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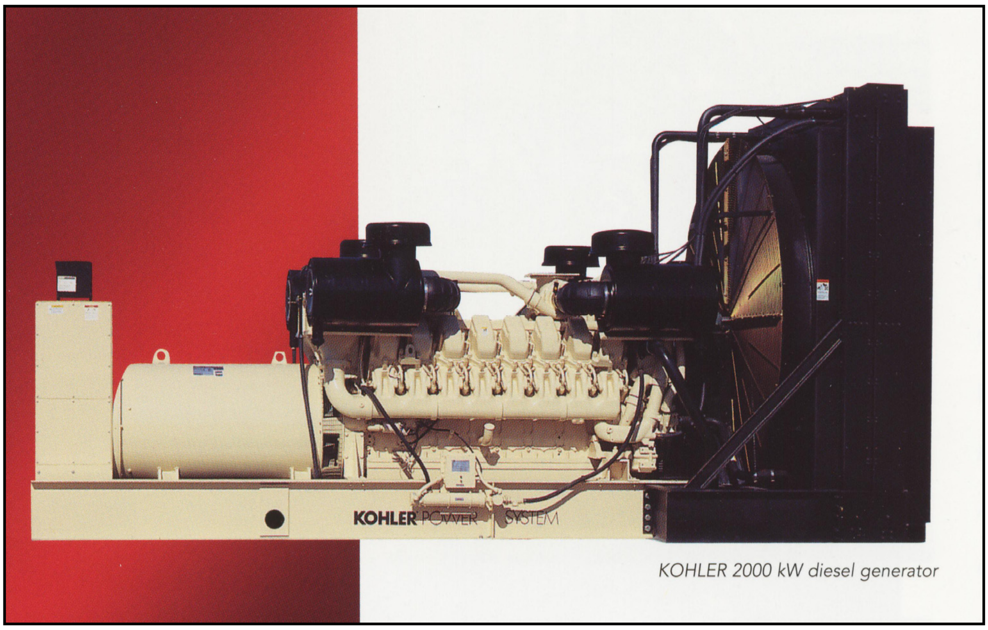
Understanding Noise



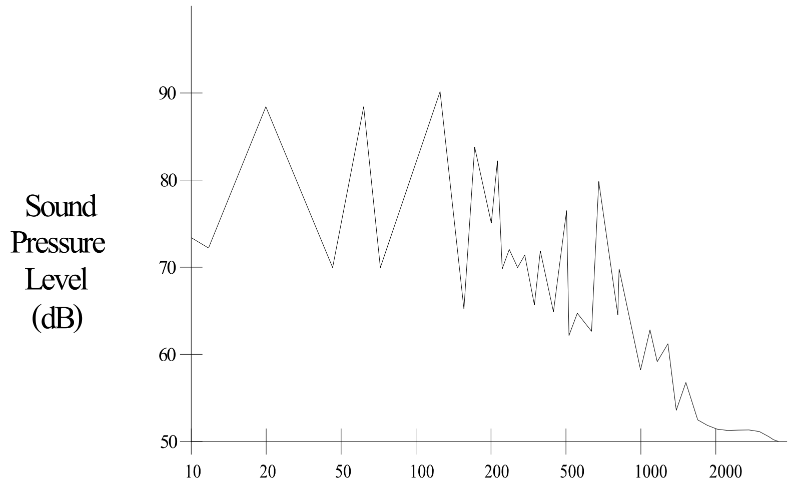
KOHLER 2000 kW diesel generator

For more information, Please contact :

Tharikan Co., Ltd.
3435 Soi Ladprao 101 (Wat Beuangtonghlang) Klongjan,Bangkapi, Bangkok 10240 Thailand
Tel. : (02) 946-7295, 519-5488 Fax. : (02) 946-7299, 5193820

E-mail : thirawatkan@tharikan.com

Understanding Noise



Understanding Noise

1. What is noise ?

A. Noise is a pressure wave of varying intensity and is a wave which carries through the air that is basically air movement caused by the creation of noise at some remote point. This wave is made up of various frequencies as shown on the graph. A typical noise measurement may appear is this form. Many frequencies go together to form the final noise that you hear. These fequencies can be broken out as we shall see later.

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Noise Produced by Gensets

Made up from :

- Engine Mechanical Noise
- Exhaust Noise
- Turbocharger
- Cooling Fan
- Induction Air Noise
- Alternator
- Cooling Air Velocity

Noise Produced by Generating Equipment

1. This noise is made up from engine mechanical noise, exhaust noise and turbochargers which are the main components of the low frequency noise you get from generating equipment. A cooling fan and air induction noise are also important factors in the total noise made-up of the generator.

   The alternator and cooling air velocity, while they do create noise, they are of a lower degree and do not affect the overall level to any great amount.

2. All of these noise sources from a generator have their own frequency make-up and all add together to summate to the final noise level of the unit. Each can be considered separately, but its generally the purpose of the noise treatment engineer to treat these as one overall noise source.

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Units of Measurement

Noise level of a source is called :

Sound power level (SWL)

W = power = Watts

Human ear can detect

10^{-12} Watts/m^2

This is a threshold limit.

Units of Measurement

1. The noise level of the source can be referred to as the sound power level having the initial SWL where W stands a power and is proportional to watts. The human ear in a very fit teenager can detect noise levels as low as 10 to the power of - 12 watts per sq meter. This is known as the threshold limit below which we cannot detect sound.

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Units of Measurement

Noise level measured away from source is called :

Sound pressure level **(SPL)**

P = pressure = newtons/m^2

- **Units are small and very wide ranging, typically, 10^{13} times from smallest to largest.**

- **We use a "bel" to indicate 10 fold changes between two quantities but this gives only 13 divisions.**

Units of Measurement

1. Noise level measured away from a source is called the sound pressure level. Pressure because the source of noise creates varying pressures which show up in your inner ear as pressure waves causing vibration of the diaphragm which then translates into the noise of which you can understand.

2. The units we deal with are very wide ranging typically over a range of 10 to the power 13 times, that is one thousand million million times, a very large number.

3. We use the bell to indicate tenfold changes between two quantities but this only gives thirteen divisions. It is necessary for the sound engineer in effectively dealing with noise to have a much broader base to work on.

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Noise Measurement

- **Each noise measurements SWL or SPL has a reference point :**

  - SWL has ref. power = 10^{-12} Watts
  - SPL has ref. pressure = 2×10^{-5} newtons/m^2

- **We use Logarithmic addition.**

Units of Measurement

1. Whether we measure noise at source as sound power, or noise at a remote point as sound pressure, each has a reference power, the SWL reference is 10 to the - 12 watts which is proportional to the threshold limit of hearing and the SPL has a reference pressure of two times ten to the minus 5 newtons per sq meter. In dealing with noise calculations we use logarithmic addition.

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Noise Measurement

- **We use the decibel (or 1/10th bel) to give 130 divisions of sound measurement.**

  - SWL $= 10 \, Log_{10} \left\{ \frac{\text{Sound Power}}{\text{Ref Power}} \right\}$ dB
  - SPL $= 10 \, Log_{10} \frac{(\text{Sound Pressure})^2}{(\text{Ref Pressure})^2}$

We also use the decibel or one tenth of a bell to give one hundred and thirty divisions of sound measurement, these are spaced out on a logarithmic scale.

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Noise Measurement

Relation to Human Ear

- Our ears do not respond directly to decibel scale,
- So we have "weighted" scales.

There are three international weighting scales ;

- 'A' For SPL up to 55 dB
- 'B' For SPL from 55 to 85 dB
- 'C' For SPL above 85 dB

Relation to the Human Ear

1. Our ears do not respond directly to the decibel scale. This is a scale which engineers have developed to measure noise sources by electrical means.

2. To get around this problem, we have what are called weighted scales, by this we mean that the instrument is damped or weighted at each end of its movement by varying degrees to give a noise measurement or noise response which closely relates to that which the human ear can detect.

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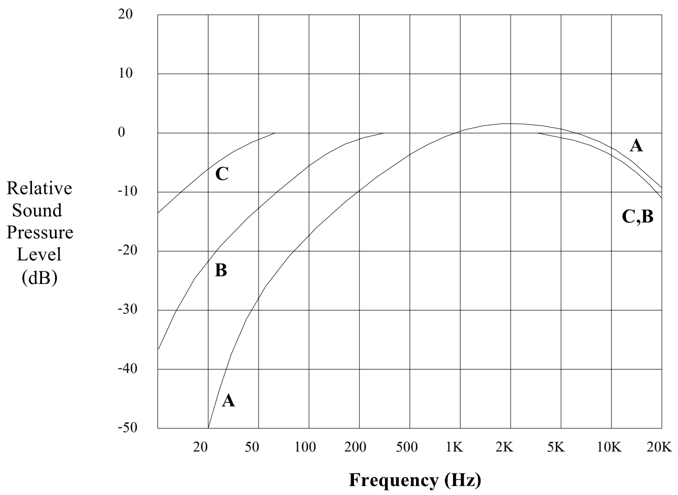
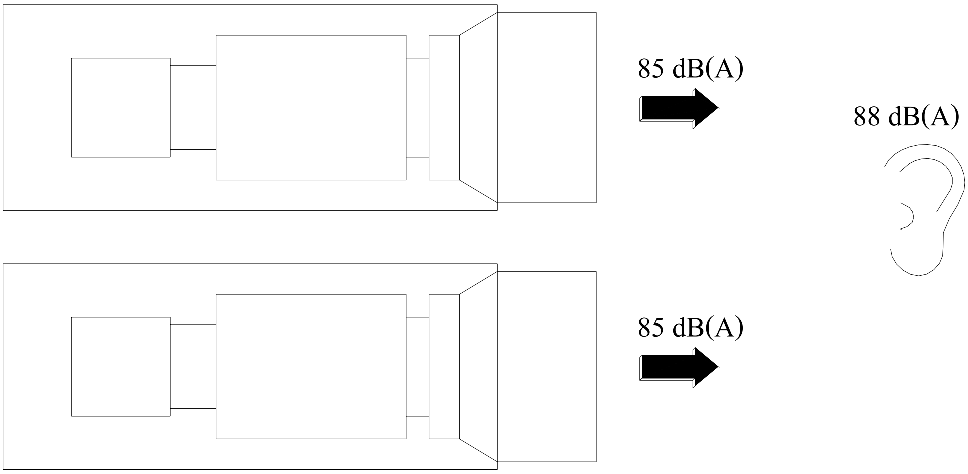
Noise Measurement



- **dB(A) gives a good indication of what people will tolerate and is generally adopted for overall noise measurements.**

3. There are three international weighting scales A,B and C. But for all practical purposes the A weighting is used when measuring overall noise quantities. The unit of measurement referred to is dB(A). The graph shows the relationship between the A, B and C scales when related to actual sound pressure level measurements in decibels. You will see that the A weighting scale has quite a reduction in the overall sound pressure which is recorded over the frequency range up to 200 cycles. Very few reductions are used over and above this, this is due to the fact that the human ear cannot detect extremely low frequencies of sound, you may feel them is your body, but your ears cannot hear these low frequencies. dB(A) then, gives a very good indication of what people will tolerate and is generally adopted for overall measurement.

Noise Addition



Noise Addition

1. The relationship between two generators or any noise developing machinery with equal noise levels and you can see that for equal noise levels the overall noise heard at a remote point will be 3 dB(A) higher than their equal noise levels caused by the units. The following table shows how this varies from zero difference to a difference of ten or more dB(A) between subjective noise levels from machines.

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Noise Addition

DIFFERENCE BETWEEN 2 LEVELS dB(A)	ADD TO HIGHER LEVEL dB(A)
0	3
1	2.5
2	2
3	2
4	1.5
5	1
6	1
7	1
8	0.5
9	0.5
10 or more	0

2. You can see that for a difference of ten or more dB(A) between two units of noise measurement you will take the higher of the noise levels measured as the final noise level.

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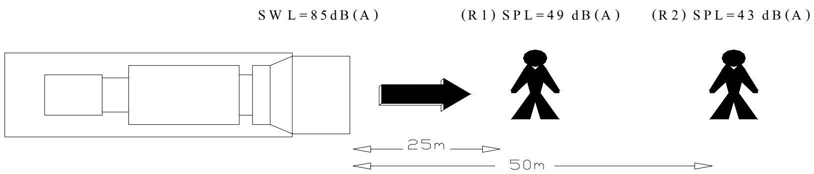
Effect of Distance

Hemispherical Propagation



- SPL = SWL - 20 Log R-8 dB

  From source to distance R (meters).

- Knowing noise level at distance R1 to find noise level at dist R2.

$$SPL_{R2} = SPL_{R1} - 20 \log \frac{R2}{R1}$$

Effects of Distance

1. In measuring noise we are generally looking at a unit standing on the floor and we use what is called hemispherical propagation, this means that the noise level is regarded as travelling away from and upwards from the unit but not below it. These formulas show the relationship between the sound power level and the sound pressure level when distance is taken into account. It can be generally regarded that for a doubling of distance from distance 1 to distance 2 the reduction in noise level will be 6 dB(A). You have to be careful when dealing with the sound power level in this respect. It is wise to use the formula to calculate the initial sound level at distance 1.

2. We also show the relationship between sound pressure levels at two different distances. If you know the level required, say as a site boundary, and you know the distance to the engine room, you can quickly find what the noise level has to be outside the engine room, by use of this formula. You can also then assess, knowing the total noise level generated by the machine, what treatment level is required for the engine room.

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Dealing With Noise

1) **Establish nearest point at which noise is a problem (Point A).**
2) **What noise level will point 'A' tolerate.**
3) **Establish noise of source (genset).**
4) **Level of total attenuation is source level minus point 'A' level.**
5) **Work out attenuation caused by distance (source to point A).**
6) **Attenuation and treatment level is result of 4 - 5.**

Dealing with Noise

1. Establish the nearest point at which noise is a problem. This may be domestic property, office blocks, hospital, any area requiring a quiet operating ambient and measure that point to the discharge wall of the diesel generator. This is point A.
2. What noise will point A tolerate? This is usually specified in the enquiry specification and may be given in decibels or dB(A) levels, NC or NR specs.
3. Establish the noise of the source. We are dealing with generator sets so our source is the genset.
4. By subtracting point A noise level from the source noise in the engine room, one meter from the genset, you have the level of total attenuation required for this installation. The attenuation occurs by building treatment, by obstacles such as walls or other buildings in the direct path of the noise to the sensitive point A and also by the distance over which the noise travels. At this point you now know the total level of attenuation.
5. Work out the attenuation caused by this distance from source to point A.
6. You now have a calculation which gives you the total attenuation and treatment level required for the engine room. This will enable your to fix the exhaust gas, discharge silencers, the cooling air discharge and intake silencers and also comment to the civil engineers regarding the building treatment required and the level of attenuation. Please remember that for equal noise levels outside the building the final level will increase by 3 dB(A). It is important therefore to engineer the building the sound attenuators and the exhaust gas treatment to a level at least 3 dB(A) less than the required level, as all of these three when added together could leave you with a number higher than you require.

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Treatment

1) **Exhaust noise using mufflers.**
2) **Cooling system mufflers.**
3) **Building treatment.**

Treatment

1. As we have said treatment can be by using exhaust gas mufflers or silencers.
2. The cooling system mufflers or air flow silencers.
3. Building treatment.

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Exhaust Mufflers

1) **Industrial Type**
Typical attenuation : 12-18 dB.

2) **Residential Type**
Typical attenuation : 18-25 dB.

3) **Critical Type**
Typical attenuation : 25-35 dB.

4) **Super Critical Type**
Typical attenuation : 35-45 dB.

Or a combination of above.

Exhaust Mufflers

1. We can supply industrial, residential and critical mufflers, but it should be remembered that it is necessary to engineer exhaust systems to match the required noise levels and not take these as cure all figures or systems. Any combinations of these silencers can be used to obtain the desired result.

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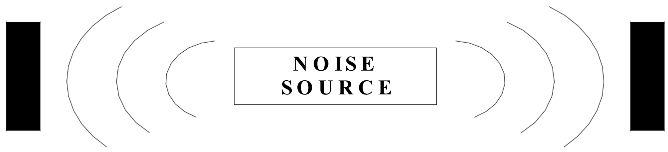
Exhaust Mufflers

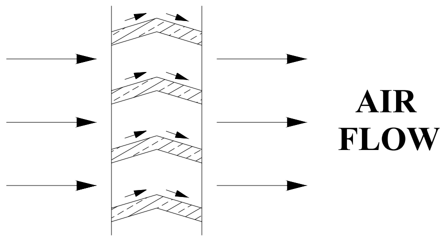
Treat both inlet and outlet

1) Baffles - only effective over line of sight



Typical Attenuation, 5 dB(A)

2) Acoustic Louvers (Chevron Louvers)



Typical Attenuation, 15 dB(A)

Cooling System

1. We must treat both the inlet and outlet apertures of the building.

2. The easy treatment is by building baffles immediately outside of the engine room front of both the air inlet and outlet apertures. Usually spaced two meters a way from the building wall. This will only affect line of sight noise treatment, buildings or sensitive areas outside of that line of sight could receive very much higher noise levels than would be desirable.

3. A simple treatment is the use of acoustic louvers or chevron louvers as they are known in the trade, this is due to the shape. These offer typical attenuations of 15 dB(A) over the noise leaving the building.

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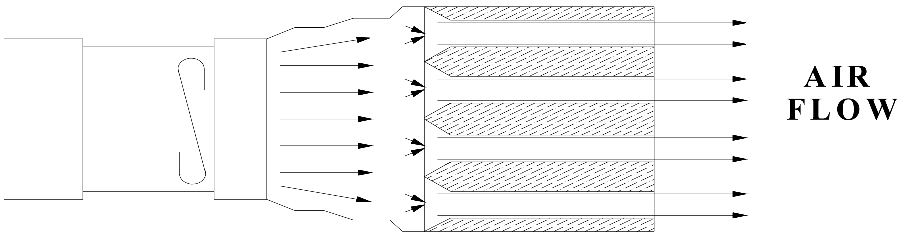
Attenuators



- **Typical Attenuation, 15 to 35 dB(A) (depends on length), 600 to 1200 mm length is norminal.**
- **Attenuation levels higher than 35 dB(A) are progressively more expensive to achieve.**

Attenuators

1. Attenuators, as they are known, are the final treatment, and come in various lengths depending on air flow, noise level treatment required, attenuation required, and also back pressure availability of the cooling system. These are placed at both the inlet and the outlet of the cooling air apertures into the building.

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Housings

1) **Sheet steel weather proof, attenuation 5 dB(A).**
2) **As 1) but with lined sound absorption walls and acoustic louvers, attenuation, 15-18 dB(A).**
3) **As 2) but with box splitter attenuators to replace acoustic louvers, attenuation 20-35 dB(A).**

We Use :

- Fabricated Housings
- Drop-over Housings
- Acoustic Rooms
- Containers (I.S.O. Standards)
- Building Treatment

Housings

We may not want to install the genset in a building so we want to consider sheet steel housings or specially constructed sound absorption housings and containers. Various levels of sound attenuation can be designed into these sheet metal buildings or containers.

1. The sheet steel weather proof housing has an attenuation of a very low level, 5 dB(A)

2. We can construct the sheet steel weather proof housing and line the walls with sound absorption material as fit the chevron louvers. This type of housing will generally have an attenuation of 15 to 18 dB(A)

3. We could go one stage further and fit the box splitter attenuators to replace the acoustic louvers. Here we get levels of 20 to 35 dB(A) attenuation.

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Points to Remember

1) **Noises of equal levels of dB or dB(A) to give 3 dB(A) higher level.**
2) **Exhaust system back pressure. Adding mufflers to system adds restriction - LIMITS.**
3) **Cooling system back pressure. Restrictions to air flow can cause overheating - LIMITS.**

Points to Remember

1. Noises of equal levels of dB(A) add to give 3 dB(A) higher level so watch the treatment design you are offering to the final user.

2. The exhaust system has a certain maximum back pressure. Back pressure capability of an engine is it's ability to purge the cylinders completely of the products of combustion, increasing this back pressure beyond that limit set by the engine manufacturer will usual result in the engine loosing power due to poor purging of the products of combustion from the cylinder. There are restrictions watch the limits.

3. The cooling system back pressure is much much lower than that allowable in the exhaust system, generally Genset operation the range of .25 to .5 inches of water. This is a very low pressure indeed and great care must be taken with the selection of attenuators and building treatment for the cooling air system. Occasionally force draft fans must be used to assist the engine cooling fan in meeting it duty.

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Noise at Source

SOUND POWER LEVEL dB	SOURCE
190	SATURN ROCKET
170	TURBO JET WITH AFTER BURNER
150	4 PROPELLER AIRLINER
140	
130	75 PIECE ORCHESTRA
120	
110	BLARING RADIO
100	AVERAGE GENSET
90	
80	CAR ON MOTORWAY
70	VOICE - CONVERSATIONAL LEVEL
60	
50	
40	
30	VOICE - VERY SOFT WHISPER

Reference Data

This table sets out for your guidance some of the general noise levels applicable to everyday equipment and general noise making machinery that we come across, it is a good idea of what a genset noise might be in relation to other items. Generators generally operate around the 100-110 decibel mark.

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Other Examples

SOUND PRESSURE LEVEL dB	ENVIRONMENT	SUBJECTIVE DESCRIPTION
140	30m From Aircraft at Take-Off.	Intolerable
130	Riveting Gun.	
120	Ships Engine Room at Full Speed.	
110	Sheet Metal Shop	Very Noisy
100	Printing press room.	
90	Heavy Truck @ 6 m. Pneumatic Drills.	
80	Busy Street.	
70	Loud Radio.	Noisy
60	Restaurant. Department Store.	
50	Conversation @ 1 m.	Quiet
40	Average Suburb Area. Quiet talk.	
30	Residential Area (night).	Very Quiet
20	Recording Studio (background level).	
10		
0	Normal Hearing Thresbold.	

Reference Data

Here we show the subjectivity description of noise from intolerable, which is in the area of riveting guns and very close to aircraft at take off, to extremely quiet or very quiet which is the normal hearing threshold and recording studio backgrounds that you may expect to be almost inaudible.