Barloworld Power
Tel National: 0860 898 000
Tel International: +27 31 569 8534
e-mail: kva@barloworldpower.com
www.barloworldpower.com

Link to Cat® Electric Power SpecSizer tool:
https://specsizer.cat.com/

SELECTION AND INSTALLATION CONSIDERATIONS FOR GENERATOR SETS

1. INTRODUCTION

When dealing with the need for generator sets there are two major considerations involved, namely, selection and installation. Getting the details involved in either or both of these considerations wrong will almost certainly lead to problems.

Knowledge around best practice for installation and correct generator set selection is something which is developed over time by engineers working in the generator set industry. (A healthy serving of specific product knowledge and local environmental factors doesn't hurt either.) This specific generator set expertise should be sought by any customer who requires proper selection and installation of diesel generator sets.

Information contained in this article cannot replace the expertise referred to above. However, it is worth developing an understanding of what is typically involved. This document thus provides an overview of considerations when selecting a generator set and installing it.

2. GENERATOR SET SELECTION

Some of the main considerations involved in generator set selection are:

- Fuel (light fuel oil such as diesel, heavy fuel oil, gas etc.)
- Application (e.g. prime, continuous, or standby use; Island operation, base load operation etc.)
- System parameters (e.g. voltage, frequency, three phase or single phase)
- Site conditions (e.g. altitude and ambient temperature)
- Exhaust emission certification (if required)
- Sizing, further detail on sizing follows:

Some of the important considerations to take into account for generator set sizing are:

- Total power requirement – Generator set sizing must consider a list of loads or the total power requirement (if known)
- The actual power factor of the load/s
- Types of loads:
  - » Loads with high transient requirements such as electric motors which require high input currents during start-up
  - » Loads with non-linear characteristics such as variable speed drives (VSD's) and uninterrupted power supplies (UPS's) which effect the generator set's performance by distorting the system voltage due to induced harmonic currents
  - » Loads with high reactive power requirements whether inductive or capacitive
  - » Regenerative loads (such as cranes, hoists etc.) which generates power back into the system which, if not utilised by other loads in the system, will cause the generator set to 'motor' and is likely to result in it over speeding.

It is important that the generator sizing process considers not only the generator set's ability to accept these loads, but also takes into account its ability to do so without suffering undesirably high voltage and frequency dips and takes into account optimal load step sequencing (considering the generators set's load acceptance capability).

DE-RATING VALUES from the effect of altitude and temperature (the performance of the reciprocating engine is affected by high ambient temperatures and high altitudes).

FUTURE NEEDS (oversizing may be necessary to allow for expansion)

It is very difficult to manually compute the size requirements and load acceptance of a generator set with the most suitable engine and alternator combination. A premium generator set company would provide a sizing software product to assist the engineer in determining (specifying) this. Specifying a generator set by using such an electric power 'SpecSizer' tool, assures one that the right generator set has been selected.

ISO 8528 is an important international standard particularly governing the sizing, behaviour and testing of generator sets. Reputable manufacturers build, test and certify their generator sets according to this standard. They also ensure that selection of a generator sets for customer's requirements maintains compliance with the requirements given in this standard.

3. INSTALLATION

A *correctly* selected generator set incorrectly installed can lead to failure. All aspects of installation cannot be fully described here. However, it is worth noting the following installation considerations. By being aware of these variables the engineer or Engineering House will be empowered to know when to call on a reputable generator provider with their specialised experience in installing large electric power generation systems.

The following aspects will be discussed:

- Plant room
- Ventilation
- Exhaust Gas management
- Foundations
- Vibration management
- Electrical Installation
- Fuel
- Sound management/attenuation

Plant room:

a. Ensure doors are wide enough to get the generator set out should major overhauls be required
b. Ensure sufficient space around the engine, alternator and control panel to allow maintenance work to be conducted, and for panels and doors to be opened
c. Ensure sufficient lighting If an open generator set is used; ensure that the plant room has sound attenuation. (see Sound Management section.)
d. Ensure compliance with fire regulations

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e. Ensure sufficient ventilation openings (see ventilation section)

Ventilation:

a. A significant percentage of fuel consumed by diesel engines is lost as heat radiated to surrounding air. Heat from generator inefficiencies and exhaust piping can easily equal engine radiated heat. Sufficient air flow is thus required around the set. Units not using radiators require a forced air draft.
b. Provide adequate clean, cool air for cooling and combustion. A high engine room temperature may require ducting cooler air from outside to the engine to avoid power de-ration. Restriction of radiator air flow reduces its cooling capability
   - » Openings for intake air should be low, near the rear of the engines.
   - » Outlets should be positioned high on the opposite wall.

   Engine room ventilation can be estimate by applying the following formula:

   V = (Q)/0.07242 ΔT

   Where:

   V = the air needed to remove the heat (in m3/min)
   Q = the total heat to be removed (in MJ/hour)
   ΔT = the permissible temperature rise in the machinery space (in C)

   A 6ºC to 10ºC (15ºF TO 20ºF) temperature rise (T) is a reasonable target for an engine room.

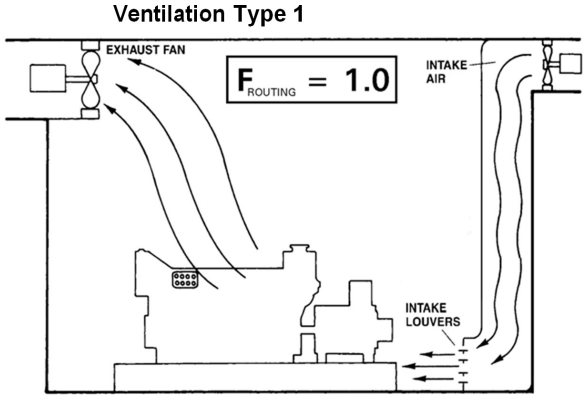

Figure 1. Ventilation Type 1 (Preferred Design)

Note: In ventilation airflow calculations, type 1 systems have a Routing Factor of 1.

Outside air is brought into the engine room through a system of ducts. These ducts should be routed between engines, at floor level, and discharge air near the bottom of the engine and generator as shown in Figure 1. Figure 2 and Figure 3 show examples of bottom-to-top airflow pattern generally used in large power plant applications.

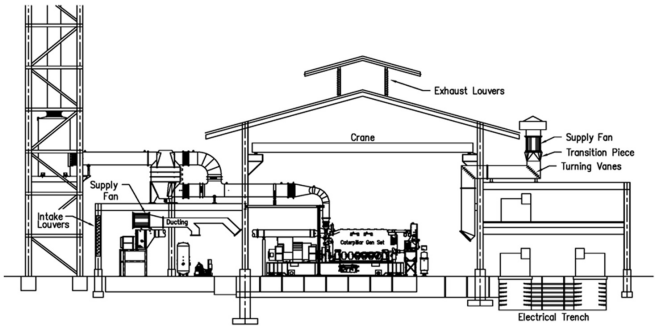

Figure 2. Bottom -to-Top Airflow (1)

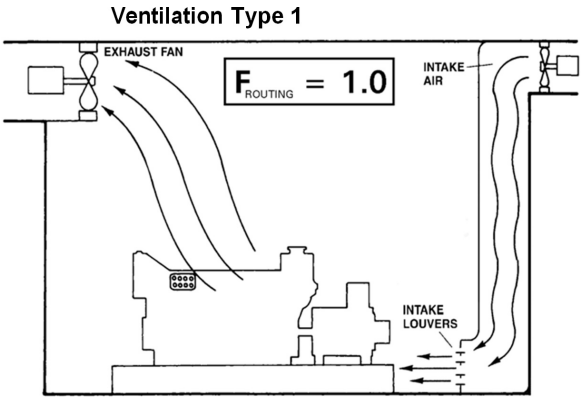

Figure 3. Bottom -to-Top Airflow (2)

Exhaust gas management (Refer Figure 4):

a. The exhaust stack and muffler need to be sized so the exhaust back pressure at the turbocharger outlet does not exceed manufacturer's recommendations. Excessive back pressure raises exhaust temperatures and reduces engine life.
b. Exhaust piping should be isolated from the engine with flexible connections.
c. The piping needs to be wrapped with a thermal blanket to keep exhaust heat out of the engine room.

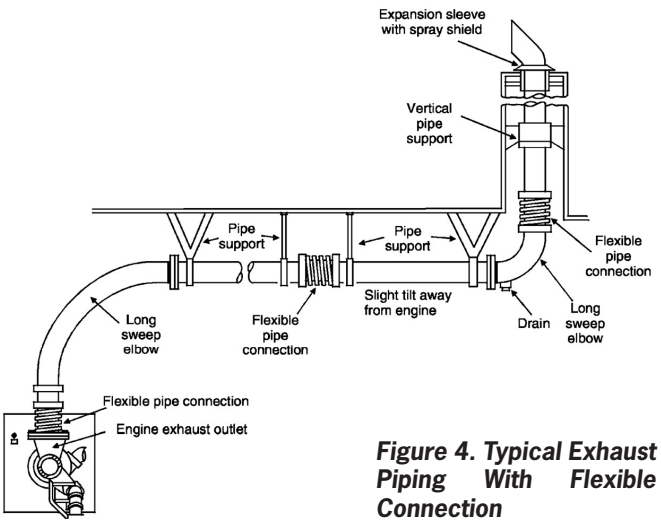

Figure 4. Typical Exhaust Piping With Flexible Connection

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Foundations:

a. It is important for the foundations to support the total weight of the generator. Support should be used where the weight bearing capacity of the supporting material exceeds pressure exerted by the equipment package and where alignment with external machinery is unimportant.
b. The generator set must have a flat and secure mounting surface.
c. The total generator set must be analysed for critical linear and torsional vibration.
d. Alignment needs to be maintained between the engine, generator and the accessory equipment.
e. Firm, level soil, gravel or rock provides satisfactory support for single bearing generator sets used in stationery or portable service.
f. Concrete foundations are often not required for modern multi-cylinder medium speed generator sets. Excessively thick, heavy bases are to be avoided in order to minimise sub-floor or soil loading. Bases need to be thick enough to prevent deflection and torque reaction, while retaining sufficient surface area for support (Non-parallel units require no foundation anchoring).
g. Factory assembled units are dynamically balanced and theoretically there is no dynamic load. Practically, the surface must support 25% more than the static weight of the unit to withstand torque and vibratory loads. Unless the engine is driving equipment which imposes side loads, no anchor bolting is required. This normally applies to all non-parallel generator set mountings. Thin rubber or composition pads minimize the unit's tendency to creep or fret foundation surfaces.

Vibration Management:

a. It is necessary to isolate generator set vibrations from building structures.
b. It's also important to limit the transfer of vibrations from adjacent equipment to the generator sets.
c. A quality generator set manufacturer will provide suitable anti-vibration mountings between the generator sets and its base frame or between the generating set's base frame and it's support structure.

The following table correlates vibration characteristics to these possible causes:

Vibration Characteristic	Correctable Causes
1 component	Mounting of component
1/2 x engine rpm (one-half order)	Misfiring of one or more cylinders
1 x engine rpm (first order)	Unbalance, misalignment, out-of- time balance weights, crankcase overfill
2 x engine rpm (second order)	Unbalance, out-of- time balance weights
1 1/2, 2 1/2, third higher orders	Normal cylinder and combustion (not correctable)
Large vibration motion	Resonance
Motion increases as load is applied	Torque reaction – insecure mounting or inadequate base

Electrical Installation:

Electrical installation work shall comply with the relevant SANS standards. In terms of the OHS Act 85 of 1993 all electrical installation work shall be supervised and signed off (Certificate of Compliance) by a registered person.

Fuel:

a. Only clean fuel should used
b. If long term storage is required, then a polishing unit will be needed.
c. Never use:

» Galvanized piping
» Zinc bearing alloy
» Solid copper, or brass piping for fuel or storage tanks.

These materials can catalyse fuel decomposition and cause fuel filters to plug prematurely. Only black steel pipe or stainless steel pipe should be used.

Sound Management / Attenuation:

a. As sound waves radiate, their strength diminishes. As distance travelled doubles, the wave amplitude is reduced by one-half. This rule applies if the first measuring point is at least two or three times the largest dimension of the noise source, usually about three feet. Be cautious when measuring sound in an environment outside of the specifications which generator set manufacturers conform to.
b. Sound waves impinging on a microphone produce voltages proportional to sound pressures. The signals measure amplitude or strength of the sound pressure waves. Amplitude and frequency are the only sound properties measurable using ordinary techniques. The extensive audible range of sound complicates noise ratings. The human ear has without damage, pressure levels 100 000 times stronger than the lowest detectable level. Noise measuring instruments have extra-ordinary range and are scaled in decibels.
c. To defeat the sound produced by the generator set:

» Mufflers are required on the exhaust
» Air vents require sound absorbing material and louvers
» Doors need to be sound proof

4. CONCLUSION:

In conclusion, the service of an experienced generator set supplier should be called upon to assist with the correct sizing of a generator set. In particular the application as well as the design of the generator set room or enclosure is a critical element when purchasing this equipment.