



## Noise Reduction of 3000 Rpm Diesel Genset through Design Optimization of Canopy

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### ABSTRACT

*Diesel generator sets have now become basic need of modern world and every sector requires Gensets either for continuous use or for power back-up solution. Diesel Gensets specifically runs either at 1500 rpm or 3000 rpm to maintain a electrical frequency of 50 Hz. Severe noise issues are associated with operation of Diesel Generator (DG) sets used in hospitals, shopping malls, offices and residential buildings, if not canopised properly. Noise levels become more significant when Diesel Engines equipped in Genset runs at 3000 rpm. In present study, passenger car automotive diesel engine was converted for 30 kVA Genset application by using 3000 rpm constant speed fuel injection pump. Entire dynamics of Engine changes due to higher rpm leading to high noise levels. Central Pollution Control Board (CPCB) has implemented a regulation for every Diesel Genset to strictly adhere noise levels of below 75 dB in order to use the same commercially. Objective of the study was to design and optimize canopy for DG set to reduce noise levels in order to comply CPCB norms along with adequate cooling requirements. Detailed evaluation of sub-systems was carried out to calculate insertion loss and identify predominant noise generating sources. Design of Experiments approach was used for canopy dimensions, selection of radiator, cooling fan, acoustic material and louvers. Validation testing was done on modified prototype canopy to assess desired noise level and cooling requirements. Adequate cooling and significant reduction in noise level of 24.6 dB was achieved in this study.*

**KEYWORDS:** Insertion Loss, DG Set, CPCB, Canopy

### INTRODUCTION

DG set is equipped with an engine operating as a prime mover and alternator which converts mechanical energy into electrical energy. As per CPCB norms, DG sets upto 1000 kVA should achieve noise levels of below 75dB when measured at one meter distance as per ISO 8528-10. Hence it is mandatory to comply legal requirements by reducing noise pollution along with meeting end customer requirements.

Open DG set includes diesel engine and alternator coupled together and mounted on a common base frame, auxiliaries like radiator, cooling fan assembly, anti-vibration mounts, silencer system & control panel. Canopy design has to perform two functions, one to reduce the engine noise and second to maintain adequate cooling without overheating. Both these functional necessities are contradictory in nature. Challenge in design is to balance the both without affecting the performance. Engine and its accessories like radiator, silencer and alternator act as major noise sources. There are two ways to control the noise emission ; first is noise reduction at source itself, second is noise source isolation. First approach calls for much involved design modifications in source characteristics which requires engine structural modification, change in combustion characteristics. Obviously these are permanent solutions but impose a heavy cost penalty and may also affect emission characteristics. Later approach only contain the noise but comparatively easy to adopt and quite economical. Hence present study is focused on adopting second approach through design and optimization of canopy.

### PROBLEM DEFINITION

In present study, passenger car automotive diesel engine with specifications of 3000 rpm, water cooled, four inline cylinders, rated power output of 30 kW is to be used for assembling open 30 kVA DG set. **Fig 1** shows Genset without canopy.

Due to higher engine speed, mechanical noise is considerably higher due to its speed dependency, due to higher noise at source and without canopy, existing noise levels were not meeting legal limit of 75 dB. Objective of the study was to design the canopy to bring down these noise levels to meet required norms and making Genset quiet without affecting the cooling requirements. Existing Noise level of Genset assembled without Canopy, was found to be **98 dB**, when measured by a calibrated Sound Pressure Level Meter. As per CPCB, all Diesel Gensets has to mandatorily pass Noise Limit within 75 dB.



**Figure 1: Open Model of DG Set**

### OBJECTIVE

- Divide & Isolate the Genset into sub-systems & carry out baseline measurements.
- Identify the sources of noise generation, contributing predominantly towards overall system sound pressure level.
- Design, evaluation & optimization of Canopy to maintain sound pressure level to below 75 dB.

### METHODOLOGY

First phase in any noise reduction program of a machine is identification of noise sources and ranking them in order of their importance. Various noise source identification technique like sound pressure level measurement, vibration measurement, intensity mapping, insertion loss measurements are used. Genset radiated noise is combination of airborne and structure borne elements. In the first phase airborne and structure borne sources are identified with their relative contributions. Design variables significantly affecting noise are identified. Methodology uses experimental design of experiments (DOE) of design variables identified in earlier stage to arrive at desired solution. Further these combinations are tested for noise levels and ventilation performance. Optimized configuration is the one from preceding step with minimum noise level and proper ventilation performance.

### BASE-LINE MEASUREMENTS OF SUB-SYSTEMS

Baseline measurements on existing open DG set were done for sound pressure levels and vibration levels. The noise measurement was carried out as per ISO 8528-10, consisted of twelve locations. A sound

pressure level was obtained at 1m from the DG set at 75% rated load. SPL measured at all locations are averaged logarithmically to arrive at final SPL value. Similar measurements were carried out for a bare Gen-set to arrive at noise levels of different sources viz engine, alternator, radiator and silencer as mentioned in Table-1.

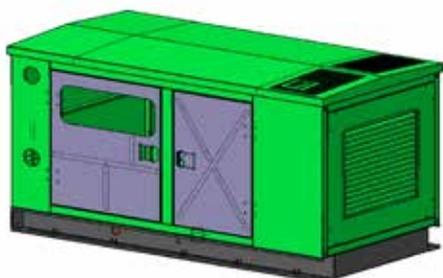
**Table-1: Insertion Loss Measurements (Sub-systems)**

Sub-system	Measured IL (dB) at 75 % Load	Remarks
Cooling Fan	3.6	Removing of fan gives reduction of 2 ~3.6 dB in overall SPL, however it is not feasible to remove the fan practically.
Silencer	20	Silencer is giving good acoustic performance with effectiveness of around 20 dB, with BP of 3 kPA.

**PRELIMINARY DESIGN OF CANOPY**

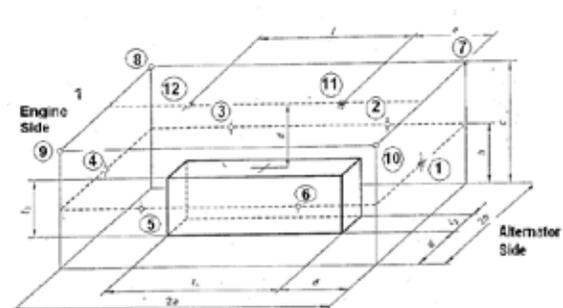
**Canopy Specifications :**

- Length = 2.1 m
- Width = 1.0 m
- Height = 1.15 m
- Rating of Genset – 30 KVA
- Engine Rated Speed – 3000 rpm.
- Foam – PU Foam with 40 mm thickness



**Figure 2: Canopy Design**

The schematic of measurement setup with all measurement locations is as shown in Figure 3.



**Figure 3 : Schematic Setup for SPL Measurement as per ISO-8528**

**Table 2 : Insertion Loss Measurements with Canopy**

Subsystem	Measured IL (dB) at 75 % Load	Remarks
Canopy	18.5	Canopy IL is Inadequate. It is less than the minimum requirement of 25 dB.
Foam	11.8	Acoustic foam is having good acoustic performance with IL of 10-12 dB.



**Figure 4: Proto Canopy & Insertion Loss measurements**

**SUGGESTIONS FOR NOISE OPTIMIZATION**

- Overall size of canopy is not sufficient to attenuate noise levels. It needs to be increased in terms of its length and height by around 25-30%.
- Louver positions and openings needs to be optimized for noise reduction with proper ventilation performance.
- Proper acoustic material with thickness needs to be selected.
- Appropriate smaller size Fan and radiator selection needs to be done for better noise reduction maintaining cooling requirements.
- Silencer can be further optimized within allowable back pressure limit.

**DESIGN MODIFICATIONS IN CANOPY**

- Length = 2.4 m
- Width = 1.0 m
- Height = 1.3 m
- Rating of Genset – 30 KVA
- Engine Rated Speed – 3000 rpm.
- Foam – PU Foam with 80 mm thickness (26 kg/m<sup>3</sup> density)

**OPTIMIZATION OF GENSET IN TERMS OF NOISE AND TEMPERATURE**

Temperature measurement test carried out in following conditions :

- 12 litre radiator with 485 mm radiator fan.
- 10 litre radiator with 440 mm radiator fan.

**Measurement of sound pressure level (SPL) of Genset carried out in following conditions :**

- 12 litre radiator, 485 mm radiator fan, large louver panel in alternator side, 80 mm foam on all four doors and alternator side.
- 10 litre radiator, 440 mm radiator fan, 9 nos. louvers in alternator side, 80 mm foam (on all four doors and alternator side) and alternator side barrier position shift to middle.
- 10 litre radiator, 440 mm radiator fan, 6 nos. louvers in alternator side, 80 mm foam (on all four doors, exhaust side front panel, alternator side) and alternator side barrier position shift to middle.
- 10 litre radiator, 440 mm radiator fan, 10 nos. louvers in alternator side, 80 mm foam (on all four doors, exhaust side front panel, alternator side), alternator side barrier position shift to middle and new air filter.
- 10 litre radiator, 440 mm radiator fan, 11 nos. louvers in alternator side, 80 mm foam (on all four doors, exhaust side front panel, alternator side), alternator side barrier position shift to middle and new air filter.
- 10 litre radiator, 440 mm radiator fan, large louver panel in alternator side, 80 mm foam (on all four doors, exhaust side front panel, alternator side), alternator side barrier position shift to middle and new air filter.

Continuously monitored Radiator Water in, Radiator Water out, Near air filter (within 50 mm from air filter) & Ambient temperatures of Genset during various loading condition in all noise tests.

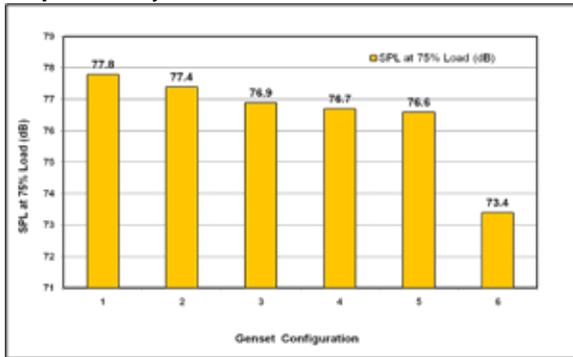
**Table 3:**  
Noise & Temperature measurements with modified canopy ; 10 L radiator ; 80 mm foam & 440 mm cooling fan

NOISE MEASUREMENTS	No Load	75% Load	100 % Load
SPL in dB	72.9	73.4	77.8

Measur-ement	Inside Temp	Outside Temp.	Radiator Water In	Radiator Water Out
Air Temp. (°C)	35.5	34	82.7	76

**Graph-1 :**  
Graphical analysis for six iterations carried out



**DISCUSSIONS**

It can be seen that increase in volume of canopy (length and height) have major effect on reduction of SPL as previous canopy volume is no sufficient to absorb the sound energy. In addition foam thickness optimization & proper selection of radiator & cooling fan contributed in achieving desired noise level without affecting internal air temperature.

**RESULTS & CONCLUSIONS**

- Average SPL at 1meter for SPL measurement at 75% load is 73.4 dB which is lower by 1.6 dB than allowable SPL limit of 75 dB as per CPCB norms.
- The 80 mm combination (40 mm + 40 mm) PU foam used in various places having 26 kg/m3 density.
- The temperature difference between inside canopy (35.5 °C) and ambient temperature (34 °C) is 1.5 °C.
- Insertion loss of the canopy is 24.6 dB (98 dB-73.4 dB).

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