t: 023 81 290160
f: 023 81 290260
www.excelpowerltd.co.uk
info@excelpowerltd.co.uk

General Thoughts on Generator Set - Acoustic Solutions & Noise Control

Written By Steve Delaney A.M.I.O.A. of TAS Ltd

Introduction

Noise levels are normally measured as Sound Pressure Levels, in decibels (dB) or dB(A), and are expressed in terms of a specified dB(A) level at a specific distance from the noise source..... In this case a diesel generator.

Examples of this could be: 85dB(A)@ 1 metre, 70dB(A)@ 5 metres, 55 dB(A) @ 1 metre, etc.

All sound level measurements are made in decibels (dB), if figures are produced in dB(A) - "A" weighted dB figures, these are the result of a correction made so that figures recorded more closely mimic what a human ear perceives.

Why are Canopies specified under Free Field Conditions?

Environment has an effect on the noise levels perceived. It is not possible/ practical to carry out very time consuming and costly Environmental back-ground noise level measurements for every potential job/location, to allow a site specific Acoustic solution to be derived to meet these challenges.

(Indeed in many cases the building the set is intended to serve may not even be built yet).

It is therefore Industry standard practice to calculate and then design Acoustic Housings as though it were to be located in Free Field Conditions.

Free Field Conditions (FFC) exist where the environment is totally free of reflecting surfaces.

In order to carry out true FFC tests the canopy needs to be located on site such as an airfield or in an Anechoic Chamber (A room designed to offer zero reflection of the sound radiated from the canopy).

Therefore a canopy designed to achieve say 80dB(A)@1m under FFC's will not take into account the further noise added to it due to reflections caused by the environment in which the set is to be located.

In the real world: Whilst it is highly unlikely that many generator sets will ever be located in true FFC's, this at least provides a level playing field for all parties likely to be quoting for any given project.

In real life situations most industrial plant will be located in or adjacent to buildings, therefore there will always be some effect from these structures on the noise levels measured on site despite the fact that the noise emitted by the canopy is unchanged.

Imagine a generator canopy (Again say 80dB(A) @1m) is located with its side wall 1m from the side wall of a building, the noise energy radiating out of said canopy wall cannot decay with distance and as it is reflected back by the building, this reflected noise will add to that emitted by the canopy and the measured noise level will increase, to say 85dB(A)@1m.

However if the same canopy is located at a distance of say 5 metres from the building the measured noise level at 1m from the canopy may only have increase to say 81dB(A) as the reflected noise from the building is significantly reduced.

This happens for 3 reasons:

i) More noise has decayed over the 5metres before it hits the building wall.

ii) Less noise is reflected.

iii) Less noise makes it back to the measuring position.

Site specific conditions such as the construction of the buildings will also have some minor effects.... Smooth concrete reflects more noise than rough brick, breeze blocks reflect even less etc.

Hard surfaces absorb very little noise, but the more broken the surface the less effective they are at reflecting sound & hence the lower the overall noise level experienced at the measurement position.

Example: We have all seen pictures of "the poor man's sound recording studio" with egg boxes stuck to the wall.... the egg boxes don't absorb much sound, they just reflect it back very badly. Thus allowing the recording equipment to pick up only the sounds (noise) that directly entering the microphone. (Anechoic chambers are effectively very sophisticated "egg box lined" rooms).

The addition of multiple noise sources are carried our logarithmically. Therefore if 2 similar noise levels are added together the total noise will be 3dB higher.

i.e. 80dB(A) + 80dB(A) = 83dB(A).

If the 2 noise sources are more than 10dB(A) different the result of the addition of these figures is the higher level + zero.

i.e. 80dB(A) + 70dB(A) = 80dB(A)   or   90dB(A) + 80 dB(A) = 90dB(A).

Above we have been discussing the effect of additive noise due to environment. In order for a 80dB(A) @1m canopy to be tested and achieve this figure the background noise must therefore not exceed 70dB(A) and reflected noise must be prevented.

Considering Project Noise Levels

One thing that must be decided at the onset of any project is where is the critical noise sensitive noise location?

On some projects it is in offices adjacent to the where the set will be located, but in many, the project noise specification is intended not to upset the neighbours. Therefore Noise level at the boundary of the clients site.

Therefore provided the Noise at Work Regulations, are not exceeded it is possible to tune the performance of the canopy to match site conditions, such things are orientation of the canopy so as best to maximise the Zero Cost attenuation due to distance achievable, the greater the distance the bigger the noise reduction.

There may also be benefits to placing barriers between the canopy and the site boundary.

Noise levels within these barriers will increase, but noise levels beyond these barriers will be lower, provided they are correctly designed/ positioned.

However care should be taken as to the location and proximity of barriers as it is imperative not to inhibit cooling flows.

The decay of noise level due to distance is dependent on the size of the canopy/ set size.

Therefore a small 50kVA generator set in a canopy being small will achieve greater noise decay with regard to distance in comparison to say a 2000kVA large generator canopy (which has a greater surface area to emit noise). So even if both units are designed to achieve 80dB(A)@1m, at 10m away the noise from the 50kVA may have decayed to 70dB(A)@10m but the 2000kVA may have only decayed to 75dB(A)@10m.

For a small canopy a common “Rule of Thumb” used with regard to noise level and distance is that when moving 5 metres distance from the noise source, noise drops by 1 dB(A) per metre and then drops by 6dB(A) per doubling of distance.

For a large canopy a similar “Rule of Thumb” may be applied from the 10m distance from the noise source, noise drops by 1 dB(A) per metre up to 10m and then drops by 6dB(A) per doubling of distance.

THIS SHOULD NOT BE CONSIDERED AS ANYTHING MORE THAN A “RULE OF THUMB” Intended for GUIDANCE ONLY.

Accurate calculations can be carried out using Sound Power equations which will give true figures as these take the size of the unit into account.

A Word on SOUND POWER vs SOUND PRESSURE.

SOUND POWER can be seen abbreviated as: LW or SWL... (Think Power = Watts)

It is also commonly seen as LW_A where the (A) simply means dB(A) “A” Weighted as discussed above.

SOUND PRESSURE can be seen abbreviated as: LP or SP(A)... (Think “P”= Pressure).

Again “A” Weighted as discussed above is the most common way of expressing this.

The Human ear and the microphone on a sound level meter are pressure sensitive devices.

The pressure of the sound waves moving through the air and impacting on them is converted into electrical signals and different noise/sound levels are perceived/ recorded.

Sound Power Levels are the total Noise emitted from a source and are totally independent of environment. As they are the noise emitted from a surface they are simply stated as a dB(A) level and distance is zero and hence not stated.

Sound Pressure levels are the noise levels perceived by the ear or recorded by the sound meter. As this will be at a distance from the noise source, they WILL be affected by environment and should always be stated at a distance.

A good analogy for this is not to think in terms of Noise but in terms of Heat, and instead of thinking of a generator set think of an Old fashioned 3-bar (3kW) electric fire.

The Power emitted is 3kW regardless of where the fire is located.

If the fire is located in say a Broom cupboard, the "Heat Pressure" perceived is significantly greater than if the same fire is placed in an Aircraft Hanger. Even if you stand at the same distance from the fire, you will be much warmer in the cupboard than you will be in the Hanger, but the 3kW of Power is the same.

(Heat Power as with Sound Power being totally independent of environment).

Whilst it may appear that the analogy falls down in that, when the generator is turned off the Noise level instantly disappears whereas the heat reduces gradually, this analogy does actually hold true, it is just the power of this noise is measured in PicoWatts and decays very quickly whereas the Heat is measured in kiloWatts and is therefore many magnitudes greater. Hence it decays over a much longer period.

(A crude analogy is to think of radioactive sources - the heavier the element the longer the half-life).

Whilst a definitive comparison between Sound Power Levels and Sound Pressure Levels is not possible without taking the size of the unit emitting the noise into account, crudely for a noise source measuring 100dB(A) Sound POWER level a comparable Sound PRESSURE

Level of 83-90dB(A) is reasonable. (The lower 83dB(A) being likely for a small canopy).

If you see reports contained measured sound POWER figures from a site, this simply means the sound meter has measured the Sound PRESSURE and then calculated the POWER figures electronically. Care should be taken with these figures ... the figures were measured as a PRESSURE and hence are not independent of environment, True POWER figures as stated above are not dependant on environment.

NR (Noise Rating) & NC (Noise Criteria) Curves.

Up to this point we have been talking of achieving a single overall figure noise levels at a distance... e.g. 65dB(A)@1m. There are other ways of specifying target noise levels.

NR and NC curves are a recognised set of target noise levels, to be met where the target is not a single figure but a range of figures across an Octave Frequency Curve from 63Hz to 8000Hz. At the Octave band centres of 63; 125; 250; 500; 1000; 2000; 4000 & 8000Hz. (Again a Logarithmic Scale).

The target may be given say as NR70, and given at any required distance.

These are Sound pressure levels and the number.... Say 70dB(A) is the figure required at 1000Hz point on that curve. SEE ATTACHED CURVES.

Whilst traditionally NR is the European convention NC the American one, whilst different, these are both widely accepted.

Noise Control

Whilst we are discussing Octave band Frequencies it is also worth discussing how Noise Control is affected. There are 2 areas which must be considered:

HIGH Frequencies (500Hz to 8000Hz) these sound waves are of progressively shorter wavelength and higher amplitude and can be controlled by the use of absorbent materials within the canopy walls, whilst these materials don't prevent the overall Noise level within the canopy from increasing above the levels generated by the components of the set (SEE BELOW) they will minimise this increase.

LOW frequency noise (sub 500Hz), is more difficult to control, these sound waves are of Long wavelength and short amplitude. Absorbent materials have no effect and the only way to control them is by use of the barrier effect i.e. MASS.

The greater the thicknesses of the outer steel skin of the canopy the lower the emitted noise levels that can be achieved. Additional high mass layers can also be introduced, within the wall panel construction, depending on requirements. On projects with very low target noise levels a canopy within canopy system can be employed .... Along with the associated costs.

Taking Noise Measurements

Weather conditions – have a significant effect when noise level readings are being taken, the most obvious one being:

WIND blowing across the face of a microphone will seriously add to the levels recorded

.... Think of listening to a live football commentary on a windy day.

RAIN: Noise will decay more quickly over distance as when it is raining the air density is greater an hence noise is trapped closer to the source, so noise levels measured at say 1m from the canopy will be higher. But at 10m the noise level will be lower than expected on a dry day as less sound pressure has managed to travel that far.

WARM DRY conditions are considered best for taking noise measurements as air density is lower and resistance to the transmission of the sound pressure waves is reduced, allowing greater dissipation.

NB. Where mention is made above of Acoustic Canopies; the words Housings / Enclosures / Containers / Pods may be substituted without change of meaning.

The above mainly considers generator sets being located external to the building they are serving; there is of course another important location which should be considered:

Generator Sets within Plantrooms:

Depending on the critical noise sensitive location there are 2 main types of plantroom installations.

1) Opens sets within rooms:

   If the noise levels required external to the plantroom are not too onerous it is practical to position the site within the room and provide inlet and discharge attenuation, exhaust silencers and potentially acoustic doors.
   The size and construction of the plantroom will have significant effect on the design and construction of the attenuation.
   As discussed above the more solid the surface of the inner walls the greater the reverberant noise and the higher the Internal noise level and hence the greater the performance of the attenuation equipment required.
   Lining the plantroom walls and ceiling with sound absorbent materials can also be considered but as with the canopy this lining will only reduce levels of reverberant noise, it will not reduce the levels below that of the engine/ fan etc.
   NB. These rooms will require to be specified as <u>hearing protection zones</u> regardless of the size of the set involved.

2) If the external noise levels to be achieved are greater than the plantroom walls themselves can achieve,
   OR
   If a mandatory noise level to be achieved within the plantroom is specified.
   It is possible to install a canopy in to the room if correctly designed both acoustically and with regard to ventilation.

PLEASE NOTE: If a standard canopy specified at say 80dB(A)@1m is installed in a room the additions of reverberant noise will mean it can never achieve this level within the room, as the room itself will effectively become "Soaked" in reverberant noise. The levels measured will be approximately the same at any point, so it is meaningless to specify target noise levels at a distance within the room.

Noise Sources on a Generator Set

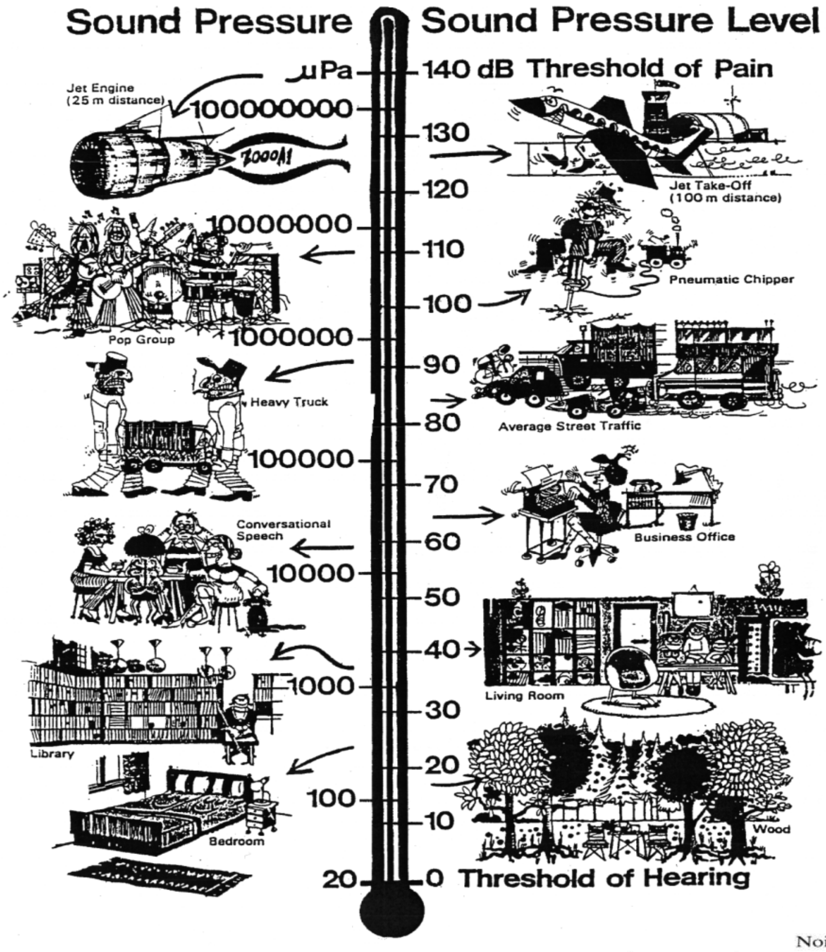
There are 4 main noise sources on a generator set:

1) **The Engine**; which emits a broad band noise over the Octave range from 63Hz to 8000Hz as discussed above. With a Typical overall level ranging from approx. 85dB(A) for a 50kVA set up to approx. 113dB(A) for a 2000kVA.
   NB. Engine speed will also affect these levels. An 1800RPM / 60Hz engine / set being approximately 3dB(A) higher than the same engine at 1500RPM.

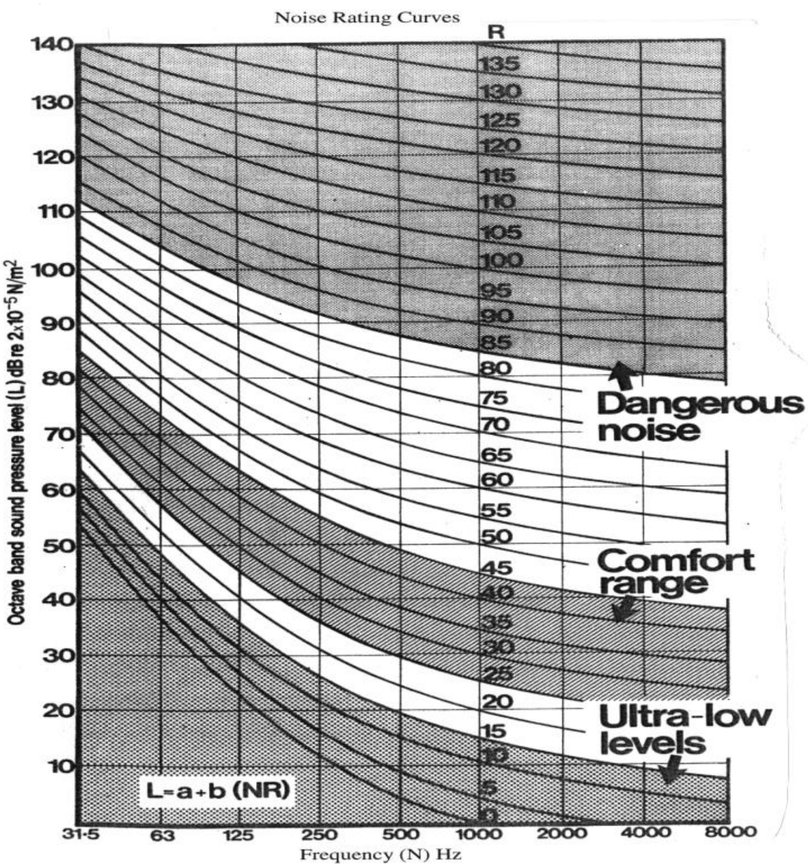
2) **The Radiator Fan**; which emits a broad band of noise but is dominant at frequency between 125 & 250Hz this frequency varies depending on several factors such as absorbed power, speed and type of fan blade amongst others. The noise levels of the fan can vary greatly with fan configuration but the low frequency dominance will have significant effect on the discharge attenuation in particular.

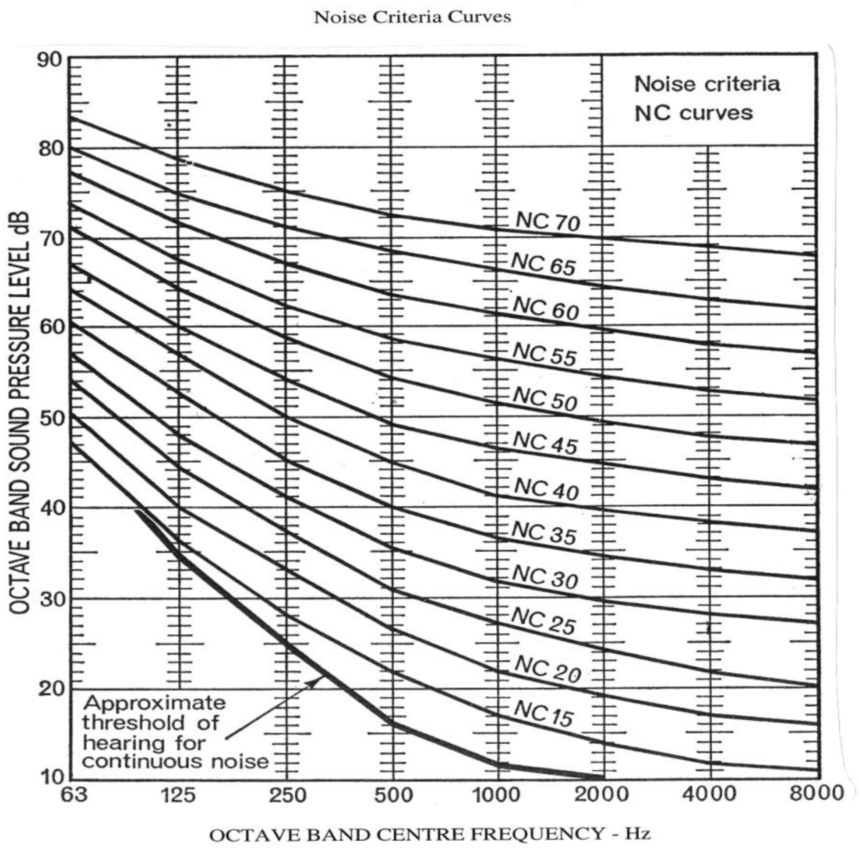
3) **The Alternator**, this source is generally more than 10dB(A) lower than the engine and hence has minimal or zero additive effect to the overall noise level of the genset.

4) **The Engine Exhaust Gas Outlet** is the final source, typically up to 20dB(A) higher than the engine. These are controlled by the use of specialist gas silencers/ mufflers. These can be supplied in many forms sometimes referred to as industrial, residential or critical types but the attenuation levels achieved / noise levels emitted will be aligned to the specified noise level of the canopy/ attenuators.



Examples of Various Noise Levels in Real Life





All of the above is intended to offer a basic guide to so some of the terms commonly seen on Project specifications for Generator Set Installations.

It is by no means intended to be fully comprehensive but offers a good starting point.