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ACOUSTIC ASSESSMENT OF NOISE FROM REFRIGERATION/AIR CONDITIONING PLANT AT CO-OP, MARKET PLACE, BUXTON, DERBYSHIRE, SK17 6EF

Client:	BJA Refrigeration Consulting Engineers Limited Bridge Mills Huddersfield Road Holmfirth HD9 3TW
Instruction:	Katy Nightingale BJA Refrigeration Consulting Engineers Limited
Project Manager:	Gary Bell-Bond BJA Refrigeration Consulting Engineers Limited
Report Author:	Ashley Shepherd
Brief:	To visit the site, take measurements and record relevant observations to assess the existing acoustic environment in the vicinity of the store. To provide advice regarding suitable acoustic criteria for the selection of replacement plant, relating this to 'typical' manufacturers' data in order to facilitate plant selection.
Plant Selection:	**Plant located on the roof of the store have no reflective vertical surfaces (walls etc) and will be approximately 6m from, with a 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 – 01:00 hours – 01:30 hours Date – Tuesday 25th November 2014 Weather – Light NW breeze approximately 1ms^{-1}, 100% low cloud, 0°C to 5°C, damp ground surfaces, light mist.
Personnel:	A Shepherd – Belair Research Limited
Instrumentation:	Cirrus Optimus Sound Level Analyser Type CR 171, Serial No. G056106 Cirrus Calibrator Type CR 515, Serial No. 57135 Cirrus Windscreen 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 building is a predominantly of three storey construction with the store located on the ground floor, a warehouse to the rear, and occupied dwellings on the first and second floor. Adjoining the store on either side, when viewed from Market Place, are a number of commercial properties, some with dwellings above. In front of the store, on the opposite side of Market Place is a large car park with several restaurants and public houses located beyond this. To the rear of the store is a small yard and beyond that an access road. The area further to the rear of the store is largely residential. Plant is to be installed on the roof to the rear of the store, the plant location will be approximately 6m from with a direct line of sight to the closest dwelling above the store. The acoustic environment was influenced by nearby and distant road traffic, some noise due to the movement of flowing water in drains, and the occasional taxi, arriving and leaving the nearby rank located on Market Place. The location picture towards the end of the report shows the layout of the store and surrounding area, together with the measurement location identified 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. Sources of ambient noise in the vicinity of the store 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.

Measurements: Sound pressure level measurements were taken at one location in the vicinity of the store. The purpose of the measurements was to assess the residual sound level at the dwellings nearest to the store, in the absence of noise from any plant at the store.

As would be expected, the ambient sound level at locations where sound from plant was dominant tended to remain relatively stable, varying primarily with changes in the operational characteristics of the plant. At locations where the sound from plant was less dominant the residual noise level tended to fluctuate to a greater extent, with the magnitude of such fluctuations depending upon variations in noise from extraneous sources such as road traffic.

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 taken in the small car park to the rear left of the store. The graph shows that the residual level varied between around 35dB(A) and 40dB(A). The occasional taxi idling, arriving, and leaving the nearby rank increased levels to between around 40dB(A) to just above 55dB(A), with passing vehicles generating similar levels intermittently during the monitoring period.

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

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 48dB(A) at the closest daytime 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 48dB(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 similar to 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 slightly 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 roof of the store will be 6m 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 -4dB(A) at 10m from the plant.

There will be a direct path between the plant and the closest sensitive window. The corresponding correction to the recommended external suitable level at the closest sensitive window is therefore +0dB(A) for screening attenuation.

As the plant will be located in the vicinity of no walls, sound will not be reflected towards the closest sensitive area. The recommended external suitable level at the closest sensitive window is therefore unchanged.

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.

In the absence of specific plant information it is assumed that sound from plant may contain acoustically distinguishing characteristics which may attract a rating penalty. To allow for this a -5dB(A) character correction is included in the calculations.

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 capacity.

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.

Acoustic screening could be installed between the plant and the noise sensitive receptors. This may enable the criterion to be relaxed by a few decibels, which could facilitate plant selection.

Conclusion: The existing ambient sound level in the vicinity of the store 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.**

The above criteria are based on the assumption that sound from plant at the food store may contain acoustically distinguishing characteristics. If the manufacturers confirm that this is not the case the criteria could be relaxed by 5dB(A).

26/11/14

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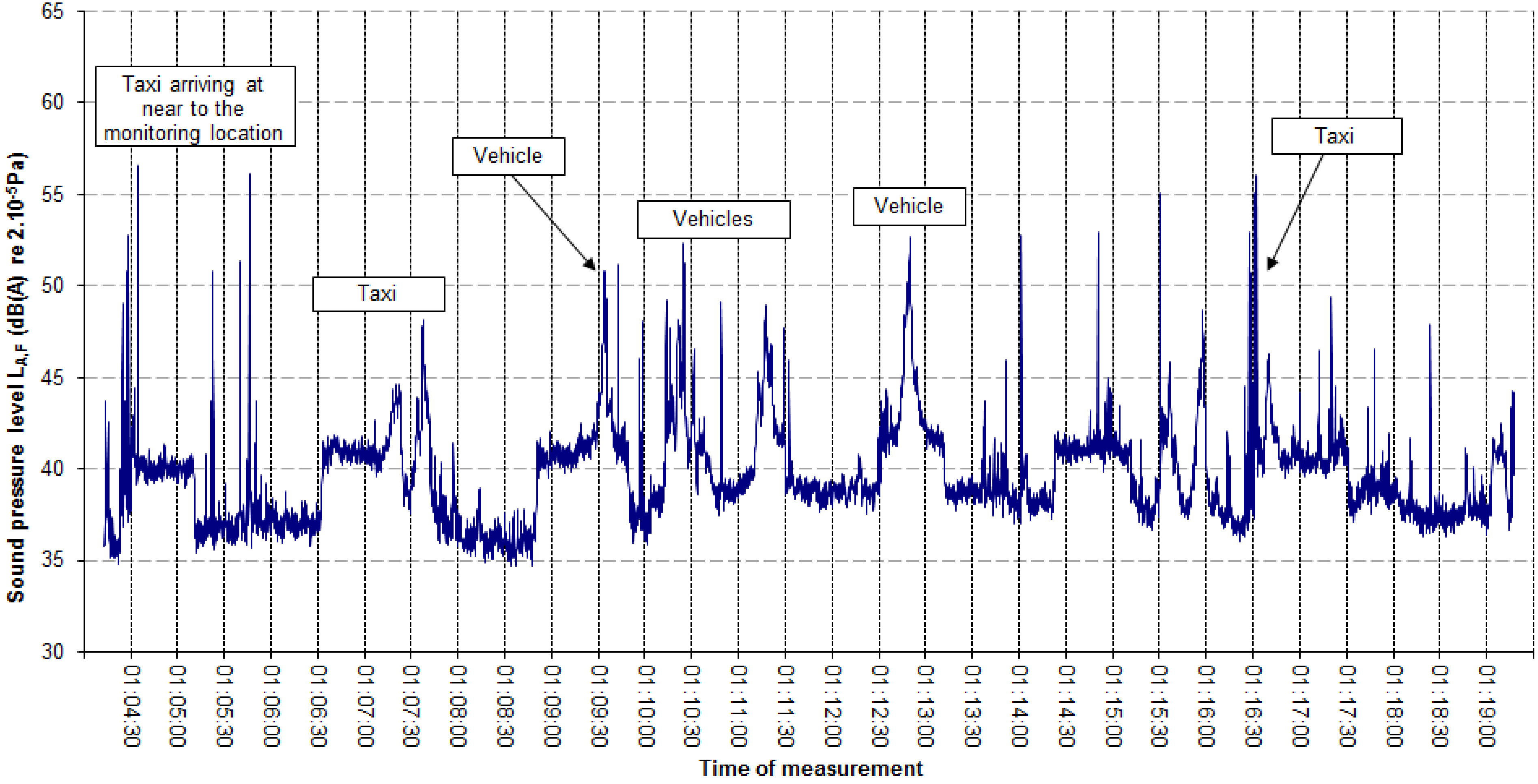
Graph 1 - Existing ambient sound level in vicinity of Market Place Store
Measured 25th November 2014



Night-time Suitable Level at Closest Residential Window		Dwelling above store	
		NR25	38dB(A)
Corrections / dB(A)	Distance from plant to receptor (m)	6	-4
	Acoustic screening	None	+0
	Plant location character	Flat surface	+0
	Receptor location character	Standard	+0
	Directivity	In front	+0
	Acoustic character (rating) penalty	Character	-5
	Existing plant correction	None	+0
	Plant at other premises	None	+0
Plant Selection - cumulative sound pressure level (Lp) at 10m			**29dB(A)**
Plant Selection - cumulative sound power level (Lw)			57dB(A)

Day-time Suitable Level at Closest Noise Receptor		Dwelling above store	
		48	48dB(A)
Corrections / dB(A)	Distance from plant to receptor (m)	6	-4
	Acoustic screening	None	+0
	Plant location character	Flat surface	+0
	Receptor location character	Standard	+0
	Directivity	In front	+0
	Acoustic character (rating) penalty	Character	-5
	Existing plant correction	None	+0
	Plant at other premises	None	+0
Plant Selection - cumulative sound pressure level (Lp) at 10m			**39dB(A)**
Plant Selection - cumulative sound power level (Lw)			67dB(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

Residential Property
Store
Monitoring Location
Plant Location
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