

The plant items serving the Co-operative are to be located in a designated plant enclosure on the First Floor roof of their own retail unit to the rear of the buildings on Gray's Inn Road. The plant items will be located in a purpose designed acoustic enclosure.

4.4 Nearest Residential Dwelling

4.4.1 Residential

The plant enclosure is located approximately 6 metres from the windows to the front of site and approximately 7 metres away from the windows to the rear of site.

Owing to the height of the plant enclosure in relation to the plant, there will also be attenuation due to the screening effect; this will be quantified in our calculations table and was calculated as a double diffraction barrier due to the shape of the roofline.

4.4.2 A1 Unit

We understand the nearest noise sensitive windows will be the First Floor residential windows of site, which are located approximately 4 metres away from the plant.

4.5

4.6 Plant Noise Impact Assessment

The following tables present our calculations relating to the proposed plant installations:

Residential Plant

Daytime Hours

Plant	Sound Pressure Level (dB re 2x10^{-5} Pa) at 1 metre at Octave Band Centre Frequency (Hz)								dBA
	63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**	
RXYSQ4PV	62	54	54	52	48	41	34	26	53
Correction for 16No. units	+12	+12	+12	+12	+12	+12	+12	+12	-
Cumulative Total for all Residential Plant	**74**	**66**	**66**	**64**	**60**	**53**	**46**	**34**	**65**
Distance Loss	-8	-8	-8	-8	-8	-8	-8	-8	-
Barrier Correction (Roof)	-10	-13	-16	-21	-25	-25	-25	-25	-
Calculated Noise Level at 1 Metre from Nearest Dwelling	**56**	**45**	**42**	**35**	**27**	**20**	**13**	**5**	**38**

We understand that the proposed units have the potential to be operational during daytime and night-time hours.

Our calculations indicate that the proposed plant will meet the requirements of the Local Authority outlined in Section 8.0 during daytime hours at the noise sensitive window.

Night-Time Hours

We understand the items of plant that serve the residential dwellings will be limited to a noise level of 41dBA at 1 metre (each) due to a setback mode that will restrict operation during night-time hours.

We have been advised the night setback mode represents a reduction of approximately 9dB per unit. This should lower the resultant noise level at a distance of 1 metre from the noise sensitive by the same amount, which would meet the requirements of the Local Authority outlined in Section 8.0.

A1 Unit Plant

The 2No. Daikin LRYEQ16AY1 items that are proposed for the A1 unit have been designed in accordance with noise limits proposed following a noise survey and report produced by Belair research Ltd. (a copy of is enclosed).

Acoustical Control Engineers Ltd. Have designed a suitable acoustic enclosure that will be capable of meeting the required noise levels of 39dB during daytime and 29dBA at night-time at a distance of 1 metre from the nearest noise sensitive façade.

From a tele-con with Acoustical Control Engineers Ltd., we understand they are instructed to provide a packaged solution that complies with the content of Belair Research's report and have signed a contract on that basis.

5.0 ANTI-VIBRATION MEASURES

5.1 Vibration Criterion

Vibration transfer from continuous sources (e.g. plant items) to internal areas should not exceed 0.01m/s^2 peak acceleration, based on W_b weighting as defined in clause 3.3 of BS 6472-1: 2008.

All items of building services plant shall be isolated on suitable anti-vibration mountings to reduce the transfer of vibration and associated structure-borne noise within the building.

5.2 Anti-Vibration Mounts

All items of building services plant should be fitted with vibration isolators to control the transmission of vibration to the building structure.

It is important that all AVM's are manufactured in accordance with our "General Specification for Acoustic and Vibration Isolation Materials and Products" which is enclosed.

A vibration isolator schedule is enclosed.

6.0 CONCLUSIONS

Using previous noise survey data by Hawkins Environmental, plant noise criterion has been proposed for the residential plant and an assessment has been carried out to determine the plant noise emissions at a distance of 1 metre away from the window of the nearest dwelling.

The plant noise assessment has been carried out for the residential plant in order to discharge Planning Condition 8.

Our assessment indicates that the proposed plant should meet the requirements of the Local Authority 1 metre away from the window during daytime hours. During night-time hours the units would be running on a nigh setback mode which restricts the units to a level that meets the night-time criteria.

The A1 unit's mechanical plant will be enclosed in an acoustic enclosure that is capable of meeting the requirements of the Local Authority. Acoustical Control engineers Ltd. are contractually obliged to provide this. This information is provided in order to demonstrate evidence in respect of Planning Condition 11.

We have provided a Vibration Isolation Schedule of which is enclosed. This should be read in conjunction with our General Specification

We have therefore proposed a number of amelioration measures which should enable compliance with the requirements of the local authority.

Prepared by
Paul Hill
Senior Consultant
HANN TUCKER ASSOCIATES

Checked by
John Ridpath
Director
HANN TUCKER ASSOCIATES

Appendix A

The acoustic terms used in this report are as follows:

dB : Decibel - Used as a measurement of sound pressure level. It is the logarithmic ratio of the noise being assessed to a standard reference level.

dBA : The human ear is more susceptible to mid-frequency noise than the high and low frequencies. To take account of this when measuring noise, the 'A' weighting scale is used so that the measured noise corresponds roughly to the overall level of noise that is discerned by the average human. It is also possible to calculate the 'A' weighted noise level by applying certain corrections to an un-weighted spectrum. The measured or calculated 'A' weighted noise level is known as the dBA level.

Because of being a logarithmic scale noise levels in dBA do not have a linear relationship to each other. For similar noises, a change in noise level of 10dBA represents a doubling or halving of subjective loudness. A change of 3dBA is just perceptible.

L_{10} & L_{90}: If a non-steady noise is to be described it is necessary to know both its level and the degree of fluctuation. The Ln indices are used for this purpose, and the term refers to the level exceeded for n% of the time, hence L_{10} is the level exceeded for 10% of the time and as such can be regarded as the 'average maximum level'. Similarly, L_{90} is the average minimum level and is often used to describe the background noise.

It is common practice to use the L_{10} index to describe traffic noise, as being a high average, it takes into account the increased annoyance that results from the non-steady nature of traffic noise.

L_{eq} : The concept of L_{eq} (equivalent continuous sound level) has up to recently been primarily used in assessing noise in industry but seems now to be finding use in defining many other types of noise, such as aircraft noise, environmental noise and construction noise.

L_{eq} is defined as a notional steady sound level which, over a stated period of time, would contain the same amount of acoustical energy as the actual, fluctuating sound measured over that period (e.g. 1 hour).

The use of digital technology in sound level meters now makes the measurement of L_{eq} very straightforward.

L_{max} : L_{max} is the maximum sound pressure level recorded over the period stated. L_{max} is sometimes used in assessing environmental noise where occasional loud noises occur, which may have little effect on the L_{eq} noise level

39-45 GRAY'S INN ROAD

ACOUSTIC SPECIFICATION FOR

ACOUSTIC LOUVRE SCREENING

Acoustic louvre screening shall extend continuously across the top of the plant area to form an enclosure.

The louvre blades shall face in the direction opposite to that which would be conventional for weather louvers, such that the plant is not visible between the louvre blades when viewed from below.

Performance

The acoustic louvres shall be at least 300mm deep and provide, in their as-installed condition, the following minimum combined sound reduction indices (SRI's)/Transmission Losses when tested in accordance with BS EN ISO 10140-2:2010:

Minimum Sound Reduction Index (dB) at Octave Band Centre Frequency (Hz)							
63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
6	7	10	12	18	18	14	13

Construction

The louvre frame shall be constructed from a suitable gauge of galvanised mild steel, or aluminium, supporting louvre blades of like material. The acoustic material in the blades shall be packed to a density of not less than $45kg/m^3$ and be inert, rot and vermin proof, non-hygroscopic incombustible mineral fibre. This shall be faced with glass fibre cloth, or other approved infill protection membrane, and retained on the lower blade face by perforated galvanised mild steel or aluminium (not "expamet" or similar derivative) having a minimum thickness of 0.5mm fixed at 200mm (max) centres.

All junctions between the acoustic screen and adjacent structures shall be made good and sealed with a heavy grout and/or non-hardening dense mastic.

The supplier shall ensure that the assembled enclosure is designed and constructed to withstand site operating conditions such as wind and snow loads, etc., as appropriate, and is suitably weatherproofed.

The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

Any deviations from the above specification must be agreed by, and confirmed in writing to, Hann Tucker Associates.

SUITABLE SUPPLIERS

of

ACOUSTIC LOUVRES

Name & Address	Telephone Number	Contact
Industrial Acoustics Company Ltd Simmons IAC House Moorside Road Heatherington Winchester Services) Hampshire SO23 7US	01962 873000	Scott (Industrial) Andy (Building
Allaway Acoustics Ltd 1 Queens Road Hertford SG14 1EN	01992 550825	Jim Grieves Roger Wade

THE ABOVE DOES NOT CONSTITUTE A RECOMMENDATION

VIBRATION ISOLATOR SCHEDULE

39-45 GRAY's INN ROAD, LONDON

Hann Tucker Associates

Woking (Head Office)
Tel: 01483 770595

Manchester (Northern Office)
Tel: 0161 832 7041

REF: HT: 20447/ VIS1

Revision: 0	Date: 8 July 2014	Comments: None					
AVM Ref.	Plant Ref	System Description	Location	Power (kW)	Base Code	Isolator Code	Static Deflection (mm)
1	-	Residential Condensers	Rooftop Plant Enclosure	-	-	OSS/R	25
2	-	A1 Condensers	1st Floor Plant Enclosure	-	-	OSS/R	25
-	-	Condenser Pipework	First 100				

Base Code and Description	HTA Spec Ref
AVR : A V Rails	4.7.1
SFB : Steel frame base	4.7.2
CIB : Concrete inertia base	4.7.3
CSP : Concrete split plinth	4.7.4

Isolator Code & Description	HTA Spec. Ref.
NP : Neoprene Pads	-
CSS : Caged steel spring	4.2
OSS : Open steel spring	4.3
NIS : Neoprene-in-shear	4.4

Isolator Code & Description	HTA Spec. Ref.
HSS : Hangers with steel springs	4.5
HNT : Hangers with neoprene turrets	4.6
_/R : Restraining or positioning device	4.1.1

Note 1 : To be read in conjunction with HTA's General Specification for Acoustic & Vibration Isolation Materials and Products (available upon request if not supplied).

Note 2 : All cased fans shall have the above specified isolators internally beneath fan/motor frame, and be additionally isolated externally with neoprene pads having 2 mm (min) deflection.

Note 3 : All pipework to be isolated between the plant and the first structural penetration using AV hangers/mounts with the above specified static deflection, and thereafter with brackets having neoprene inserts. CW booster pipework to be isolated on AV hangers throughout.

BELAIR RESEARCH LIMITED
BROADWAY . BOURN . CAMBRIDGESHIRE . CB23 2TA
Tel: (01954) 718366 Fax: (01954) 718355
Email: brl@acoustical.co.uk

ACOUSTIC ASSESSMENT OF NOISE FROM REFRIGERATION/AIR CONDITIONING PLANT AT CO-OP, GRAYS INN ROAD, LONDON WC1X 8PR

Client:	BJA Refrigeration Consulting Engineers Limited Bridge Mills Huddersfield Road Holmfirth HD9 3TW
Instruction:	Teresa Sleigh BJA Refrigeration Consulting Engineers Limited
Project Manager:	Shaun Law BJA Refrigeration Consulting Engineers Limited
Report Author:	T S Leach
Brief:	To visit the site, take measurements and record relevant observations to assess the existing acoustic environment in the vicinity of the site. To provide advice regarding suitable acoustic criteria for the selection of future plant, relating this to 'typical' manufacturers' data in order to facilitate plant selection.
Plant Selection:	**Plant located on the roof of the store will have several reflective vertical surfaces (walls, etc.) and will be approximately 4m from, with significant screening preventing any direct line of sight to the nearest noise sensitive windows.** **The equivalent cumulative global average 'free field' sound pressure level from all new and existing plant should not exceed 29dB(A) at a distance of 10m from the plant when operating at maximum night time capacity. This equates to a sound power level of 57dB(A). As a guide, typical ambient day time levels are generally assumed to be around 10dB(A) higher than during the night. It is likely that the plant selection will therefore be most significantly constrained by the requirement to achieve a suitable level during the night.** **Ideally this should be achieved with the use of inverter speed control systems where this is appropriate. Sound from the plant should not contain significant tonal or impulsive components and should not be significantly directional.**

Survey: Time – 00:15 hours – 01:30 hours
Date – Thursday 10th January 2013
Weather – Still, 100% low cloud, 5°C, dry ground surfaces, light fog.

Personnel: T S Leach – Belair Research Limited

Instrumentation: Rion 1/3 Octave Band Analyzer Type NA-28, Serial No. 01070575
Rion Sound Calibrator Type NC-74, Serial No. 35173526
Rion Windshield

Tripod

In accordance with relevant Standards, the performance of calibrators is checked by an accredited laboratory annually, with sound level analysers being checked on a bi-annual basis.

Observations: The store will be located on the ground floor of a four storey residential building as part of a terrace of similar buildings facing Grays Inn Road, situated in the busy borough of Camden. In front of the store on the opposite side of Grays Inn Road are a number of commercial buildings with residential accommodation above. Above the rear of the store facing King's Mews are a number of dwellings on the first floor of the building. To the rear of the store on the opposite side of King's Mews are a number of dwellings and a small car park. Plant is to be located within a screened area on the first floor flat roof between the dwellings located above the store entrance and the dwellings to the rear of the store.

There do not appear to be any different locations at this site where plant could be installed that provide significant acoustic advantages in comparison with the proposed plant arrangement.

The location picture towards the end of the report shows the layout of the store and surrounding area, together with the measurement location identified and numbered as appropriate. The outline of the store is approximately indicated in brown, with some potential night time noise sensitive areas shown in green. Existing plant is shown with a solid blue area with a blue outline denoting a potential plant location.

Sources of ambient noise in the vicinity of the site included road traffic, of which more distant vehicles produced a relatively steady underlying sound level, with nearby vehicles producing relatively short duration increases superimposed upon this. Noise from passing traffic dominated the soundscape in the vicinity of the store. Other sources of residual noise at the time of the survey included pedestrians – particularly when conversing, occasional aircraft, plant at other premises and some noise due to the movement of flowing water in drains.

Measurements:

Sound pressure level measurements were taken at one location in the vicinity of the site. The purpose of the measurements was to assess the residual sound level at the dwellings nearest to the site.

The measurements consist of consecutive instantaneous sound pressure levels recorded every one tenth of a second throughout the measurement period. This method has the advantage of allowing individual events such as vehicles passing by to be identified and quantified, together with providing longer term statistical information where this is appropriate. The data is presented in a graphical format, which assists subsequent analysis and enables relevant comparisons to be made of measurements at different locations or under different operating conditions.

Graph 1 provides details of the measurements taken during the survey. The measurements were undertaken in front of the dwellings to the rear of the store. From the graph it can be seen that the residual sound level varied between around 45dB(A) and 55dB(A) with frequently passing traffic causing levels to rise somewhat to around 60dB(A). Passing busses resulted in noise levels of around 63dB(A) on several occasions, with their air brakes causing levels of around 70dB(A).

Criteria:

When considering noise sources that operate for 24 hours per day, as is typical for retail refrigeration plant and associated equipment, the most critical times in terms of sleep disturbance are when residents are preparing for and going to sleep and some time before people awaken in the morning. In this case, it is important to ensure that a suitable noise level is achieved inside the bedrooms of nearby houses. The World Health Organisation[1], Department for Communities[2], DEFRA[3], the European Communities Commission[4], British Standards Institute[5] and the professional bodies for Building Services Engineers[6] provide useful guidance for this assessment.

World Health Organisation

The WHO publication 'Guidelines for Community Noise – 1999' provides guidance regarding suitable levels of noise that will protect vulnerable groups against sleep disturbance. A steady level of 30dB(A) in bedrooms, with occasional maximum levels of 45dB(A) are identified as being suitable to achieve this, with an assumed difference of approximately 15dB(A) between the noise level outdoors and that resulting in the bedroom, assuming that the bedroom windows are partly open for ventilation. This means that the corresponding targets for the noise level outdoors are steady levels of up to about 45dB(A) and occasional maxima of up to around 60dB(A).

The more recent WHO guidance 'Night Noise Guidelines for Europe – 2009' is more concerned with the longer term average noise levels that are covered by the EU Directive on Environmental Noise, although this does appear to suggest slightly lower external maximum noise levels of around 57dB(A) outside bedrooms during the night.

Furthermore the 1999 guidance states that: *To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55dBL_{Aeq} on balconies, terraces and in outdoor living areas. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50dBL_{Aeq}. Where it is practicable and feasible, the lower outdoor level should be considered the maximum desirable sound level for new development.*

BS8233: 1999 Sound insulation and noise reductions for buildings – Code of practice

This document provides guidance regarding suitable noise levels for different locations such as bedrooms, offices, living rooms, gardens, libraries, churches and factories. For bedrooms, a steady internal level of 30dB(A) represents 'good' conditions for sleeping and 35dB(A) represents 'reasonable' conditions, with individual noise events not exceeding 45dB(A). This is consistent with the current WHO guidance. Also consistent with the WHO document are the recommended maximum sound levels for outdoor living spaces to protect residents' amenity.

National Planning Policy Framework (NPPF) & Noise Policy Statement for England (NPSE)

The National Planning Policy Framework (NPPF) sets out the Government's planning policies for England and how these are expected to be applied. It sets out the Government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities

Paragraph 123 of NPPF states that:

Planning policies and decisions should aim to:

- avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
- mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;
- recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and
- identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

The Noise Policy Statement for England (NPSE) sets out the long term vision of Government noise policy by promoting good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.

Paragraph 2.23 of NPSE clarifies the first part of the above excerpt:

- The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development

Similarly paragraph 2.24 of NPSE clarifies the second part:

- The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL (Lowest Observed Adverse Effect Level) and SOAEL (Significant Observed Adverse Effect Level). It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur.

These make it clear that noise must not be considered in isolation but as part of the overall sustainability and associated impacts of the proposed development. There is no benefit in reducing noise to an excessively low level, particularly if this creates or increases some other adverse impact. Similarly, it may be appropriate for noise to have an adverse impact if this is outweighed by the reduction or removal of some other adverse impact that is of greater significance when considering the overall sustainability of the proposed development.

NPSE clarifies the difference between NOEL (No Observed Effect Level) and LOAEL as used in Night Noise Guidelines for Europe, which gives values of 30dB(A) and 40dB(A) for the night time average level measured outside dwellings respectively. This indicates that there may be no significant overall benefit in achieving an average level of less than around 40dB(A) outside dwellings during the night.

It should also be considered that in order to make equipment quieter it is often necessary to use larger equipment that operates more slowly and for longer periods of time. This may increase energy consumption and hence the carbon footprint of the equipment. The overall impact of this may outweigh any acoustic benefit of the equipment being slightly quieter.

BS4142: 1997 Method for Rating industrial noise affecting mixed residential and industrial areas

The BS4142 methodology compares the Rating Level (average source noise level with a 5dB 'Rating Penalty' if applicable), against the existing Background Level and provides an indication of the likelihood of complaints based upon this differential. If it is more than 10dB then 'there is a likelihood of complaints', 5dB is of 'marginal significance' and -10dB is a 'positive indication that complaints are unlikely'. This means that there is a difference of 15dB (or 20dB if there is uncertainty regarding the applicability or otherwise of a Rating Penalty) between the level at which complaints are unlikely and that of marginal significance. Also depending upon the way the text of the standard is interpreted, there can be a difference of around 15dB when applying the same standard to the same situation.

The standard is often mis-applied to a diverse range of situations outside of the stated scope of the document. The scope of this standard is very precise in that it provides a method for assessing whether an industrial type of noise source in industrial or commercial buildings is likely to give rise to complaints from residents, based on the noise level <u>outside</u> their dwelling. It is not appropriate for the assessment of the noise from fixed plant and equipment, specifically during the early hours of the morning, when the primary concern is to ensure that the noise level <u>inside</u> the dwellings is at a suitable level.

Whilst it may appear reasonable to extrapolate a comparison of the outdoor source and background noise levels to within the property, this is not valid. This approach can lead to a requirement that the source noise be far quieter than levels that represent 'good' acoustic conditions within bedrooms, which will themselves protect residents against sleep disturbance, at times when the residents will be asleep. This also ignores the fact that noise within dwellings comes not only from external noise breaking into the building but also from sources within the dwelling, such as boilers, pumps, refrigerators and fans during the night, together with activity noise during the day and other sources such as televisions, music and radios.

This approach also considers only the average noise level (plus a 5dB Rating penalty if applicable). This means that occasional loud events are simply assessed in terms of the average noise level plus 5dB(A), which takes only limited account of the maximum level, duration and number of events.

For example, six events per hour (one every ten minutes) each producing a level of 64dB(A) would have a Rating Level of 41dB(A), as would the same number of events, but each one of five seconds duration and only producing a level of 57dB(A). According to WHO guidance the first would be likely to cause sleep disturbance, whereas the second would not, but a BS4142 assessment would yield the same outcome in both cases, which would be totally dependent upon only the background sound level.

In a location with a background sound level of 31dB(A) a BS4142 assessment would indicate that this is 'likely to cause complaints'. However, such a location could be in a relatively remote rural area where the events would be readily noticeable within the dwelling (with open windows), or beside a road with vehicles passing every five minutes at relatively high speed, possibly producing maximum levels of over 70dB(A) at the same dwelling, where the events would be relatively insignificant.

CIBSE & ASHRAE – Guide to Current Practice

The Chartered Institute of Building Services Engineers (CIBSE) is the professional body for engineers responsible for the design, selection and specification of building services plant such as fans, pumps and chillers. It provides guidance for suitable levels of noise from mechanical plant depending upon the use and associated sensitivity of the area to be considered. ASHRAE, which is CIBSE's counterpart in the USA also provides similar guidance. For bedrooms the recommended level varies from around NR20 for quiet rural locations, NR25 for suburban locations, to NR30 for busy urban locations.

Applying a conversion factor of about 6 from an NR value to a dB(A) value and a 'open window' attenuation of 10dB(A) to 15dB(A), this equates to a level of approximately 36dB(A) to 51dB(A) outside the dwellings. However, mechanical plant noise has different frequency components to transportation noise and it may be more prudent to use a differential of about 13, as a result of which the recommended range equates to free field levels of about 33dB(A) to 43dB(A) outside the dwellings.

Discussion

The London Borough of Camden's planning policy with regards to noise from mechanical plant states in Development Policy 28 – Table E; that noise 1m from a sensitive façade should be no more than 5dB(A) below the measured L_{A90}, with a 5dB(A) penalty applied to machinery that has audibly distinguishing features.

Current planning policy contained in the NPPF and NPSE suggests that there may be no significant benefit in limiting external sound levels to much below 40dB(A). It is also clear that noise should not be considered in isolation but must be regarded as one of many elements to be balanced in order to produce a sustainable outcome. The sound levels set out in the new policy documents are built upon principles contained within guidance from the WHO and BS8233 which indicates that a steady level of 30dB(A) within bedrooms represents 'good' acoustic conditions.

Applying a conservative correction for the attenuation provided by windows that are partly open for ventilation and conversion to dB(A) figures to NR25 recommended by CIBSE for mechanical plant noise within the bedrooms of dwellings such as this, equates to an external noise level of around 38dB(A), which is consistent with the recently published planning policy.

The WHO guidelines suggest that to prevent residents from being moderately annoyed, the sound level in outdoor living spaces should generally not exceed $50dBL_{Aeq}$. The vast majority of gardens and other outdoor living spaces are subject to a varied soundscape comprising many different sound sources of which new refrigeration or air conditioning plant may be one of them. Therefore it is necessary to take account of the cumulative effect of all noise sources affecting a particular area. For this reason it is appropriate to ensure that noise from plant does not exceed around 45dB(A) to 50dB(A) at the closest garden or other outdoor noise sensitive area.

During the day the ambient noise level is generally significantly higher than during the night. Nearby locations are also less sensitive to noise. This means that the corresponding 'suitable' day time level is significantly higher than at night. Inverter control systems can take advantage of this, by limiting the speed and noise of plant at night (when lower capacity is required) and operating at higher speeds during the day when the higher levels of noise are acceptable. This means that by selecting plant to achieve suitable noise levels at night, suitable levels of noise are produced during the day time.

Care must be taken to ensure that noise from the plant does not contain any tonal or impulsive characteristics that would otherwise draw a listener's attention to this source of noise otherwise this may increase any apparent intrusiveness of the noise source.

The plant should therefore be selected to achieve a 'free field' level of 38dB(A) at the nearest dwelling when operating at maximum night time capacity and 45dB(A) at the nearest appropriate noise sensitive location when operating at full capacity during the day. This means that the actual level produced under normal conditions will be lower than this, particularly if inverter speed control systems are used where this is appropriate. However, care must also be taken to ensure that noise from the plant does not contain any significant tonal or impulsive components.

Analysis:

Graph 1 shows that the identified 'suitable' noise level was somewhat lower than the residual noise level in the vicinity of the store at the time of the survey. However, it should also be remembered that this 'suitable' level will be achieved with all plant operating at maximum night time capacity. For the vast majority of time the plant will operate at lower capacity than this during the night which means that the actual noise level at the nearest dwellings will be lower than this. Therefore the actual noise level at the nearest noise sensitive locations will be significantly lower than the existing residual sound level during the quietest part of the night. This level has also been identified as suitable to ensure that noise from the plant does not disturb the nearest residents, even when sleeping with open bedroom windows.

Although sound level meters generally show the measured level to 0.1dB resolution, this is not the accuracy of the measurement for a variety of reasons. In addition to measurement uncertainty, which is likely to be somewhat more than 1dB, it should be noted that the sound level at any location varies often by many dB(A), even at the same time of the day or night. This can be due to many different factors including meteorological conditions, noise source characteristics such as equipment operation, human or animal activity and even foliage. This does not mean that there is an 'error' in the measurements, but that even under apparently ideal measurement conditions the 'measurement uncertainty' will inevitably be several dB(A). Good measurement practice such as ensuring appropriate wind speed and direction, no significant precipitation effects or unrepresentative measurement conditions, using 'accurate' reliable instrumentation to measure appropriate parameters, will reduce this uncertainty and the associated variability in measurements, but it is still to be expected that measurements taken under apparently similar conditions on different occasions will differ considerably, and usually by somewhat more than the variation noted during the quieter part of any one night, for example.

However, even though the residual noise level may vary considerably it is likely that this will not generally be noticed by residents who are more likely to pay relatively little attention to the underlying soundscape, and are probably relatively unaware of its characteristics and level during the night, when they are asleep indoors, albeit possibly with open bedroom windows.

This means that the sound level measured at any specific location on one particular occasion under certain measurement conditions can only be an indication of the sound level at that time and place under those specific conditions. It is likely that even under apparently similar conditions the sound level at a different time – even at the same time of the day/night and same location will differ considerably.

This means that if a criterion is solely dependent upon the measured sound level there will be a considerable range in what the criterion may be, depending upon the specific circumstances when such measurements are taken. However, using the character of the existing soundscape to inform the appropriate selection of objective criteria such as those previously identified ensures a consistent approach to the determination of suitable criteria and generally prevents this particular problem from arising.

The sound level from a relatively small noise source is attenuated by 6dB(A) for every doubling of distance. Unless the position of a noise source is known and fixed, there is no direct equivalent between the sound pressure level outside a house and that at the boundary of the site. This is best illustrated by an example:

> If a noise source is located 2m inside the boundary and the nearest house is 30m away from the boundary, there will be a doubling of distance from the source (relative to the boundary) at distances of 4m, 8m, 16m and 32m (at the house) from the source. These four doublings of distance mean that the noise level at the house will be 4 x 6 i.e. 24dB(A) less than the level measured at the boundary.
>
> This should be compared with a source located 30m inside the boundary, for the same house. In this case, the house is exactly twice the distance from the source than the boundary is, so the noise level at the house will be only 6dB(A) lower than at the boundary.

Clearly, for the two different sources to produce the same noise level at the house, one must be 18dB(A) lower than the other when measured at the site boundary.

A boundary noise limit designed to protect off-site noise sensitive locations from noise sources at unspecified locations on a site may inadequately protect the noise sensitive locations or could potentially require massive over attenuation of noise sources which are close to the site boundary. The most appropriate location for the specification of noise limits is outside any noise sensitive locations (houses).

If the speed of fans is halved the corresponding aerodynamic noise level falls by approximately 16dB(A) to 18dB(A). If instead the number of fans operating is halved, the corresponding reduction in noise is only 3dB(A). This means that acoustically it is far better to keep all plant operating at lower speed, when lower capacity is required, than simply to switch some of the plant off and keep the remainder operating at full capacity. For the vast majority of the time when refrigeration or air conditioning plant does not need to operate at its full capacity (which is intended to cope with the greatest demand during the peak of the summer), the plant can operate at lower capacity. Inverter speed control systems provide this capability, consequently producing significantly lower levels of noise than the 'worst case' situation with the plant operating at maximum capacity.

Some motor/inverter combinations can produce higher levels of noise than is the case without an inverter. This is due to the interaction between the inverter and motor and often tends to be of a 'tonal' nature. Tonal noise can also be produced by other factors, such as the rate at which fan blades pass an obstruction.

Where the noise level rapidly changes by a significant amount this 'impulsive' characteristic tends to draw a listener's attention to the changing level of noise. This can happen when non inverter controlled units suddenly start or stop (particularly with noise from relays).

Manufacturers generally state the noise (sound pressure, Lp) level that their plant will produce at a specific distance from the plant. The sound power level (Lw) is the actual sound energy produced by the plant and should be corrected to give the corresponding sound pressure level at the required distance from the plant. For many items of plant a default distance of 10m is used. This report will therefore recommend suitable levels at this distance from plant for ease of comparison with manufacturers' data.

Most plant emits different levels of sound in different directions. Care must be taken to ensure that the level of noise emitted in the direction of any noise sensitive locations is not higher than may be expected from a simplistic reading of manufacturer's data. For example the sound level 10m directly above a vertical airflow flat bed condenser is typically about 6dB(A) to 7dB(A) higher than the corresponding level in a horizontal direction from the fan deck. A 'global average' sound pressure level is the logarithmic average of the levels measured in all directions from the plant. This tends to be biased towards the higher levels of noise.

As previously noted the level of sound from a 'point' source reduces at a rate of 6dB for every doubling of distance from the source. This means that the level at 20m will be 6dB less than at 10m and the level at 40m (two doublings) will be 12dB less than at 10m. Similarly the level at 100m will be 20dB less than at 10m, although other factors can also affect the sound level at relatively great distances from a noise source

If there is no direct 'line of sight' between a noise source and listener, the resultant noise level at the listener's location will be lower than would otherwise be the case (typically by between about 5dB and 15dB) due to the 'acoustic screening' along the propagation path.

Manufacturer's data also relates to the sound level measured under 'free field' conditions (without any reflective surfaces nearby). When plant is installed near to reflective surfaces such as walls (often the case) the resultant sound level is increased – generally by between 3dB(A) and 10dB(A).

The aim of this analysis is to provide a single figure for plant selection purposes that equates to the manufacturer's specification, but takes into account the site-specific factors that influence sound propagation from source to receiver. Each of the corrections discussed below is applied to the recommended external suitable level of 38dB(A) to derive an appropriate level at 10m for plant selection purposes.

Plant located on the first floor flat roof of the store will be 4m from the closest noise sensitive window. As noted above plant specifications are often stated at 10m from the source which means that the corresponding correction to the recommended external suitable level is therefore -8dB(A) at 10m from the plant.

There will be no line of sight between the plant and the closest sensitive window provided by intervening structures. The corresponding correction to the recommended external suitable level at the closest sensitive window is therefore +5dB(A) for screening attenuation.

As the plant will be located in the vicinity of several walls, sound will be reflected towards the closest sensitive area. The recommended external suitable level at the closest sensitive window is therefore corrected by -6dB(A) for any reverberant effect.

If multiple items of plant are to be installed it will be necessary to select plant such that the overall sound level at the closest sensitive location does not exceed the recommended suitable level and additional guidance should be sought in this case.

Applying the corrections identified above to the recommended suitable night-time external sound level of 38dB(A), indicates that the plant should be selected based on a cumulative global average free field sound pressure level of 29dB(A) at a distance of 10m from the plant, when operating at maximum night time

Where several types of plant are to be installed some may be easier and less costly to attenuate than others. Generally it is relatively easy to attenuate noise from a compressor pack, but more costly to do so for a condenser (which may also be larger in order to achieve a lower noise level). This means that it may be most cost effective to select/attenuate some plant to 'just' comply with the required level and to over-attenuate the remaining plant so that it does not significantly increase the overall noise level. For example, in order to achieve a total level of 40dB(A) at a location, it may be appropriate to select a condenser that produces a level of 39dB(A) at the nearest noise sensitive location with all other plant producing a cumulative level of 34dB(A) at the same location.

If appropriate, in order to reduce the level of reflected/reverberant sound, acoustically absorptive surface treatment could be applied to some surfaces. There do not appear to be any appropriate alternative locations for plant to be installed at this store.

Conclusion: The existing ambient sound level in the vicinity of the site is due to a variety of nearby and more distant sources.

If appropriate the plant should make use of inverter speed control so that the criterion is achieved with the plant operating at maximum night time capacity. Care must be taken to ensure that noise from the plant does not contain any significant tonal or impulsive content and that it is not significantly directional. As further data becomes available regarding plant selections and location, more specific advice can be provided to acoustically optimise the plant installation. This can minimise the resultant noise level at identified sensitive locations and the cost/difficulty of achieving a 'suitable' noise level in order to protect the occupants of neighbouring premises.

Plant should be selected based on a cumulative manufacturer's free field global average sound pressure level of 29dB(A) at a distance of 10m from the plant when operating at maximum night time capacity. This is based on free field hemispherical propagation from a point source with a cumulative sound power level of 57dB(A) at night, in order to achieve the identified cumulative 'suitable' level of 38dB(A) at the nearest noise sensitive windows. As a guide, typical ambient day time noise levels are generally assumed to be around 10dB(A) higher than during the night. **It is likely that the plant selection will therefore be most significantly constrained by the requirement to achieve a suitable level during the night.**

Thomas S Leach

25/01/13

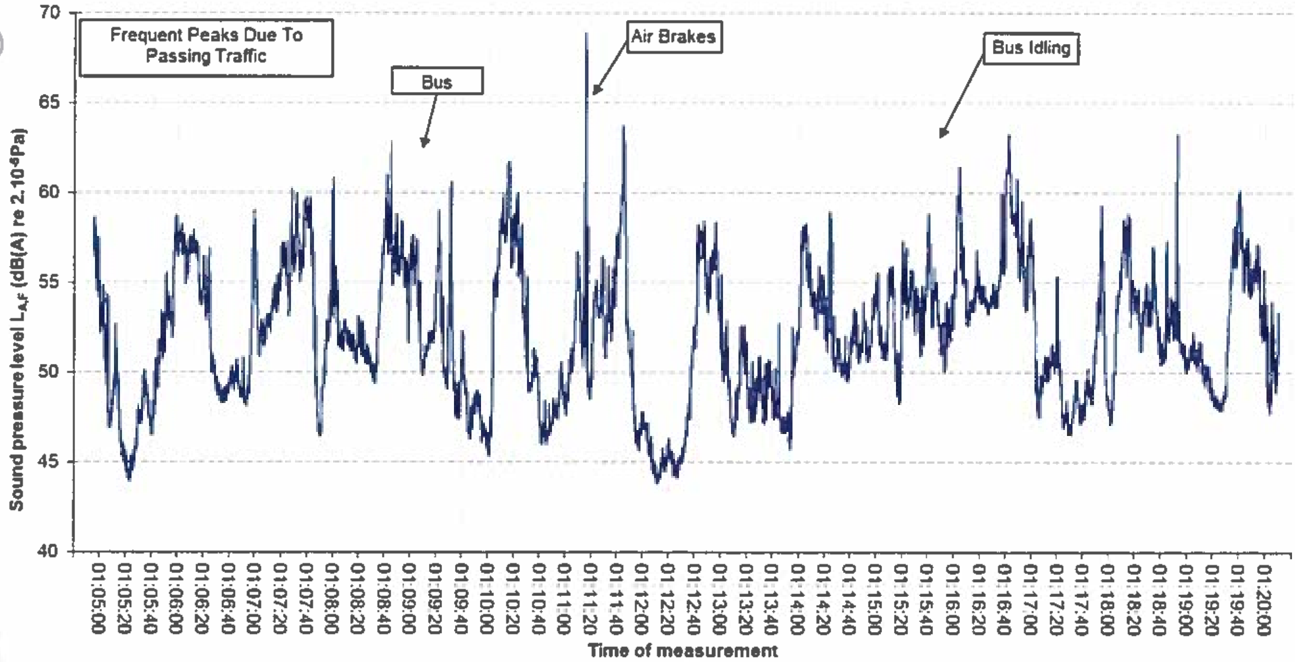
Thomas Leach, BSc (Hons), MSc, AMIOA
Acoustic Consultant

L. D

25/01/13

Lee Dursley, BSc (Hons), MIOA, MInstP
Acoustic Consultant

Graph 1 - Existing ambient sound level in vicinity of Grays Inn Road Store
Measured 10th January 2013 in front of dwellings to rear of store



Calculation Summary				
Night-time Suitable Level at Closest Residential Window		NR25	38dB(A)	**Note**
Corrections	Distance		-8	4m
	Screening		+5	line of sight
	Reverberant		-6	multiple walls
	Directivity		-	-
	Plant at other premises / Cumulative correction		-	-
Plant Selection Cumulative Sound Pressure Level, Lp at 10m			**29dB(A)**	
Plant Selection Cumulative Sound Power, Lw			**57dB(A)**	

EXPLANATION OF SOME ACOUSTIC TERMINOLOGY

Sound is measured in terms of decibels (dB). There are many different methods of assessing the loudness of a sound. The most frequently used is the 'A Weighting', which simulates the effect of the human hearing mechanism. This method is widely used for sound assessment and the resulting level is expressed as dB(A). The table below gives an indication of different sound levels in terms of dB(A).

Sound Level dB(A)	Sound Source
0	Threshold of hearing
20	Recording Studio
40	Living Room
60	Conversational Speech
80	Light Factory Noise
100	Discotheque
120	Road Breaker
140	Threshold of pain

For a steady, continuous sound, a change of 1dB(A) is just perceptible to the ear. In the case of intermittent sounds, the change must be at least 3dB(A) to be perceptible. For steady sounds, a difference of 10dB(A) sounds twice as loud.

Unwanted sounds are classed as noise, these are a fundamental part of life. The level of such noise changes constantly. This may be due to dogs barking, telephones ringing or even during normal conversation. As a consequence, some method of quantifying the overall level of noise is required.

The equivalent continuous sound level (L_{Aeq}) is the level averaged over a specified period of time. This is widely used for both measurement and assessment. Because the L_{Aeq} is an average level over a specified period of time, a steady continuous sound and a shorter duration sound at a higher level can have the same L_{Aeq} over the same time period.

The level exceeded for 90% of the time (L_{A90}) is frequently used to determine the level of background noise. It ignores the loudest 90% of the measurements obtained. Therefore, although it does have a useful purpose, it takes no account of what happens for 90% of the time. This parameter together with the L_{Aeq} and the level exceeded for 10% of the time (L_{A10}) give a fairly good overview of the prevailing acoustic environment.

When A weighted, the maximum sound pressure level measured during a period is termed L_{AMax}. This gives an indication of the intrusiveness of a noise event, which is lost with the averaging effect of the corresponding L_{Aeq}.

EXPLANATION OF SOME ACOUSTIC TERMINOLOGY Cont'd

Different sound sources produce an overall level that depends upon the louder source and the difference in sound level between the two sources. If the difference is within 1dB, they act as identical sources, with the overall level being 3dB greater than the louder source. If the difference is 2dB or 3dB, the overall level is only 2dB greater than the louder source. For example, if a machine produces 84dB and a second machine produces 82dB, the overall sound level will be 86dB. This is summarised in the table below:

Difference in Levels (dB)	Increase in Level (dB)
0,1	3
2,3	2
4..9	1
10+	0

The sound level rises as a point source becomes closer. This increase is 6dB for every halving of distance. The effect is similar to the addition of sound sources, but with changes of 6dB rather than 3dB. A machine that produces 80dB at 200m will produce 86dB at 100m and 92dB at 50m. This effect is summarised in the table below:

Ratio of Distances	Increase in Sound Level (dB)
2	6
3	10
4	12
10	20
20	26

The **A Weighting** system attempts to replicate the way in which the human hearing mechanism works. An A Weighted sound is expressed as a single value in terms of **dB(A)**. This allows the loudness of different sounds to be compared, the louder having a higher level in dB(A).

Whilst a single figure value is ideal for noise assessment purposes, it is inadequate for noise control requirements. This is because the most appropriate control techniques will be dependent upon the characteristics of the noise.

EXPLANATION OF SOME ACOUSTIC TERMINOLOGY Cont'd

In this case, the noise is analysed in terms of its frequency content, from a low frequency rumble to a high frequency hiss. To achieve this, eight octave bands are normally used. This set of eight values is termed a **sound spectrum** and analyses a sound in terms of frequency content as the table below shows:

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
	low frequency				high frequency			

The A Weighting system simulates the effect of the average human hearing mechanism by weighting each frequency and adding the corresponding levels. In an attempt to improve on this, Beranek developed the Noise Criterion (**NC**) curves. These show equal loudness levels at different frequencies. As such, if a sound spectrum matches a given NC curve e.g. NC 40, all octave bands will sound equally loud. This would equate to a level of approximately 49dB(A).

Kosten and Van Os then adapted the NC system specifically for room design and produced the Noise Rating (**NR**) system. Broadly speaking the two systems are equivalent. A major advantage of the NC or NR system for noise control purposes is that noise which meets a required curve will not have a significant tonal content, making it much less intrusive.

While the sound pressure level (Lp) is useful, this only provides information about the sound level produced by a source at a particular point in space. It cannot immediately let us compare one piece of machinery against another because it depends upon where the meter is located.

The sound power level (Lw) is used to describe the sound energy output from a machine, independent of location. This is the amount of energy that the machine converts to sound energy, considered on the decibel scale. There are conversion factors we can use to convert a sound pressure level reading into a power level reading. These conversion factors rely on the surroundings of the machine being reasonably simple. For example, to rely on the conversion factors, we would not want buildings or uneven ground between the plant and the sound level meter.

REFERENCES

1 World Health Organisation:
a) Guidelines for Community Noise, 1999
b) Night Noise Guidelines for Europe , 2009

2 Department for Communities
National Planning Policy Framework, 2012

3 DEFRA
Noise Policy Statement for England, 2010

4 CEC. EUR Report 5398e.
Damage and Annoyance Caused by Noise (1975).

5 British Standards Institute:
a) BS 8233: Sound insulation and noise reduction for buildings – Code of practice – 1999
b) BS 4142: Method for Rating industrial noise affecting mixed residential and industrial areas – 1997

6 CIBSE & ASHRAE:

Guide to Current Practice,
Chartered Institute Building Service Engineers

Guide to Current Practice,
American Society Heating, Refrigeration and Air Conditioning Engineers

Co op Grays Inn Road
King's Mews
A401
Google earth

GENERAL SPECIFICATION FOR ACOUSTIC AND VIBRATION ISOLATION MATERIALS AND PRODUCTS

ISSUE GS/2013

HANN TUCKER ASSOCIATES
Consultants in Acoustics
Noise and Vibration Control

Head Office:
Duke House, 1-2 Duke Street
Woking, Surrey, GU21 5BA
Tel: (01483) 770595
Fax: (01483) 729565

Northern Office:
First Floor, 346 Deansgate
Manchester, M3 4LY
Tel: (0161) 832 7041
Fax: (0161) 832 8075

E-mail: Enquiries@HannTucker.co.uk
www.hanntucker.co.uk

GENERAL SPECIFICATION FOR ACOUSTIC AND VIBRATION ISOLATION MATERIALS AND PRODUCTS

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1. ATTENUATORS/SILENCERS (ABSORPTIVE TYPE)

N.B. Attenuators are often referred to as silencers.

1.1 Performance

1.1.1 Each attenuator shall provide an insertion loss under operating conditions of not less than that indicated on the relevant acoustic hardware schedule. Manufacturers shall specify the insertion losses expected from the attenuators offered, under the operating conditions, with the data derived from tests carried out in accordance with BS EN ISO 7235.

1.1.2 Each attenuator shall have a pressure loss at the design flow and temperature of not greater than that shown in the schedules. The manufacturer's quoted pressure losses shall be derived from tests carried out in accordance with BS EN ISO 7235. Where the attenuator location is known, the supplier shall indicate the expected effect of turbulence due to adjacent duct elements on the quoted pressure losses.

1.1.3 Suppliers of attenuators shall provide, with the certified insertion loss data, information relating to the attenuator generated octave band sound power levels (125 - 8kHz) at the operating conditions.

1.2 Construction

1.2.1 The outer casing of all duct attenuators shall be constructed in accordance with the current relevant ductwork specification in terms of thickness and seams.

1.2.2 All attenuators shall be fitted with drilled angle flange connections, unless alternative connections are specified in the schedule or by the Mechanical Services Consultant or Contractor. Flanges should also conform to the relevant code or its equivalent.

1.2.3 Acoustic elements in rectangular attenuators of length equal to or greater than 900mm shall incorporate faired leading and trailing edges (not square ends). Attenuators having a length of less than 900mm should have a faired leading edge, unless otherwise specified.

1.2.4 The inert, rot and vermin proof, non-hygroscopic and non-combustible mineral wool or glass fibre acoustic medium shall be packed to a density of not less than $48kg/m^3$. This shall be faced with a glass fibre cloth, or other approved infill protection membrane, retained by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded ("Expamet") sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

The manufacturer will also note any particular requirements, e.g. painting, special materials, etc., indicated in the schedules or on the drawings.

1.2.5 Where acoustic elements form splitters within the attenuator, the arrangement shall be with a half-width splitter fixed to each side wall of the casing and preferably with the splitters vertical. The configuration should have a regular splitter/airway dimension across the full width of the attenuator. However, it is the responsibility of the supplier to ensure that the parallel splitter elements in the attenuator are correctly orientated for the adjacent duct geometry, particularly when attenuators are located near bends, bifurcations, etc. Horizontal splitters should be suitably stiffened to prevent flexing and restriction of the airways and will normally be limited to silencers having a module width of 900mm or less.

1.2.6 In the case of circular attenuators, all internal acoustic elements shall comprise mineral or glass fibre as the acoustic medium, as specified above for rectangular attenuators, retained by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded (“Expamet”) sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

1.2.7 When attenuators are manufactured in modules each unit shall be shop assembled (unless the Mechanical Services Contractor instructs to the contrary) and this specification, together with the manufacturer's own guarantee and performance ratings, shall apply to the unit as a whole.

1.2.8 Attenuator units shall be delivered to site with blocked ends to prevent ingress of rubble, etc., while on site and to reduce the risk of damage. The direction of airflow through the attenuator shall be clearly marked on the casing.

1.2.9 Attenuators for high temperature applications (e.g. diesel exhausts, boiler flues, etc.) should have casings manufactured from a suitable gauge steel, with adequate precautions taken to cater for expansion and thermal shock. The internal elements shall be packed with an inert, rot and vermin proof, non-hygroscopic and non-combustible mineral or glass fibre acoustic medium of at least 96kg/m^3 density. This shall be faced with glass fibre cloth retained by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded (“Expamet”) sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers). For very high temperatures, steel wool or equivalent approved materials may be used as the acoustic medium.

1.2.10 The attenuator cross-sectional sizes shown in the schedules are to be followed exactly, since they often relate to duct sizes and thus avoid the unnecessary use of transition sections. However, subject to agreement with the Mechanical Services Consultant or Contractor, the supplier may propose alternative dimensions in line with his own standard sizes, provided the acoustic and aerodynamic requirements are met.

1.2.11 The use of Melinex or other plastic film between the perforated sheet steel facing and the infill medium may be required for certain applications. It should be noted that such materials may reduce the acoustic performance of the attenuator significantly and this must be taken into account when interpreting the schedules. Film thicknesses greater than 0.05mm will not be permitted, and use of very thin films (0.008-0.010mm) is preferred.

1.2.12 Where corrosive or toxic gases or substances are being handled, special constructions and materials may be specified as an addendum to this specification.

1.2.13 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

2. ENGINE EXHAUST SILENCERS (REACTIVE TYPE)

2.1 Performance

2.1.1 All silencers shall provide an insertion loss at the operating temperatures of not less than that indicated on the relevant acoustic hardware schedules.

2.1.2 All silencers shall have a static pressure loss, under maximum operating conditions, of not greater than that shown in the schedules.

2.2 Construction

2.2.1 The outer casings of all silencers shall be constructed from a suitably heavy gauge steel with all seams and joints continuously welded. Acoustic elements within the silencer shall be designed and constructed with due allowance for differential expansion and thermal shock.

2.2.2 All silencers shall also be fitted with suitable flanges and drain plugs and shall be manufactured and finished with due allowance made for the operating temperatures and environmental conditions.

2.2.3 Silencers shall be delivered to site with blocked ends to prevent ingress of rubble, etc., during installation and to reduce the risk of damage. The direction of gas flow through the silencer shall be clearly marked on the casing.

2.2.4 The silencer sizes shown in the schedules are indicative only, and the supplier may modify these in line with his own standard sizes, provided the acoustic and aerodynamic requirements are met. It is the supplier's responsibility to ensure that the Client is advised of the actual sizes being offered, where these differ from the schedules.

2.2.5 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

3. ACOUSTIC WEATHER LOUVRES

3.1 Performance

3.1.1 All acoustic weather louvres shall provide an insertion loss under the operating conditions of not less than that indicated in the relevant acoustic hardware schedules. In addition, the static pressure loss, under maximum operating duty, shall not exceed that shown in the schedules.

3.1.2 The louvre shall be designed to prevent the ingress of rain, etc. under normally encountered meteorological conditions.

3.2 Construction

3.2.1 The louvre frame shall be constructed from a suitable gauge of galvanised mild steel, or aluminium, supporting louvre blades of like material. The acoustic material in the blades shall have a density of 60-100kg/m^3 and be inert, rot and vermin proof, non-hygroscopic incombustible mineral fibre. This shall be faced with glass fibre cloth, or other approved infill protection membrane, and retained on the lower blade face by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded (“Expamet”) sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

3.2.2 When the louvres are actually manufactured in sections, each unit shall be shop assembled as a whole unit (unless the Mechanical Services Contractor instructs to the contrary) and this specification, together with the manufacturer's own guarantee and performance ratings, must apply to the unit as a whole.

3.2.3 Acoustic weather louvres shall be supplied with an integral bird screen of galvanised mild steel or aluminium mesh, fixed to its internal face. The mesh pitch shall be a maximum of 25mm.

3.2.4 The louvres shall be supplied complete with all necessary fixings, flanges, etc., for fitting into the louvred opening as required by the Mechanical Services Contractor.

3.2.5 All gaps between the outside of the louvre frame and the wall or duct shall be made good and sealed with a heavy grout and/or non-hardening dense mastic.

3.2.6 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

4. ANTI-VIBRATION MOUNTINGS

4.1 General

4.1.1 Where so indicated in the schedules by the code /R, the mountings/hangers shall be provided with a positioning or restraining device, which will prevent the equipment position changing if its load changes; for example, during draining down of the equipment or other maintenance. The device shall consist of a stud passing through an oversize hole with a nut and locknut providing restraint. A fibre or neoprene washer should be fitted between nut and restraining member, leaving a clearance of at least 3mm. Alternative methods of restraint must be approved by the Acoustic Consultant in writing.

4.1.2 All mountings shall provide the static deflection, under the equipment weight, shown in the schedules. Mounting selection should allow for any eccentric load distribution or torque reaction, so that the design deflection is achieved on all mountings under operating conditions.

4.1.3 It is the supplier's responsibility to ensure that all mountings offered are suitable for the loads, operating and environmental conditions which will prevail. Particular attention should be paid to mountings which will be exposed to atmospheric conditions to prevent corrosion.

4.1.4 All mountings shall be colour coded, or otherwise marked, to indicate their load capacity to facilitate identification during installation.

4.1.5 Where use of resilient supports allows omission of pipe flexible connections for vibration/noise isolation, it shall be the Mechanical Service Consultant's or Contractor's responsibility to decide whether such devices are required to compensate for misalignment or thermal strain.

4.2 Caged Steel Spring Mountings (CSS)

4.2.1 Each mounting shall consist of cast or fabricated telescopic top and bottom housings enclosing one or more helical steel springs as the principle isolation elements and shall incorporate a built-in levelling device. The housing should be designed to permit visual inspection of the springs after installation, i.e. the spring must not be totally enclosed.

4.2.2 The springs shall have an outside diameter of not less than 75% of the operating height and be selected to have at least 50% overload capacity before becoming coil-bound.

4.2.3 The bottom plate of each mounting shall have bonded to it a rubber/neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

4.2.4 Mountings incorporating snubbers or restraining devices shall be designed so that the snubbing, damping or restraining mechanism is capable of being adjusted to have no significant effect during the normal running of the isolated machine.

4.2.5 All nuts, bolts or other elements used for adjustment of a mounting shall incorporate locking mechanisms to prevent the isolator going out of adjustment as a result of vibration or accidental or unauthorised tampering.

4.3 Open Steel Spring Mountings (OSS)

4.3.1 Each mounting shall consist of one or more helical steel springs as the principal isolation elements and shall incorporate a built-in levelling device.

4.3.2 The springs shall be fixed or otherwise securely located to cast or fabricated top and bottom plates having an outside diameter of not less than 75% of the operating height and shall be selected to have at least 50% overload capacity before becoming coil-bound.

4.3.3 The bottom plate shall have bonded to it a rubber/ neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

4.4 Neoprene-in-Shear Mountings (NIS)

Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant rubber/neoprene. Each mounting shall be capable of being fitted with a levelling device, have bolt holes in the base plate and have a threaded metal insert in the top plate so they can be bolted to the floor and equipment where required.

4.5 Hangers with Steel Springs (HSS)

4.5.1 The hanger shall incorporate a helical steel spring securely located in a steel cage.

4.5.2 The clearance hole in the bottom of the cage should allow a lateral movement of the lower hanger rod of at least 15^o included angle.

4.5.3 Where hangers incorporate a positioning device, the adjustment system should incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration, or accidental/unauthorised tampering.

4.6 Hangers with Neoprene Turrets (HNT)

The hanger shall be essentially as described in 4.5 above except it shall incorporate a neoprene in shear element as described in 4.4.

4.7 Plant Bases

4.7.1 AV Rails (AVR)

An A.V. Rail shall comprise a steel beam with two or more height-saving brackets. The steel sections must be sufficiently rigid to prevent undue strain in the equipment and if necessary should be checked by the Structural Engineer.

4.7.2 Steel Frame Base (SFB)

Steel plant bases shall comprise an all-welded steel framework of sufficient rigidity to provide adequate support for the equipment and fitted with isolator height saving brackets. The frame depth shall be approximately 1/10 of the longest dimension of the equipment with a minimum of 150mm. This form of base may be used as a composite A.V. Rail system.

4.7.3 Concrete Inertia Base (CIB)

These shall consist of an all-welded steel pouring frame-work with height saving brackets and a frame depth of approximately 1/12 of the longest dimension of the equipment, with a minimum of 100mm. The bottom of the pouring frame should be blanked off and concrete (2300 kg/m^3) poured in over steel reinforcing rods positioned 35mm above the bottom. The inertia base should be sufficiently large to provide support for all parts of the equipment, including any components which over-hang the equipment base, such as suction and discharge elbows on centrifugal pumps.

4.7.4 Concrete Split Plinth Bases (CIB) (For neoprene mounts/pads)

These should comprise a concrete inertia base of sufficient size to permit support for all parts of the equipment, including any components which overhang the equipment base, such as suction and discharge elbows on centrifugal pumps. The inertia base should be cast onto a permanent bottom shuttering and supported on the specified neoprene mounts or pads, the whole resting on a plinth as required. It should be noted that the construction of concrete bases on cork, expanded polystyrene or mineral wool slabs is not normally permitted. Where neoprene pads are used, small areas of pad must be equally spaced to provide the correct deflection. The number, dimensions and locations of such pads should be advised by the supplier.

5. ACOUSTIC DOORS

5.1 Performance

5.1.1 All acoustic doors shall provide a sound reduction index (SRI) as tested in accordance with BS EN ISO 140-3: 1995 of not less than that shown in the relevant schedule. Where the schedule refers to a mean SRI, the equivalent SRI spectrum should not be less than indicated below:-

Mean SRI dB (100-3150Hz)	SRI (dB) at Octave Band Centre Frequencies (Hz)					
	125	250	500	1k	2k	4k
30	21	26	30	33	35	36
35	24	30	35	38	39	40
40	27	35	40	42	46	47
45	33	36	44	48	52	54
50	35	40	50	54	60	60

5.1.2 The manufacturer or supplier of acoustic doors shall guarantee the specified SRI and ensure the method of installation does not detract from the guaranteed performance. Any failure to meet the specification because of faulty design, manufacture or installation, will result in the manufacturer or supplier being held liable for remedial or replacement costs including consequential liability.

5.2 Construction

5.2.1 The acoustic doors shall be of hardwood or steel and be complete with all seals, frames and furniture as specified by the Architect.

5.2.2 It is recommended that, where a mean SRI equal to or greater than 35dB is required, the door should be of steel construction with double neoprene/rubber compression (or knife-edge) seals to head, jambs and threshold. Double doors should incorporate a central jamb or overlapping leaves to ensure a good seal at the middle joint. Lower performance doors (35dB or less) may be fitted with magnetic seals.

5.2.3 The door fastener or lock should be designed to ensure the seals operate over the whole periphery of the door.

5.2.4 Wiper seals will not be permitted at thresholds; doors must be fitted with a raised threshold and a compression seal, or with a mechanical drop-down seal for doors with ratings up to 35dB.

6. ACOUSTIC ENCLOSURES (MODULAR)

6.1 Performance

6.1.1 The acoustic enclosure shall provide in its as-installed condition an overall sound reduction index (SRI) of not less than that shown in the relevant schedule. Full allowance shall be taken of any loss of insulation due to doors, windows, ventilation openings and panel joints.

6.1.2 The manufacturer or supplier shall guarantee the specified SRI, and ensure that the method of installation does not detract from the guaranteed performance.

6.1.3 The internal surfaces of the enclosure panels shall be designed to give the following minimum average absorption coefficients (ISO) when tested in accordance with BS EN ISO 354:2003.

Frequency	125	250	500	1k	2k	4k
Minimum average absorption coefficient	0.5	0.5	0.8	0.95	0.95	0.95

6.2 Construction

6.2.1 The enclosed outer panels shall be constructed from galvanized sheet steel having a minimum thickness of 1.6mm and fixed at 300mm (max) centres. The enclosure inner panels shall be constructed from punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.7mm fixed at 300mm (max) centres.

Flattened-expanded ("Expamet") sheet shall not be used, unless all edges of the sheet are mechanically fixed to the panel casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

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6.2.2 The inert, rot and vermin proof, non-hygroscopic and non-combustible mineral wool or glass fibre acoustic medium shall be packed to a density of not less than $48kg/m^{3.}$ This shall be faced with a glass fibre cloth, or other approved infill protection membrane. Panels shall be constructed and assembled so that no egress of the acoustic medium will occur under the operating conditions.

6.2.3 Doors, access panels, windows and ventilation ducts or electrical cable penetrations hall be treated so as to maintain the specified acoustic insulation of the assembled enclosure.

6.2.4 Demountable sections shall be designed to allow easy disassembly and reassembly by unskilled personnel without affecting the acoustic performance.

6.2.5 The supplier shall ensure that the assembled enclosure is designed and constructed to withstand site operating conditions such as wind and snow loads, roof mounted plant, etc., as appropriate, and if outside, to be suitably weatherproofed.

6.2.6 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

7. LIABILITY

All tenderers are advised that failure to comply with any part of the above specification may result in either their tender being discounted or liability for any resulting remedial or replacement costs on site, including consequential liability, unless variations are accepted in writing by their client and/or the Acoustic Consultant.

It is recommended that all tenderers shall have undergone the necessary assessment and registration procedure to BS EN ISO 9001:2008 and shall not sub-contract the manufacture of any products to an unregistered third party fabricator.

It is also recommended that the purchaser of acoustic equipment checks the manufacturer's standard conditions of sale forming part of his quotation do not contravene this specification.

BELAIR RESEARCH LIMITED

BROADWAY . BOURN . CAMBRIDGESHIRE . CB23 2TA
Tel: (01954) 718366 Fax: (01954) 718355
Email: brl@acoustical.co.uk

ACOUSTIC ASSESSMENT OF NOISE FROM REFRIGERATION/AIR CONDITIONING PLANT AT CO-OP, GRAYS INN ROAD, LONDON WC1X 8PR

Client:	BJA Refrigeration Consulting Engineers Limited Bridge Mills Huddersfield Road Holmfirth HD9 3TW
Instruction:	Teresa Sleigh BJA Refrigeration Consulting Engineers Limited
Project Manager:	Shaun Law BJA Refrigeration Consulting Engineers Limited
Report Author:	T S Leach
Brief:	To visit the site, take measurements and record relevant observations to assess the existing acoustic environment in the vicinity of the site. To provide advice regarding suitable acoustic criteria for the selection of future plant, relating this to 'typical' manufacturers' data in order to facilitate plant selection.
Plant Selection:	**Plant located on the roof of the store will have several reflective vertical surfaces (walls, etc.) and will be approximately 4m from, with significant screening preventing any direct line of sight to the nearest noise sensitive windows.** **The equivalent cumulative global average 'free field' sound pressure level from all new and existing plant should not exceed 29dB(A) at a distance of 10m from the plant when operating at maximum night time capacity. This equates to a sound power level of 57dB(A). As a guide, typical ambient day time levels are generally assumed to be around 10dB(A) higher than during the night. It is likely that the plant selection will therefore be most significantly constrained by the requirement to achieve a suitable level during the night.** **Ideally this should be achieved with the use of inverter speed control systems where this is appropriate. Sound from the plant should not contain significant tonal or impulsive components and should not be significantly directional.**

Survey: Time – 00:15 hours – 01:30 hours
Date – Thursday 10th January 2013
Weather – Still, 100% low cloud, 5°C, dry ground surfaces, light fog.

Personnel: T S Leach – Belair Research Limited

Instrumentation: Rion 1/3 Octave Band Analyzer Type NA-28, Serial No. 01070575
Rion Sound Calibrator Type NC-74, Serial No. 35173526
Rion Windshield

Tripod

In accordance with relevant Standards, the performance of calibrators is checked by an accredited laboratory annually, with sound level analysers being checked on a bi-annual basis.

Observations: The store will be located on the ground floor of a four storey residential building as part of a terrace of similar buildings facing Grays Inn Road, situated in the busy borough of Camden. In front of the store on the opposite side of Grays Inn Road are a number of commercial buildings with residential accommodation above. Above the rear of the store facing King's Mews are a number of dwellings on the first floor of the building. To the rear of the store on the opposite side of King's Mews are a number of dwellings and a small car park. Plant is to be located within a screened area on the first floor flat roof between the dwellings located above the store entrance and the dwellings to the rear of the store.

There do not appear to be any different locations at this site where plant could be installed that provide significant acoustic advantages in comparison with the proposed plant arrangement.

The location picture towards the end of the report shows the layout of the store and surrounding area, together with the measurement location identified and numbered as appropriate. The outline of the store is approximately indicated in brown, with some potential night time noise sensitive areas shown in green. Existing plant is shown with a solid blue area with a blue outline denoting a potential plant location.

Sources of ambient noise in the vicinity of the site included road traffic, of which more distant vehicles produced a relatively steady underlying sound level, with nearby vehicles producing relatively short duration increases superimposed upon this. Noise from passing traffic dominated the soundscape in the vicinity of the store. Other sources of residual noise at the time of the survey included pedestrians – particularly when conversing, occasional aircraft, plant at other premises and some noise due to the movement of flowing water in drains.

Measurements:

Sound pressure level measurements were taken at one location in the vicinity of the site. The purpose of the measurements was to assess the residual sound level at the dwellings nearest to the site.

The measurements consist of consecutive instantaneous sound pressure levels recorded every one tenth of a second throughout the measurement period. This method has the advantage of allowing individual events such as vehicles passing by to be identified and quantified, together with providing longer term statistical information where this is appropriate. The data is presented in a graphical format, which assists subsequent analysis and enables relevant comparisons to be made of measurements at different locations or under different operating conditions.

Graph 1 provides details of the measurements taken during the survey. The measurements were undertaken in front of the dwellings to the rear of the store. From the graph it can be seen that the residual sound level varied between around 45dB(A) and 55dB(A) with frequently passing traffic causing levels to rise somewhat to around 60dB(A). Passing busses resulted in noise levels of around 63dB(A) on several occasions, with their air brakes causing levels of around 70dB(A).

Criteria:

When considering noise sources that operate for 24 hours per day, as is typical for retail refrigeration plant and associated equipment, the most critical times in terms of sleep disturbance are when residents are preparing for and going to sleep and some time before people awaken in the morning. In this case, it is important to ensure that a suitable noise level is achieved inside the bedrooms of nearby houses. The World Health Organisation[1], Department for Communities[2], DEFRA[3], the European Communities Commission[4] , British Standards Institute[5] and the professional bodies for Building Services Engineers[6] provide useful guidance for this assessment.

World Health Organisation

The WHO publication 'Guidelines for Community Noise – 1999' provides guidance regarding suitable levels of noise that will protect vulnerable groups against sleep disturbance. A steady level of 30dB(A) in bedrooms, with occasional maximum levels of 45dB(A) are identified as being suitable to achieve this, with an assumed difference of approximately 15dB(A) between the noise level outdoors and that resulting in the bedroom, assuming that the bedroom windows are partly open for ventilation. This means that the corresponding targets for the noise level outdoors are steady levels of up to about 45dB(A) and occasional maxima of up to around 60dB(A).

The more recent WHO guidance 'Night Noise Guidelines for Europe – 2009' is more concerned with the longer term average noise levels that are covered by the EU Directive on Environmental Noise, although this does appear to suggest slightly lower external maximum noise levels of around 57dB(A) outside bedrooms during the night.

Furthermore the 1999 guidance states that: *To protect the majority of people from being seriously annoyed during the daytime, the outdoor sound level from steady, continuous noise should not exceed 55dBL_{Aeq} on balconies, terraces and in outdoor living areas. To protect the majority of people from being moderately annoyed during the daytime, the outdoor sound level should not exceed 50dBL_{Aeq}. Where it is practicable and feasible, the lower outdoor level should be considered the maximum desirable sound level for new development.*

BS8233: 1999 Sound insulation and noise reductions for buildings – Code of practice

This document provides guidance regarding suitable noise levels for different locations such as bedrooms, offices, living rooms, gardens, libraries, churches and factories. For bedrooms, a steady internal level of 30dB(A) represents 'good' conditions for sleeping and 35dB(A) represents 'reasonable' conditions, with individual noise events not exceeding 45dB(A). This is consistent with the current WHO guidance. Also consistent with the WHO document are the recommended maximum sound levels for outdoor living spaces to protect residents' amenity.

National Planning Policy Framework (NPPF) & Noise Policy Statement for England (NPSE)

The National Planning Policy Framework (NPPF) sets out the Government's planning policies for England and how these are expected to be applied. It sets out the Government's requirements for the planning system only to the extent that it is relevant, proportionate and necessary to do so. It provides a framework within which local people and their accountable councils can produce their own distinctive local and neighbourhood plans, which reflect the needs and priorities of their communities

Paragraph 123 of NPPF states that:

Planning policies and decisions should aim to:

- avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
- mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;
- recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and
- identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.

The Noise Policy Statement for England (NPSE) sets out the long term vision of Government noise policy by promoting good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.

Paragraph 2.23 of NPSE clarifies the first part of the above excerpt:

- The first aim of the NPSE states that significant adverse effects on health and quality of life should be avoided while also taking into account the guiding principles of sustainable development

Similarly paragraph 2.24 of NPSE clarifies the second part:

- The second aim of the NPSE refers to the situation where the impact lies somewhere between LOAEL (Lowest Observed Adverse Effect Level) and SOAEL (Significant Observed Adverse Effect Level). It requires that all reasonable steps should be taken to mitigate and minimise adverse effects on health and quality of life while also taking into account the guiding principles of sustainable development. This does not mean that such adverse effects cannot occur.

These make it clear that noise must not be considered in isolation but as part of the overall sustainability and associated impacts of the proposed development. There is no benefit in reducing noise to an excessively low level, particularly if this creates or increases some other adverse impact. Similarly, it may be appropriate for noise to have an adverse impact if this is outweighed by the reduction or removal of some other adverse impact that is of greater significance when considering the overall sustainability of the proposed development.

NPSE clarifies the difference between NOEL (No Observed Effect Level) and LOAEL as used in Night Noise Guidelines for Europe, which gives values of 30dB(A) and 40dB(A) for the night time average level measured outside dwellings respectively. This indicates that there may be no significant overall benefit in achieving an average level of less than around 40dB(A) outside dwellings during the night.

It should also be considered that in order to make equipment quieter it is often necessary to use larger equipment that operates more slowly and for longer periods of time. This may increase energy consumption and hence the carbon footprint of the equipment. The overall impact of this may outweigh any acoustic benefit of the equipment being slightly quieter.

BS4142: 1997 Method for Rating industrial noise affecting mixed residential and industrial areas

The BS4142 methodology compares the Rating Level (average source noise level with a 5dB 'Rating Penalty' if applicable), against the existing Background Level and provides an indication of the likelihood of complaints based upon this differential. If it is more than 10dB then 'there is a likelihood of complaints', 5dB is of 'marginal significance' and -10dB is a 'positive indication that complaints are unlikely'. This means that there is a difference of 15dB (or 20dB if there is uncertainty regarding the applicability or otherwise of a Rating Penalty) between the level at which complaints are unlikely and that of marginal significance. Also depending upon the way the text of the standard is interpreted, there can be a difference of around 15dB when applying the same standard to the same situation.

The standard is often mis-applied to a diverse range of situations outside of the stated scope of the document. The scope of this standard is very precise in that it provides a method for assessing whether an industrial type of noise source in industrial or commercial buildings is likely to give rise to complaints from residents, based on the noise level outside their dwelling. It is not appropriate for the assessment of the noise from fixed plant and equipment, specifically during the early hours of the morning, when the primary concern is to ensure that the noise level inside the dwellings is at a suitable level.

Whilst it may appear reasonable to extrapolate a comparison of the outdoor source and background noise levels to within the property, this is not valid. This approach can lead to a requirement that the source noise be far quieter than levels that represent 'good' acoustic conditions within bedrooms, which will themselves protect residents against sleep disturbance, at times when the residents will be asleep. This also ignores the fact that noise within dwellings comes not only from external noise breaking into the building but also from sources within the dwelling, such as boilers, pumps, refrigerators and fans during the night, together with activity noise during the day and other sources such as televisions, music and radios.

This approach also considers only the average noise level (plus a 5dB Rating penalty if applicable). This means that occasional loud events are simply assessed in terms of the average noise level plus 5dB(A), which takes only limited account of the maximum level, duration and number of events.

For example, six events per hour (one every ten minutes) each producing a level of 64dB(A) would have a Rating Level of 41dB(A), as would the same number of events, but each one of five seconds duration and only producing a level of 57dB(A). According to WHO guidance the first would be likely to cause sleep disturbance, whereas the second would not, but a BS4142 assessment would yield the same outcome in both cases, which would be totally dependent upon only the background sound level.

In a location with a background sound level of 31dB(A) a BS4142 assessment would indicate that this is 'likely to cause complaints'. However, such a location could be in a relatively remote rural area where the events would be readily noticeable within the dwelling (with open windows), or beside a road with vehicles passing every five minutes at relatively high speed, possibly producing maximum levels of over 70dB(A) at the same dwelling, where the events would be relatively insignificant.

CIBSE & ASHRAE – Guide to Current Practice

The Chartered Institute of Building Services Engineers (CIBSE) is the professional body for engineers responsible for the design, selection and specification of building services plant such as fans, pumps and chillers. It provides guidance for suitable levels of noise from mechanical plant depending upon the use and associated sensitivity of the area to be considered. ASHRAE, which is CIBSE's counterpart in the USA also provides similar guidance. For bedrooms the recommended level varies from around NR20 for quiet rural locations, NR25 for suburban locations, to NR30 for busy urban locations.

Applying a conversion factor of about 6 from an NR value to a dB(A) value and a 'open window' attenuation of 10dB(A) to 15dB(A), this equates to a level of approximately 36dB(A) to 51dB(A) outside the dwellings. However, mechanical plant noise has different frequency components to transportation noise and it may be more prudent to use a differential of about 13, as a result of which the recommended range equates to free field levels of about 33dB(A) to 43dB(A) outside the dwellings.

Discussion

The London Borough of Camden's planning policy with regards to noise from mechanical plant states in Development Policy 28 – Table E; that noise 1m from a sensitive façade should be no more than 5dB(A) below the measured L_{A90}, with a 5dB(A) penalty applied to machinery that has audibly distinguishing features.

Current planning policy contained in the NPPF and NPSE suggests that there may be no significant benefit in limiting external sound levels to much below 40dB(A). It is also clear that noise should not be considered in isolation but must be regarded as one of many elements to be balanced in order to produce a sustainable outcome. The sound levels set out in the new policy documents are built upon principles contained within guidance from the WHO and BS8233 which indicates that a steady level of 30dB(A) within bedrooms represents 'good' acoustic conditions.

Applying a conservative correction for the attenuation provided by windows that are partly open for ventilation and conversion to dB(A) figures to NR25 recommended by CIBSE for mechanical plant noise within the bedrooms of dwellings such as this, equates to an external noise level of around 38dB(A), which is consistent with the recently published planning policy.

The WHO guidelines suggest that to prevent residents from being moderately annoyed, the sound level in outdoor living spaces should generally not exceed 50dBL_{Aeq}. The vast majority of gardens and other outdoor living spaces are subject to a varied soundscape comprising many different sound sources of which new refrigeration or air conditioning plant may be one of them. Therefore it is necessary to take account of the cumulative effect of all noise sources affecting a particular area. For this reason it is appropriate to ensure that noise from plant does not exceed around 45dB(A) to 50dB(A) at the closest garden or other outdoor noise sensitive area.

During the day the ambient noise level is generally significantly higher than during the night. Nearby locations are also less sensitive to noise. This means that the corresponding 'suitable' day time level is significantly higher than at night. Inverter control systems can take advantage of this, by limiting the speed and noise of plant at night (when lower capacity is required) and operating at higher speeds during the day when the higher levels of noise are acceptable. This means that by selecting plant to achieve suitable noise levels at night, suitable levels of noise are produced during the day time.

Care must be taken to ensure that noise from the plant does not contain any tonal or impulsive characteristics that would otherwise draw a listener's attention to this source of noise otherwise this may increase any apparent intrusiveness of the noise source.

The plant should therefore be selected to achieve a 'free field' level of 38dB(A) at the nearest dwelling when operating at maximum night time capacity and 45dB(A) at the nearest appropriate noise sensitive location when operating at full capacity during the day. This means that the actual level produced under normal conditions will be lower than this, particularly if inverter speed control systems are used where this is appropriate. However, care must also be taken to ensure that noise from the plant does not contain any significant tonal or impulsive components.

Analysis:

Graph 1 shows that the identified 'suitable' noise level was somewhat lower than the residual noise level in the vicinity of the store at the time of the survey. However, it should also be remembered that this 'suitable' level will be achieved with all plant operating at maximum night time capacity. For the vast majority of time the plant will operate at lower capacity than this during the night which means that the actual noise level at the nearest dwellings will be lower than this. Therefore the actual noise level at the nearest noise sensitive locations will be significantly lower than the existing residual sound level during the quietest part of the night. This level has also been identified as suitable to ensure that noise from the plant does not disturb the nearest residents, even when sleeping with open bedroom windows.

Although sound level meters generally show the measured level to 0.1dB resolution, this is not the accuracy of the measurement for a variety of reasons. In addition to measurement uncertainty, which is likely to be somewhat more than 1dB, it should be noted that the sound level at any location varies often by many dB(A), even at the same time of the day or night. This can be due to many different factors including meteorological conditions, noise source characteristics such as equipment operation, human or animal activity and even foliage. This does not mean that there is an 'error' in the measurements, but that even under apparently ideal measurement conditions the 'measurement uncertainty' will inevitably be several dB(A). Good measurement practice such as ensuring appropriate wind speed and direction, no significant precipitation effects or unrepresentative measurement conditions, using 'accurate' reliable instrumentation to measure appropriate parameters, will reduce this uncertainty and the associated variability in measurements, but it is still to be expected that measurements taken under apparently similar conditions on different occasions will differ considerably, and usually by somewhat more than the variation noted during the quieter part of any one night, for example.

However, even though the residual noise level may vary considerably it is likely that this will not generally be noticed by residents who are more likely to pay relatively little attention to the underlying soundscape, and are probably relatively unaware of its characteristics and level during the night, when they are asleep indoors, albeit possibly with open bedroom windows.

This means that the sound level measured at any specific location on one particular occasion under certain measurement conditions can only be an indication of the sound level at that time and place under those specific conditions. It is likely that even under apparently similar conditions the sound level at a different time – even at the same time of the day/night and same location will differ considerably.

This means that if a criterion is solely dependent upon the measured sound level there will be a considerable range in what the criterion may be, depending upon the specific circumstances when such measurements are taken. However, using the character of the existing soundscape to inform the appropriate selection of objective criteria such as those previously identified ensures a consistent approach to the determination of suitable criteria and generally prevents this particular problem from arising.

The sound level from a relatively small noise source is attenuated by 6dB(A) for every doubling of distance. Unless the position of a noise source is known and fixed, there is no direct equivalent between the sound pressure level outside a house and that at the boundary of the site. This is best illustrated by an example:

> If a noise source is located 2m inside the boundary and the nearest house is 30m away from the boundary, there will be a doubling of distance from the source (relative to the boundary) at distances of 4m, 8m, 16m and 32m (at the house) from the source. These four doublings of distance mean that the noise level at the house will be 4 x 6 i.e. 24dB(A) less than the level measured at the boundary.
>
> This should be compared with a source located 30m inside the boundary, for the same house. In this case, the house is exactly twice the distance from the source than the boundary is, so the noise level at the house will be only 6dB(A) lower than at the boundary.

Clearly, for the two different sources to produce the same noise level at the house, one must be 18dB(A) lower than the other when measured at the site boundary.

A boundary noise limit designed to protect off-site noise sensitive locations from noise sources at unspecified locations on a site may inadequately protect the noise sensitive locations or could potentially require massive over attenuation of noise sources which are close to the site boundary. The most appropriate location for the specification of noise limits is outside any noise sensitive locations (houses).

If the speed of fans is halved the corresponding aerodynamic noise level falls by approximately 16dB(A) to 18dB(A). If instead the number of fans operating is halved, the corresponding reduction in noise is only 3dB(A). This means that acoustically it is far better to keep all plant operating at lower speed, when lower capacity is required, than simply to switch some of the plant off and keep the remainder operating at full capacity. For the vast majority of the time when refrigeration or air conditioning plant does not need to operate at its full capacity (which is intended to cope with the greatest demand during the peak of the summer), the plant can operate at lower capacity. Inverter speed control systems provide this capability, consequently producing significantly lower levels of noise than the 'worst case' situation with the plant operating at maximum capacity.

Some motor/inverter combinations can produce higher levels of noise than is the case without an inverter. This is due to the interaction between the inverter and motor and often tends to be of a 'tonal' nature. Tonal noise can also be produced by other factors, such as the rate at which fan blades pass an obstruction.

Where the noise level rapidly changes by a significant amount this 'impulsive' characteristic tends to draw a listener's attention to the changing level of noise. This can happen when non inverter controlled units suddenly start or stop (particularly with noise from relays).

Manufacturers generally state the noise (sound pressure, Lp) level that their plant will produce at a specific distance from the plant. The sound power level (Lw) is the actual sound energy produced by the plant and should be corrected to give the corresponding sound pressure level at the required distance from the plant. For many items of plant a default distance of 10m is used. This report will therefore recommend suitable levels at this distance from plant for ease of comparison with manufacturers' data.

Most plant emits different levels of sound in different directions. Care must be taken to ensure that the level of noise emitted in the direction of any noise sensitive locations is not higher than may be expected from a simplistic reading of manufacturer's data. For example the sound level 10m directly above a vertical airflow flat bed condenser is typically about 6dB(A) to 7dB(A) higher than the corresponding level in a horizontal direction from the fan deck. A 'global average' sound pressure level is the logarithmic average of the levels measured in all directions from the plant. This tends to be biased towards the higher levels of noise.

As previously noted the level of sound from a 'point' source reduces at a rate of 6dB for every doubling of distance from the source. This means that the level at 20m will be 6dB less than at 10m and the level at 40m (two doublings) will be 12dB less than at 10m. Similarly the level at 100m will be 20dB less than at 10m, although other factors can also affect the sound level at relatively great distances from a noise source

If there is no direct 'line of sight' between a noise source and listener, the resultant noise level at the listener's location will be lower than would otherwise be the case (typically by between about 5dB and 15dB) due to the 'acoustic screening' along the propagation path.

Manufacturer's data also relates to the sound level measured under 'free field' conditions (without any reflective surfaces nearby). When plant is installed near to reflective surfaces such as walls (often the case) the resultant sound level is increased – generally by between 3dB(A) and 10dB(A).

The aim of this analysis is to provide a single figure for plant selection purposes that equates to the manufacturer's specification, but takes into account the site-specific factors that influence sound propagation from source to receiver. Each of the corrections discussed below is applied to the recommended external suitable level of 38dB(A) to derive an appropriate level at 10m for plant selection purposes.

Plant located on the first floor flat roof of the store will be 4m from the closest noise sensitive window. As noted above plant specifications are often stated at 10m from the source which means that the corresponding correction to the recommended external suitable level is therefore -8dB(A) at 10m from the plant.

There will be no line of sight between the plant and the closest sensitive window provided by intervening structures. The corresponding correction to the recommended external suitable level at the closest sensitive window is therefore +5dB(A) for screening attenuation.

As the plant will be located in the vicinity of several walls, sound will be reflected towards the closest sensitive area. The recommended external suitable level at the closest sensitive window is therefore corrected by -6dB(A) for any reverberant effect.

If multiple items of plant are to be installed it will be necessary to select plant such that the overall sound level at the closest sensitive location does not exceed the recommended suitable level and additional guidance should be sought in this case.

Applying the corrections identified above to the recommended suitable night-time external sound level of 38dB(A), indicates that the plant should be selected based on a cumulative global average free field sound pressure level of 29dB(A) at a distance of 10m from the plant, when operating at maximum night time

Where several types of plant are to be installed some may be easier and less costly to attenuate than others. Generally it is relatively easy to attenuate noise from a compressor pack, but more costly to do so for a condenser (which may also be larger in order to achieve a lower noise level). This means that it may be most cost effective to select/attenuate some plant to 'just' comply with the required level and to over-attenuate the remaining plant so that it does not significantly increase the overall noise level. For example, in order to achieve a total level of 40dB(A) at a location, it may be appropriate to select a condenser that produces a level of 39dB(A) at the nearest noise sensitive location with all other plant producing a cumulative level of 34dB(A) at the same location.

If appropriate, in order to reduce the level of reflected/reverberant sound, acoustically absorptive surface treatment could be applied to some surfaces. There do not appear to be any appropriate alternative locations for plant to be installed at this store.

Conclusion:

The existing ambient sound level in the vicinity of the site is due to a variety of nearby and more distant sources.

If appropriate the plant should make use of inverter speed control so that the criterion is achieved with the plant operating at maximum night time capacity. Care must be taken to ensure that noise from the plant does not contain any significant tonal or impulsive content and that it is not significantly directional. As further data becomes available regarding plant selections and location, more specific advice can be provided to acoustically optimise the plant installation. This can minimise the resultant noise level at identified sensitive locations and the cost/difficulty of achieving a 'suitable' noise level in order to protect the occupants of neighbouring premises.

Plant should be selected based on a cumulative manufacturer's free field global average sound pressure level of 29dB(A) at a distance of 10m from the plant when operating at maximum night time capacity. This is based on free field hemispherical propagation from a point source with a cumulative sound power level of 57dB(A) at night, in order to achieve the identified cumulative 'suitable' level of 38dB(A) at the nearest noise sensitive windows. As a guide, typical ambient day time noise levels are generally assumed to be around 10dB(A) higher than during the night. **It is likely that the plant selection will therefore be most significantly constrained by the requirement to achieve a suitable level during the night.**

Thomas S Leach

Thomas Leach, BSc (Hons), MSc, AMIOA
Acoustic Consultant

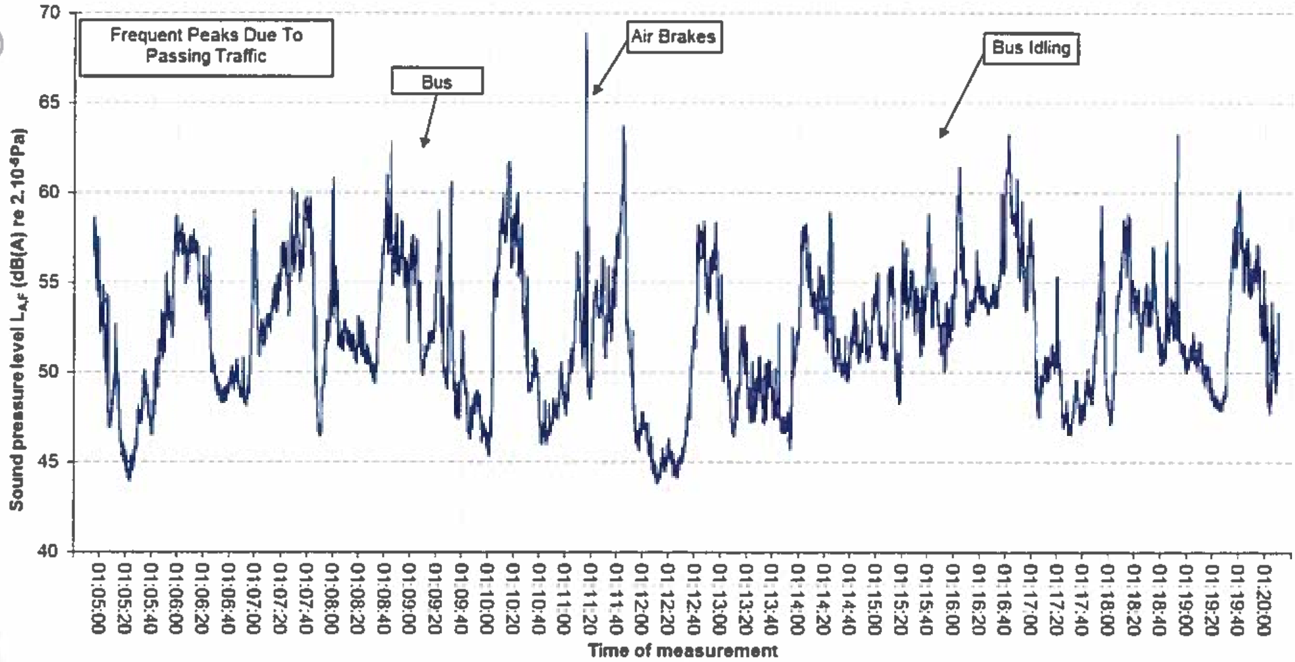
25/01/13

L. D

Lee Dursley, BSc (Hons), MIOA, MInstP
Acoustic Consultant

25/01/13

Graph 1 - Existing ambient sound level in vicinity of Grays Inn Road Store
Measured 10th January 2013 in front of dwellings to rear of store



Calculation Summary				
	Night-time Suitable Level at Closest Residential Window	NR25	38dB(A)	Note
Corrections	Distance		-8	4m
	Screening		+5	line of sight
	Reverberant		-6	multiple walls
	Directivity		-	-
	Plant at other premises / Cumulative correction		-	-
Plant Selection Cumulative Sound Pressure Level, Lp at 10m			29dB(A)	
Plant Selection Cumulative Sound Power, Lw			57dB(A)	

EXPLANATION OF SOME ACOUSTIC TERMINOLOGY

Sound is measured in terms of decibels (dB). There are many different methods of assessing the loudness of a sound. The most frequently used is the 'A Weighting', which simulates the effect of the human hearing mechanism. This method is widely used for sound assessment and the resulting level is expressed as dB(A). The table below gives an indication of different sound levels in terms of dB(A).

Sound Level dB(A)	Sound Source
0	Threshold of hearing
20	Recording Studio
40	Living Room
60	Conversational Speech
80	Light Factory Noise
100	Discotheque
120	Road Breaker
140	Threshold of pain

For a steady, continuous sound, a change of 1dB(A) is just perceptible to the ear. In the case of intermittent sounds, the change must be at least 3dB(A) to be perceptible. For steady sounds, a difference of 10dB(A) sounds twice as loud.

Unwanted sounds are classed as noise, these are a fundamental part of life. The level of such noise changes constantly. This may be due to dogs barking, telephones ringing or even during normal conversation. As a consequence, some method of quantifying the overall level of noise is required.

The equivalent continuous sound level (L_{Aeq}) is the level averaged over a specified period of time. This is widely used for both measurement and assessment. Because the L_{Aeq} is an average level over a specified period of time, a steady continuous sound and a shorter duration sound at a higher level can have the same L_{Aeq} over the same time period.

The level exceeded for 90% of the time (L_{A90}) is frequently used to determine the level of background noise. It ignores the loudest 90% of the measurements obtained. Therefore, although it does have a useful purpose, it takes no account of what happens for 90% of the time. This parameter together with the L_{Aeq} and the level exceeded for 10% of the time (L_{A10}) give a fairly good overview of the prevailing acoustic environment.

When A weighted, the maximum sound pressure level measured during a period is termed L_{AMax}. This gives an indication of the intrusiveness of a noise event, which is lost with the averaging effect of the corresponding L_{Aeq}.

EXPLANATION OF SOME ACOUSTIC TERMINOLOGY Cont'd

Different sound sources produce an overall level that depends upon the louder source and the difference in sound level between the two sources. If the difference is within 1dB, they act as identical sources, with the overall level being 3dB greater than the louder source. If the difference is 2dB or 3dB, the overall level is only 2dB greater than the louder source. For example, if a machine produces 84dB and a second machine produces 82dB, the overall sound level will be 86dB. This is summarised in the table below:

Difference in Levels (dB)	Increase in Level (dB)
0,1	3
2,3	2
4..9	1
10+	0

The sound level rises as a point source becomes closer. This increase is 6dB for every halving of distance. The effect is similar to the addition of sound sources, but with changes of 6dB rather than 3dB. A machine that produces 80dB at 200m will produce 86dB at 100m and 92dB at 50m. This effect is summarised in the table below:

Ratio of Distances	Increase in Sound Level (dB)
2	6
3	10
4	12
10	20
20	26

The **A Weighting** system attempts to replicate the way in which the human hearing mechanism works. An A Weighted sound is expressed as a single value in terms of **dB(A).** This allows the loudness of different sounds to be compared, the louder having a higher level in dB(A).

Whilst a single figure value is ideal for noise assessment purposes, it is inadequate for noise control requirements. This is because the most appropriate control techniques will be dependent upon the characteristics of the noise.

EXPLANATION OF SOME ACOUSTIC TERMINOLOGY Cont'd

In this case, the noise is analysed in terms of its frequency content, from a low frequency rumble to a high frequency hiss. To achieve this, eight octave bands are normally used. This set of eight values is termed a **sound spectrum** and analyses a sound in terms of frequency content as the table below shows:

Octave Band Centre Frequency (Hz)	63	125	250	500	1k	2k	4k	8k
	low frequency				high frequency			

The A Weighting system simulates the effect of the average human hearing mechanism by weighting each frequency and adding the corresponding levels. In an attempt to improve on this, Beranek developed the Noise Criterion (**NC**) curves. These show equal loudness levels at different frequencies. As such, if a sound spectrum matches a given NC curve e.g. NC 40, all octave bands will sound equally loud. This would equate to a level of approximately 49dB(A).

Kosten and Van Os then adapted the NC system specifically for room design and produced the Noise Rating (**NR**) system. Broadly speaking the two systems are equivalent. A major advantage of the NC or NR system for noise control purposes is that noise which meets a required curve will not have a significant tonal content, making it much less intrusive.

While the sound pressure level (Lp) is useful, this only provides information about the sound level produced by a source at a particular point in space. It cannot immediately let us compare one piece of machinery against another because it depends upon where the meter is located.

The sound power level (Lw) is used to describe the sound energy output from a machine, independent of location. This is the amount of energy that the machine converts to sound energy, considered on the decibel scale. There are conversion factors we can use to convert a sound pressure level reading into a power level reading. These conversion factors rely on the surroundings of the machine being reasonably simple. For example, to rely on the conversion factors, we would not want buildings or uneven ground between the plant and the sound level meter.

REFERENCES

1 World Health Organisation:
a) Guidelines for Community Noise, 1999
b) Night Noise Guidelines for Europe , 2009

2 Department for Communities
National Planning Policy Framework, 2012

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Noise Policy Statement for England, 2010

4 CEC. EUR Report 5398e.
Damage and Annoyance Caused by Noise (1975).

5 British Standards Institute:
a) BS 8233: Sound insulation and noise reduction for buildings – Code of practice – 1999
b) BS 4142: Method for Rating industrial noise affecting mixed residential and industrial areas – 1997

6 CIBSE & ASHRAE:

Guide to Current Practice,
Chartered Institute Building Service Engineers

Guide to Current Practice,
American Society Heating, Refrigeration and Air Conditioning Engineers

Co op Grays Inn Road
King's Mews
A401
Google earth

GENERAL SPECIFICATION FOR ACOUSTIC AND VIBRATION ISOLATION MATERIALS AND PRODUCTS

ISSUE GS/2013

HANN TUCKER ASSOCIATES
Consultants in Acoustics
Noise and Vibration Control

Head Office:
Duke House, 1-2 Duke Street
Woking, Surrey, GU21 5BA
Tel: (01483) 770595
Fax: (01483) 729565

Northern Office:
First Floor, 346 Deansgate
Manchester, M3 4LY
Tel: (0161) 832 7041
Fax: (0161) 832 8075

E-mail: Enquiries@HannTucker.co.uk
www.hanntucker.co.uk

GENERAL SPECIFICATION FOR ACOUSTIC AND VIBRATION ISOLATION MATERIALS AND PRODUCTS

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1. ATTENUATORS/SILENCERS (ABSORPTIVE TYPE)

N.B. Attenuators are often referred to as silencers.

1.1 Performance

1.1.1 Each attenuator shall provide an insertion loss under operating conditions of not less than that indicated on the relevant acoustic hardware schedule. Manufacturers shall specify the insertion losses expected from the attenuators offered, under the operating conditions, with the data derived from tests carried out in accordance with BS EN ISO 7235.

1.1.2 Each attenuator shall have a pressure loss at the design flow and temperature of not greater than that shown in the schedules. The manufacturer's quoted pressure losses shall be derived from tests carried out in accordance with BS EN ISO 7235. Where the attenuator location is known, the supplier shall indicate the expected effect of turbulence due to adjacent duct elements on the quoted pressure losses.

1.1.3 Suppliers of attenuators shall provide, with the certified insertion loss data, information relating to the attenuator generated octave band sound power levels (125 - 8kHz) at the operating conditions.

1.2 Construction

1.2.1 The outer casing of all duct attenuators shall be constructed in accordance with the current relevant ductwork specification in terms of thickness and seams.

1.2.2 All attenuators shall be fitted with drilled angle flange connections, unless alternative connections are specified in the schedule or by the Mechanical Services Consultant or Contractor. Flanges should also conform to the relevant code or its equivalent.

1.2.3 Acoustic elements in rectangular attenuators of length equal to or greater than 900mm shall incorporate faired leading and trailing edges (not square ends). Attenuators having a length of less than 900mm should have a faired leading edge, unless otherwise specified.

1.2.4 The inert, rot and vermin proof, non-hygroscopic and non-combustible mineral wool or glass fibre acoustic medium shall be packed to a density of not less than 48kg/m^3. This shall be faced with a glass fibre cloth, or other approved infill protection membrane, retained by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded (“Expamet”) sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

The manufacturer will also note any particular requirements, e.g. painting, special materials, etc., indicated in the schedules or on the drawings.

1.2.5 Where acoustic elements form splitters within the attenuator, the arrangement shall be with a half-width splitter fixed to each side wall of the casing and preferably with the splitters vertical. The configuration should have a regular splitter/airway dimension across the full width of the attenuator. However, it is the responsibility of the supplier to ensure that the parallel splitter elements in the attenuator are correctly orientated for the adjacent duct geometry, particularly when attenuators are located near bends, bifurcations, etc. Horizontal splitters should be suitably stiffened to prevent flexing and restriction of the airways and will normally be limited to silencers having a module width of 900mm or less.

1.2.6 In the case of circular attenuators, all internal acoustic elements shall comprise mineral or glass fibre as the acoustic medium, as specified above for rectangular attenuators, retained by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded (“Expamet”) sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

1.2.7 When attenuators are manufactured in modules each unit shall be shop assembled (unless the Mechanical Services Contractor instructs to the contrary) and this specification, together with the manufacturer's own guarantee and performance ratings, shall apply to the unit as a whole.

1.2.8 Attenuator units shall be delivered to site with blocked ends to prevent ingress of rubble, etc., while on site and to reduce the risk of damage. The direction of airflow through the attenuator shall be clearly marked on the casing.

1.2.9 Attenuators for high temperature applications (e.g. diesel exhausts, boiler flues, etc.) should have casings manufactured from a suitable gauge steel, with adequate precautions taken to cater for expansion and thermal shock. The internal elements shall be packed with an inert, rot and vermin proof, non-hygroscopic and non-combustible mineral or glass fibre acoustic medium of at least 96kg/m^3 density. This shall be faced with glass fibre cloth retained by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded (“Expamet”) sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers). For very high temperatures, steel wool or equivalent approved materials may be used as the acoustic medium.

1.2.10 The attenuator cross-sectional sizes shown in the schedules are to be followed exactly, since they often relate to duct sizes and thus avoid the unnecessary use of transition sections. However, subject to agreement with the Mechanical Services Consultant or Contractor, the supplier may propose alternative dimensions in line with his own standard sizes, provided the acoustic and aerodynamic requirements are met.

1.2.11 The use of Melinex or other plastic film between the perforated sheet steel facing and the infill medium may be required for certain applications. It should be noted that such materials may reduce the acoustic performance of the attenuator significantly and this must be taken into account when interpreting the schedules. Film thicknesses greater than 0.05mm will not be permitted, and use of very thin films (0.008-0.010mm) is preferred.

1.2.12 Where corrosive or toxic gases or substances are being handled, special constructions and materials may be specified as an addendum to this specification.

1.2.13 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

2. ENGINE EXHAUST SILENCERS (REACTIVE TYPE)

2.1 Performance

2.1.1 All silencers shall provide an insertion loss at the operating temperatures of not less than that indicated on the relevant acoustic hardware schedules.

2.1.2 All silencers shall have a static pressure loss, under maximum operating conditions, of not greater than that shown in the schedules.

2.2 Construction

2.2.1 The outer casings of all silencers shall be constructed from a suitably heavy gauge steel with all seams and joints continuously welded. Acoustic elements within the silencer shall be designed and constructed with due allowance for differential expansion and thermal shock.

2.2.2 All silencers shall also be fitted with suitable flanges and drain plugs and shall be manufactured and finished with due allowance made for the operating temperatures and environmental conditions.

2.2.3 Silencers shall be delivered to site with blocked ends to prevent ingress of rubble, etc., during installation and to reduce the risk of damage. The direction of gas flow through the silencer shall be clearly marked on the casing.

2.2.4 The silencer sizes shown in the schedules are indicative only, and the supplier may modify these in line with his own standard sizes, provided the acoustic and aerodynamic requirements are met. It is the supplier's responsibility to ensure that the Client is advised of the actual sizes being offered, where these differ from the schedules.

2.2.5 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

3. ACOUSTIC WEATHER LOUVRES

3.1 Performance

3.1.1 All acoustic weather louvres shall provide an insertion loss under the operating conditions of not less than that indicated in the relevant acoustic hardware schedules. In addition, the static pressure loss, under maximum operating duty, shall not exceed that shown in the schedules.

3.1.2 The louvre shall be designed to prevent the ingress of rain, etc. under normally encountered meteorological conditions.

3.2 Construction

3.2.1 The louvre frame shall be constructed from a suitable gauge of galvanised mild steel, or aluminium, supporting louvre blades of like material. The acoustic material in the blades shall have a density of 60-100kg/m^3 and be inert, rot and vermin proof, non-hygroscopic incombustible mineral fibre. This shall be faced with glass fibre cloth, or other approved infill protection membrane, and retained on the lower blade face by punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.5mm fixed at 200mm (max) centres. Flattened-expanded ("Expamet") sheet shall not be used, unless all edges of the sheet are mechanically fixed to the splitter casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

3.2.2 When the louvres are actually manufactured in sections, each unit shall be shop assembled as a whole unit (unless the Mechanical Services Contractor instructs to the contrary) and this specification, together with the manufacturer's own guarantee and performance ratings, must apply to the unit as a whole.

3.2.3 Acoustic weather louvres shall be supplied with an integral bird screen of galvanised mild steel or aluminium mesh, fixed to its internal face. The mesh pitch shall be a maximum of 25mm.

3.2.4 The louvres shall be supplied complete with all necessary fixings, flanges, etc., for fitting into the louvred opening as required by the Mechanical Services Contractor.

3.2.5 All gaps between the outside of the louvre frame and the wall or duct shall be made good and sealed with a heavy grout and/or non-hardening dense mastic.

3.2.6 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure fibre migration is prevented.

4. ANTI-VIBRATION MOUNTINGS

4.1 General

4.1.1 Where so indicated in the schedules by the code /R, the mountings/hangers shall be provided with a positioning or restraining device, which will prevent the equipment position changing if its load changes; for example, during draining down of the equipment or other maintenance. The device shall consist of a stud passing through an oversize hole with a nut and locknut providing restraint. A fibre or neoprene washer should be fitted between nut and restraining member, leaving a clearance of at least 3mm. Alternative methods of restraint must be approved by the Acoustic Consultant in writing.

4.1.2 All mountings shall provide the static deflection, under the equipment weight, shown in the schedules. Mounting selection should allow for any eccentric load distribution or torque reaction, so that the design deflection is achieved on all mountings under operating conditions.

4.1.3 It is the supplier's responsibility to ensure that all mountings offered are suitable for the loads, operating and environmental conditions which will prevail. Particular attention should be paid to mountings which will be exposed to atmospheric conditions to prevent corrosion.

4.1.4 All mountings shall be colour coded, or otherwise marked, to indicate their load capacity to facilitate identification during installation.

4.1.5 Where use of resilient supports allows omission of pipe flexible connections for vibration/noise isolation, it shall be the Mechanical Service Consultant's or Contractor's responsibility to decide whether such devices are required to compensate for misalignment or thermal strain.

4.2 Caged Steel Spring Mountings (CSS)

4.2.1 Each mounting shall consist of cast or fabricated telescopic top and bottom housings enclosing one or more helical steel springs as the principle isolation elements and shall incorporate a built-in levelling device. The housing should be designed to permit visual inspection of the springs after installation, i.e. the spring must not be totally enclosed.

4.2.2 The springs shall have an outside diameter of not less than 75% of the operating height and be selected to have at least 50% overload capacity before becoming coil-bound.

4.2.3 The bottom plate of each mounting shall have bonded to it a rubber/neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

4.2.4 Mountings incorporating snubbers or restraining devices shall be designed so that the snubbing, damping or restraining mechanism is capable of being adjusted to have no significant effect during the normal running of the isolated machine.

4.2.5 All nuts, bolts or other elements used for adjustment of a mounting shall incorporate locking mechanisms to prevent the isolator going out of adjustment as a result of vibration or accidental or unauthorised tampering.

4.3 Open Steel Spring Mountings (OSS)

4.3.1 Each mounting shall consist of one or more helical steel springs as the principal isolation elements and shall incorporate a built-in levelling device.

4.3.2 The springs shall be fixed or otherwise securely located to cast or fabricated top and bottom plates having an outside diameter of not less than 75% of the operating height and shall be selected to have at least 50% overload capacity before becoming coil-bound.

4.3.3 The bottom plate shall have bonded to it a rubber/ neoprene pad designed to attenuate any high frequency energy transmitted by the springs.

4.4 Neoprene-in-Shear Mountings (NIS)

Each mounting shall consist of a steel top plate and base plate completely embedded in oil resistant rubber/neoprene. Each mounting shall be capable of being fitted with a levelling device, have bolt holes in the base plate and have a threaded metal insert in the top plate so they can be bolted to the floor and equipment where required.

4.5 Hangers with Steel Springs (HSS)

4.5.1 The hanger shall incorporate a helical steel spring securely located in a steel cage.

4.5.2 The clearance hole in the bottom of the cage should allow a lateral movement of the lower hanger rod of at least 15^{o} included angle.

4.5.3 Where hangers incorporate a positioning device, the adjustment system should incorporate a locking mechanism to prevent the hanger going out of adjustment as a result of vibration, or accidental/unauthorised tampering.

4.6 Hangers with Neoprene Turrets (HNT)

The hanger shall be essentially as described in 4.5 above except it shall incorporate a neoprene in shear element as described in 4.4.

4.7 Plant Bases

4.7.1 AV Rails (AVR)

An A.V. Rail shall comprise a steel beam with two or more height-saving brackets. The steel sections must be sufficiently rigid to prevent undue strain in the equipment and if necessary should be checked by the Structural Engineer.

4.7.2 Steel Frame Base (SFB)

Steel plant bases shall comprise an all-welded steel framework of sufficient rigidity to provide adequate support for the equipment and fitted with isolator height saving brackets. The frame depth shall be approximately 1/10 of the longest dimension of the equipment with a minimum of 150mm. This form of base may be used as a composite A.V. Rail system.

4.7.3 Concrete Inertia Base (CIB)

These shall consist of an all-welded steel pouring frame-work with height saving brackets and a frame depth of approximately 1/12 of the longest dimension of the equipment, with a minimum of 100mm. The bottom of the pouring frame should be blanked off and concrete (2300 kg/m^3) poured in over steel reinforcing rods positioned 35mm above the bottom. The inertia base should be sufficiently large to provide support for all parts of the equipment, including any components which overhang the equipment base, such as suction and discharge elbows on centrifugal pumps.

4.7.4 Concrete Split Plinth Bases (CIB) (For neoprene mounts/pads)

These should comprise a concrete inertia base of sufficient size to permit support for all parts of the equipment, including any components which overhang the equipment base, such as suction and discharge elbows on centrifugal pumps. The inertia base should be cast onto a permanent bottom shuttering and supported on the specified neoprene mounts or pads, the whole resting on a plinth as required. It should be noted that the construction of concrete bases on cork, expanded polystyrene or mineral wool slabs is not normally permitted. Where neoprene pads are used, small areas of pad must be equally spaced to provide the correct deflection. The number, dimensions and locations of such pads should be advised by the supplier.

5. ACOUSTIC DOORS

5.1 Performance

5.1.1 All acoustic doors shall provide a sound reduction index (SRI) as tested in accordance with BS EN ISO 140-3: 1995 of not less than that shown in the relevant schedule. Where the schedule refers to a mean SRI, the equivalent SRI spectrum should not be less than indicated below:-

Mean SRI dB (100-3150Hz)	SRI (dB) at Octave Band Centre Frequencies (Hz)					
	125	250	500	1k	2k	4k
30	21	26	30	33	35	36
35	24	30	35	38	39	40
40	27	35	40	42	46	47
45	33	36	44	48	52	54
50	35	40	50	54	60	60

5.1.2 The manufacturer or supplier of acoustic doors shall guarantee the specified SRI and ensure the method of installation does not detract from the guaranteed performance. Any failure to meet the specification because of faulty design, manufacture or installation, will result in the manufacturer or supplier being held liable for remedial or replacement costs including consequential liability.

5.2 Construction

5.2.1 The acoustic doors shall be of hardwood or steel and be complete with all seals, frames and furniture as specified by the Architect.

5.2.2 It is recommended that, where a mean SRI equal to or greater than 35dB is required, the door should be of steel construction with double neoprene/rubber compression (or knife-edge) seals to head, jambs and threshold. Double doors should incorporate a central jamb or overlapping leaves to ensure a good seal at the middle joint. Lower performance doors (35dB or less) may be fitted with magnetic seals.

5.2.3 The door fastener or lock should be designed to ensure the seals operate over the whole periphery of the door.

5.2.4 Wiper seals will not be permitted at thresholds; doors must be fitted with a raised threshold and a compression seal, or with a mechanical drop-down seal for doors with ratings up to 35dB.

6. ACOUSTIC ENCLOSURES (MODULAR)

6.1 Performance

6.1.1 The acoustic enclosure shall provide in its as-installed condition an overall sound reduction index (SRI) of not less than that shown in the relevant schedule. Full allowance shall be taken of any loss of insulation due to doors, windows, ventilation openings and panel joints.

6.1.2 The manufacturer or supplier shall guarantee the specified SRI, and ensure that the method of installation does not detract from the guaranteed performance.

6.1.3 The internal surfaces of the enclosure panels shall be designed to give the following minimum average absorption coefficients (ISO) when tested in accordance with BS EN ISO 354:2003.

Frequency	125	250	500	1k	2k	4k
Minimum average absorption coefficient	0.5	0.5	0.8	0.95	0.95	0.95

6.2 Construction

6.2.1 The enclosed outer panels shall be constructed from galvanized sheet steel having a minimum thickness of 1.6mm and fixed at 300mm (max) centres. The enclosure inner panels shall be constructed from punch-perforated (round-hole) galvanised sheet steel facing, having a minimum thickness of 0.7mm fixed at 300mm (max) centres.

Flattened-expanded ("Expamet") sheet shall not be used, unless all edges of the sheet are mechanically fixed to the panel casing and galvanised steel cover strips are used to prevent rivet heads pulling through the perforated sheet (trapping the Expamet between two solid steel layers).

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6.2.2 The inert, rot and vermin proof, non-hygroscopic and non-combustible mineral wool or glass fibre acoustic medium shall be packed to a density of not less than 48kg/m$^{3.}$ This shall be faced with a glass fibre cloth, or other approved infill protection membrane. Panels shall be constructed and assembled so that no egress of the acoustic medium will occur under the operating conditions.

6.2.3 Doors, access panels, windows and ventilation ducts or electrical cable penetrations hall be treated so as to maintain the specified acoustic insulation of the assembled enclosure.

6.2.4 Demountable sections shall be designed to allow easy disassembly and reassembly by unskilled personnel without affecting the acoustic performance.

6.2.5 The supplier shall ensure that the assembled enclosure is designed and constructed to withstand site operating conditions such as wind and snow loads, roof mounted plant, etc., as appropriate, and if outside, to be suitably weatherproofed.

6.2.6 The acoustic media shall not comprise materials which are generally composed of mineral fibres, either man made or naturally occurring, which have a diameter of 3 microns or less and a length of 200 microns or less or which contain any fibres not sealed or otherwise stabilised to ensure that fibre migration is prevented.

7. LIABILITY

All tenderers are advised that failure to comply with any part of the above specification may result in either their tender being discounted or liability for any resulting remedial or replacement costs on site, including consequential liability, unless variations are accepted in writing by their client and/or the Acoustic Consultant.

It is recommended that all tenderers shall have undergone the necessary assessment and registration procedure to BS EN ISO 9001:2008 and shall not sub-contract the manufacture of any products to an unregistered third party fabricator.

It is also recommended that the purchaser of acoustic equipment checks the manufacturer's standard conditions of sale forming part of his quotation do not contravene this specification.