ICSV14
Cairns • Australia
9-12 July, 2007
14th International Congress on Sound & Vibration

ACOUSTICAL TREATMENT OF EMERGENCY POWER GENERATOR

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Abstract

Noise pollution is one of the dangerous invisible pollutants, which has been blamed for everything from hypertension and learning difficulties, to hearing loss. So many international organizations label noise as a "real and present danger". The best way to reduce noise is at the source of the noise: adjust or repair the source so it no longer produces (as much) noise. It's also possible to alter the workplace environment to adequately compensate for the noise, for example, building sound barriers between workers and the noise source. This paper is a study to reduce noise level of emergency power generator at the source by using special acoustical treatment design which reduces noise levels by about 36 dB.

1. INTRODUCTION

Nowadays, more consideration is being given to environmental issues. The excessive noise is considered a form of pollution which, in the long run, may cause permanently reduced hearing. As a consequence, authorities now demand that noise levels are kept below certain specified limits. Today, there are numerous national and international codes which both recommend, and demand, maximum permissible noise levels [1]. Noise is present in every human activity, and when assessing its impact on human well-being it is usually classified either as occupational noise (i.e. noise in the workplace), or as environmental noise, which includes noise in all other settings, whether at the community, residential, or domestic level (e.g. traffic, playgrounds, sports, music). The health effects of environmental noise are covered in the publication (de Hollander et al., 2004). High levels of occupational noise remain a problem in all regions of the world. In the United States of America (USA), for example, more than 30 million workers are exposed to hazardous noise (NIOSH, 1998). In Germany, 4−5 million people (12−15% of the workforce) are exposed to noise levels defined as hazardous by (World Health Organization) (WHO, 2001). Although noise is associated with almost every work activity, some activities are associated with particularly high levels of noise, the most important of which are working with impact processes, handling certain types of materials, and flying commercial jets. The average noise levels in developing countries may be increasing because industrialization is not always accompanied by protection [2].

Because noise can be a problem in many workplaces, not just on construction sites and in factories, but anywhere from farms to schools to concert halls. Whatever the workplace, so eliminating or reducing excessive noise at work is not simply a legal responsibility for employers; it is also in an organization's commercial interests. The safer and healthier the working environment is, the lower the probability of costly absenteeism, accidents and under-performance [3].

2. NOISE CONTROL

The options for noise control, in an application such as under consideration here, can be broadly divided into two categories, namely passive control and active control. Passive control consists of the use of sound absorbing and attenuating enclosures to reduce the noise radiated into the environment. Active control is a technique of more recent practicality, in which a secondary source of sound such as a loudspeaker is used to interfere destructively with the noise from the original source [4].

2.1 Passive control

This can include a range of measures taken to reduce the transmission and radiation of noise. These include, passive mufflers for the intake and exhaust, vibration-isolating mounts for the engine, dampening of surfaces subject to vibration such as oil pan covers and finally enclosures that cover the engine generator set partially or completely. Mufflers and silencers for reducing the inlet and exhaust noise have been practical for a long time. Typically over 20 decibel reductions in the sound pressure levels can be achieved with well designed silencers. Some general features of passive control should be noted. The technology, including the sound absorbing materials, has evolved over years of development so that it is relatively cheap and easy to apply. It is being extended to more effectively particularly in automotive applications [4].

2.2 Active control

The prospect of active control and cancellation of noise has interested scientists and engineers since its original conception and patenting by P. Lueg in 1936. His basic idea was to superimpose a secondary acoustic wave to interact destructively with the primary noise and lead to lower sound pressure levels. From a practical point of view, the generation of a stable destructive interference pattern is possible only at low frequencies of 500 Hertz or less and with slowly changing conditions. This restriction necessitates the combining of active control measures with passive control for broad band noise control. Active noise control that uses a loudspeaker to lower sound levels far from the noise source does not seem to be viable for the present application, as it can lead to increase of the noise levels over some regions. A better approach would be to use active control of the noise near the source [4].

3. NOISE SOURCES IN THE ENGINE

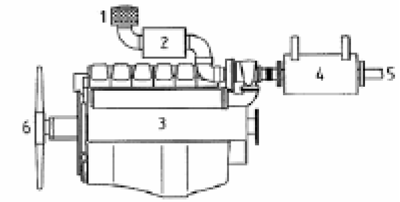

Figure 1. Sound generation in engine.

The airborne sound emission of a combustion engine increases due to the sound radiation of the following noise sources (Fig. 1).

- Sound emission of the engine surface (3)
- Noise of the air filter or the inlet silencer (2)
- Surface noise of a exhaust gas silencer (silencer surface noise (4))
- Sound emission of the aspirating hole (standard muffled inlet noise) (1)
- Sound emission of the exhaust gas outlet (exhaust) (5)
- Sound emission of the cooling fan (6)

As a general principle, fixed diesel engines should be installed in a separate room [3].

4. NOISE REDUCTION

The diesel generator sets in open condition has noise level of 95dB(A) to 107dB(A). Acoustic Enclosures designed to reduce the noise level to be within the parameter laid down by the Pollution Control Board. The insertion loss is always more than 25dB(A) [1].

Sound level reduction is necessary, the engine or the entire unit must be encapsulated. A sound level reduction of up to 10dB can be achieved by means of sound-insulating casing secured directly at the engine; sound-insulating casings with self-contained construction achieve insertion insulation rates of up to 25dB [5].

In general, depending, of course, on the type of engine, the average airborne noise level of a nominally rated engine will be around 105dB(A), whereas the maximum level measured around the engine, and normally near a turbocharger, will be about 110dB(A), but higher for bigger engines and lower for smaller engines. The airborne noise emitted from the engine in the engine room is so high that, in some cases, there is a risk that the noise limits for the engine room cannot be met, unless additional noise reduction measures are introduced [1].

From the basic system requirements for On-Site generating unit is to design the generator room or building for noise attenuation in accordance with OSHA standards [6]. Exhaust noise can be attenuated by using proper mufflers. To attenuate other noises, use line-of-sight acoustical barriers, acoustical enclosures, sound attenuating duct treatment, or install the generators away from critical areas.

Sound barriers, or sound screens as they are called in ISO 9613-21, are one of the primary tools used in noise control engineering. The ability to accurately estimate the attenuation of a sound barrier is critical to the successful noise control design of many industrial facilities [7].

Power generation facilities typically require customized noise abatement features to achieve various local and state noise regulations. Differing equipment or equipment arrangements, size and placement of equipment on the plant owner's property, and location within a community can all affect the amount of noise control necessary for a given facility. Selecting the correct amount of silencing for each piece of plant equipment is essential when optimizing for reduced cost of the overall noise control treatments [8].

5. CONTROL OF NOISE AT SOURCE

The reduction of noise, either at its source or in its path should be a major focus of noise management, considering both equipment and workplace design and maintenance. A range of engineering controls can achieve this, including, isolation of the source, via location, enclosure, or vibration damping using metal or air springs and reduction at the source or in the path, using enclosures and barriers, mufflers or silencers on exhausts [3].

6. EXPERIMENTAL WORK

The measurements were carried out on- site emergency power generator of power 160 K.V.A for determining the noise levels inside and outside of the generator room area before and after the acoustical treatment. The acoustical treatment included each of the two openings of air and the walls, the ceiling and the door of the room. The precision sound level meter type 2260 (Bruel & Kjaer) was used with condenser microphone type 4189 in the field measurements. Sound calibrator type 4230 is used for calibration where it provide 94 d B at 1000 Hz [9].

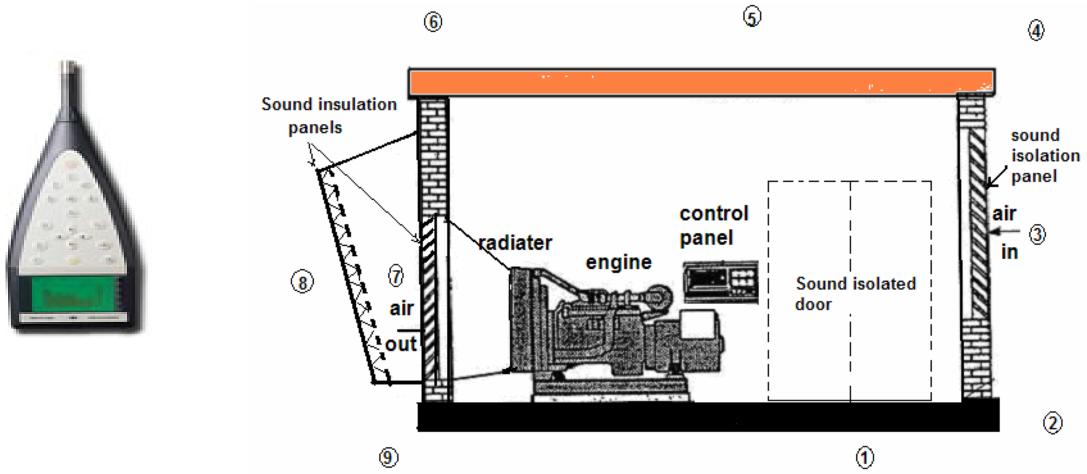

Figure 2. Generator room and the sound level meter used in measurements.

The generator room is of dimension (500 × 400 × 300cm) and constructed from double wall of thickness 12 cm- 10cm air space- 25cm from cement block brick. The floor is constructed from 30 cm reinforced concrete and the base of the generator is 20cm concrete covered with anti-vibration material then the generator fixed on this base. The ceiling is 15 cm concrete covered with anti-moisture layer and 10cm layer of (foam) and finally a layer of ceramic. There are two opening one for entrance of air (150 × 150cm) and the other for outgoing of air (100 × 100cm) and the door of dimension (220 × 160cm).

6.1 Equivalent Continuous Noise Level (Leq)

Equivalent continuous noise level (Leq) is the A-weighted sound pressure level of the noise averaged over the measured period. It can be considered as the continuous noise which would have the same total A-weighted acoustic energy as the real fluctuating noise measured over the same period of time. It is an important measurement for hearing loss risk and permissible noise level in building.

6.2 Acoustical Treatment of Generator Room

All openings and the door are acoustically treated to reduce the high level of noise emitted from the generator as follow:

a) The door of the generator room was made of double layers of steel sheet of thickness 2mm and in between was filled with foam layer of 5cm. The door was acoustically treated by adding 2mm perforated layer of steel with 30% perforation percentage and 5 cm of rock wool in between of the door and the perforated steel layer, see Fig. 6.
b) The entrance of air opening was made of steel grills of 1mm thickness and spaced by 5cm and tiled down with 45 degrees. The acoustical treatment was carried out by replacing The steel grilles by acoustical modules of double layer of perforated steel with

30% perforation percentage and 5 cm of rock wool in between the two perforated steel layers and the 10cm interspaces between modules to allow the sufficient air for ventilation, see Fig. 3-a and Fig. 4.

c) The outgoing of air opening was made of steel grills of 1mm thickness and spaced by 5cm and tiled down with 45 degrees. The acoustical treatment was carried out by replacing The steel grilles by acoustical modules of double layer of perforated steel with 30% perforation percentage and 10 cm of rock wool in between the two perforated steel layer and the 10cm interspaces between modules see Fig. 3-a and Fig. 5.

d) Acoustical plate fixed in the front of outgoing of air opening at a mean distance about 30 cm and make 30 degrees with the vertical plane. The acoustical plate is of the same dimension of the outgoing air opening and is consisting of double layers of 2mm steel and 10 cm rock wool in between of the two layers, one layer which is in face to the opening was perforated by 30% perforation percentage to allow the sound wave to enter through holes absorbed partially inside the plate, see Fig. 5.

7. RESULTS AND DISCUSSION

The results of the measurements of the noise levels emitted from the emergency generator inside and outside the emergency generator room before and after the acoustical treatment are shown in table (1) and the spectrum analysis of the measurements of sound pressure level at 1/3 octave frequency band are shown in Figs. 7, 8, 9 and 10.

Figure 3-a
Opening before treatment

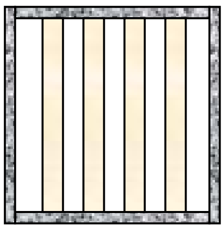

Figure 3-b
Opening after treatment

Figure 3-c
Opening after treatment

Figure 4
Entrance of air opening
After treatment

Figure 5
Outgoing of air opening
After treatment

Figure 6. The room door after treatment.

Table 1. The summarized results of measurements.

Position	Leq. dB(A) inside generator room	Leq. dB(A) before treatment 2m away	Leq. dB(A) after treatment						
			20cm	0.5m	1m	2m	4m	10m	Inside the nearest meeting room 15m
1		**96.5**	---	---	**82.2**	**80.4**	**76.7**	---	
2		**94.2**				**78.5**			
3		**100.3**	---	**91**	**89.8**	**86.5**	**79.6**	---	
4		**93.1**			**79.1**				
5	**104.3**	**92.4**	---	---	**78.3**	---	----	---	**47.4**
6		**94**			**79**				
7		**102.5**	**93.6**	---	---	---	---	---	
8		---		**83.8**	**82.1**	**80.5**	**77.9**	**68.4**	
9		**95.6**	---	---	---	**78.4**	**76**	**68.2**	

From Fig. 7 it can be noticed that, the noise level is high at all the frequency band and very high at certain frequency band from 200 to 2000Hz. From Fig. 8 it can be shown that when the door is acoustically treated and closed the noise level is reduced to 82.2dB(A). From Fig. 9 it can be noticed that the noise level decrease as the distance increase from the noise source where the noise level reduced to 68.2dB(A) at distance 10m away. Figure (10) shows the frequency spectrum of noise level all over the frequency range in the nearest meeting room which indicates the noise level is reduced with a great value at high frequency range and with a reasonable value at low frequency range. And the equivalent noise level is reduced to 47.7dB(A) which is suitable for meeting room.

From Table 1 it can be observed that the noise levels before acoustical treatment are very high at all positions, so it was necessary to make acoustical treatment to reduce noise level to the acceptable level. The highest levels were at the positions 1,2 and 3 which are the positions of the door and the incoming and outgoing of air opening. The effect of the acoustical treatment of the door reduced noise level by 16.5dB(A) from 96.5 to 80.4 dB(A). The effect of the acoustical treatment of the incoming air opening by 13.8dB(A) from 100.3 to 86.5 dB(A). and the effect of treatment of the outgoing opening is reducing noise level by 22 dB(A) from 102.5 to 80.5 dB(A)

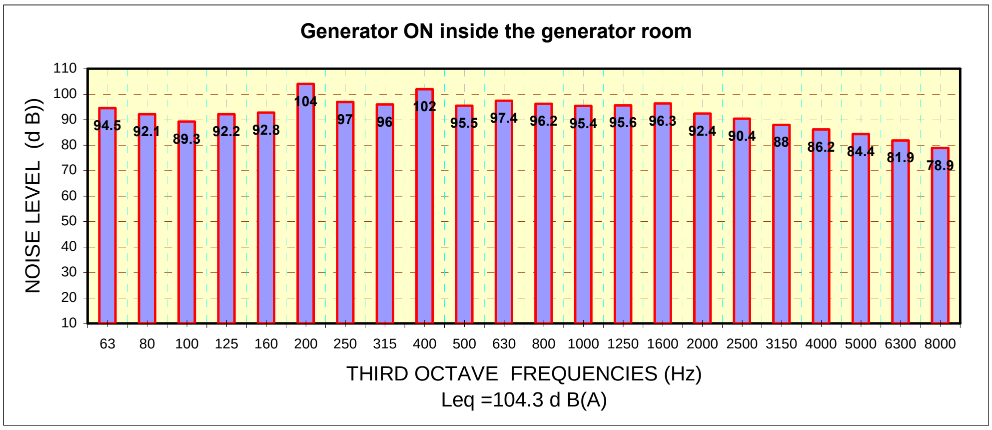

Figure 7.

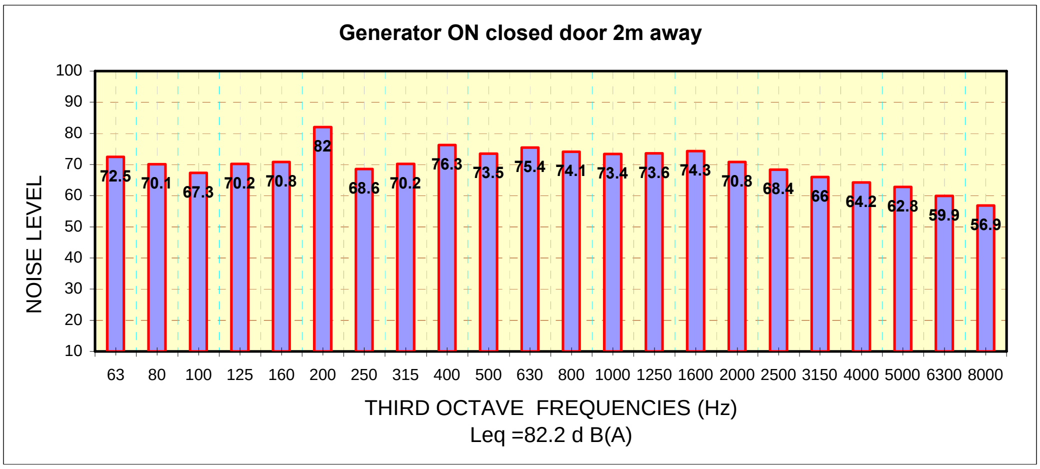

Figure 8.

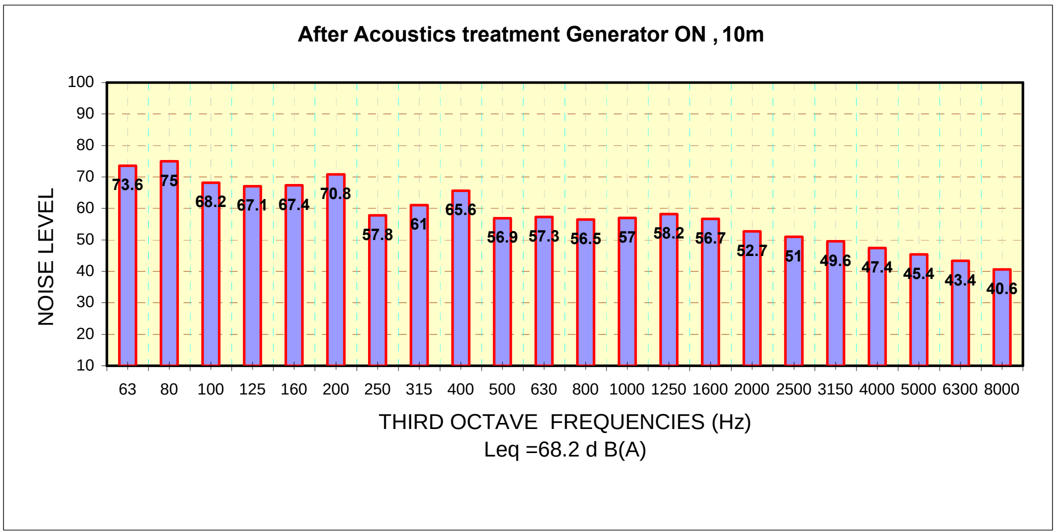

Figure 9.

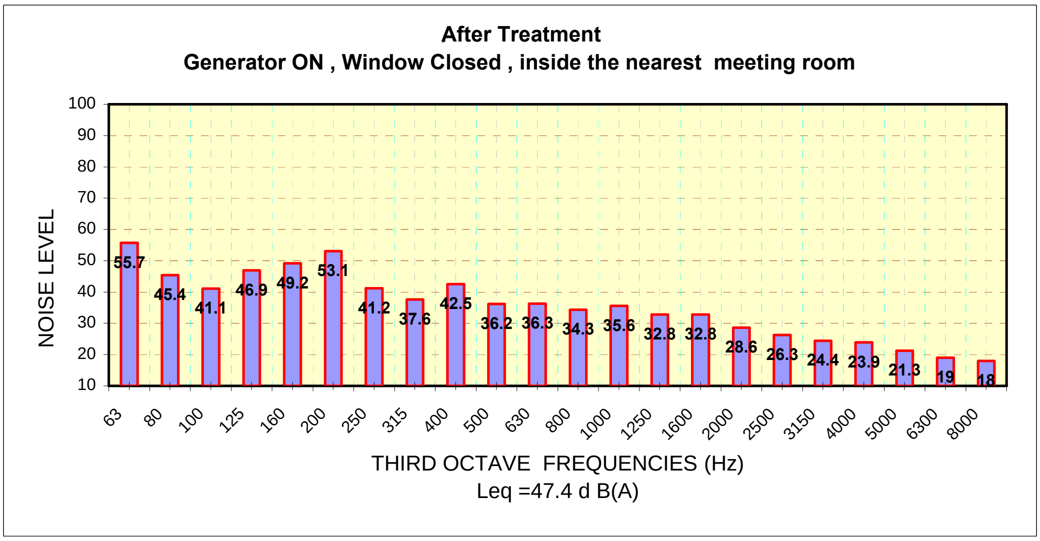

Figure 10.

8. CONCLUSION

The acoustical treatment can reduce noise level to the acceptable noise level. The highest levels were at the positions 1, 2 and 3 which are the positions of the door and the incoming and outgoing of air opening where the sound transmitted and flanked through the door and any opening. The effect of the acoustical treatment of the door reduced noise level by 16.5dB(A) from 96.5 to 80.4 dB(A). The effect of the acoustical treatment of the incoming air opening by 13.8dB(A) from 100.3 to 86.5 dB(A), and the effect of treatment of the outgoing opening is reducing noise level by 22 dB(A) from 102.5 to 80.5 dB(A), and the overall noise reduction of the room and all treatments reached to 36.1 dB(A) from 104.3 to 68.2 dB(A). This acoustical treatment reduced the noise level to the acceptable noise level due to the requirements of international recommendation.

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