Generator
Guideline

2012

Logistics Department
Action Against Hunger

ACTION AGAINST HUNGER

Document revision history:

Revision date	Author	Summary of changes
2012	Logistic Department	Initial release

Notes:

Table of contents:

1 - Foreword

This document provides technical insight but also a presentation and explanation of Action Against Hunger standards when existing.

There are two levels of standards:

(Mandatory) indicates a standard intended to ensure uniformity and safety of Action Against Hunger's installations. Derogation may be possible under special circumstances (emergency, etc.) after validation by the energy referent at the HQ.

(Recommended) indicates a recommendation: derogations are possible according to local constraints without validation from the HQ. However be careful as these recommendations, usually lesson-learned from past Action Against Hunger's experiences, are intended to guarantee simplicity and availability of energy systems on the long-run in real field conditions.

Indicates a point of attention or a cause of common mistake

Indicates an useful technical concept

Hurried readers can refer directly to the annex 1 where all standards are summed-up.

2 - Introduction

2.1 Scope

This guideline applies to all engine-generator sets (also called gensets or more commonly generators) used to provide electricity to an Action Against Hunger building.
Generators used for WASH are not addressed here although much information contained in this document may be of some use for them as well.

2.2 What is a generator

A generator is a combination of an engine (prime mover) that produces mechanical energy from fuel and an electrical generator (alternator) that converts mechanical energy into electricity. These two parts are mounted together to form a single piece of equipment.

2.3 When do you need to use a generator

See energy management guideline for more extensive information about the choice of main and back-up power supplies.

Generators are useful to provide large quantity of electricity with limited initial investment. However operating a generator is expensive requires frequent and complex maintenance as well as a constant fuel supply and causes nuisance (noise, vibration, pollution…).

Generators are useful mainly in three types of situation:

- As a main power supply when there is no public electricity grid available or when the grid has a very poor reliability,
- As a back-up power supply when investing in a more efficient power supply is not possible: emergency, short-term installation, etc.
- As a back-up power supply for buildings with very large energy needs (mainly buildings equipped with air-conditioning or electric heaters)

In any other case, a more complete evaluation should be performed to assess alternatives to the generator (battery systems, solar…).

Currently there is at least one generator in the vast majority of Action Against Hunger building.

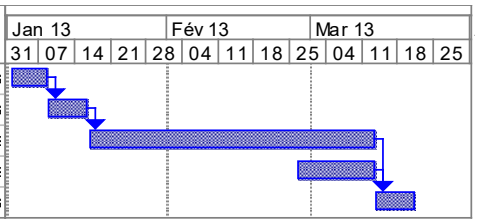
3 - Project planning

3.1 Planning

Step	Approximate duration (weeks)
Installation sizing (energy diagnostic)	1
Procurement and delivery - local - import	 2 10
Generator room preparation	1
Installation	1

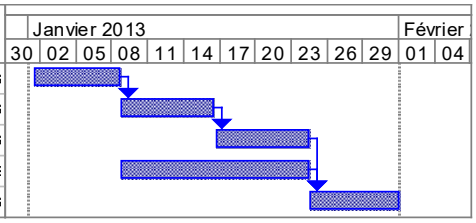
Project planning (import):

N°	Nom de la tâche	Durée
1	Installation sizing (energy diagnostic)	5 jours
2	Request for quotation	5 jours
3	Purchase (import)	35 jours
4	Generator room preparation	10 jours
5	Installation	5 jours



Project planning (local procurement):

N°	Nom de la tâche	Durée
1	Installation sizing (energy diagnostic)	5 jours
2	Request for quotation	5 jours
3	Purchase	5 jours
4	Generator room preparation	10 jours
5	Installation	5 jours



3.2 Budget

3.2.1 Purchase

A generator price will be determined mainly by its rated power (see below for more details on power rating). However, other specification may have a great impact on the price of a generator:

- Noise level : an acoustic canopy for a medium-sized generator will increase the price by at least 2000€,
- Fuel: diesel generators are usually 30% to 80% more expensive than gasoline generator

As a rule of thumb, the average Action Against Hunger budget for a generator is 500€ for each kilovolt-ampere. For example a 8kVA generator purchased locally will be paid around 4000€.

3.2.2 Operation

In addition to purchase price, generators have significant running costs:

- Fuel: an average 1500 rpm generator needs approximately 0.3L of fuel to produce 1kWh. This ratio may increase sharply for old or ill-maintained generators, and it will also be higher for 3000rpm generators.
- Maintenance and spare parts: maintenance costs are difficult to foresee but according to Action Against Hunger's financial data they represent 60% of fuel cost.

Example of running cost evaluation:
You are planning to buy a 9kW generator as a main power supply for an office. This generator will be running 10 hours/day. The fuel cost is around 1.3€/L.
If the generator was well sized, its average load factor will be around 1/3. That means that the generator will, in average, produce: 9kW x 1/3 = 3kWh per hour. The energy production in a day will be then 30kWh (which is actually a realistic evaluation of the energy consumed by a 10 workstations office).
As it is a new generator, we can estimate that the fuel consumption is 0.30L/kWh. Then the daily fuel consumption will be: 0.30 x 30 = 9L/day
And fuel cost will be: 9 x 1.3 = 11.7€/day
Maintenance costs are estimated at 60% of fuel costs: 11.7 x 0.6 = 7€/day

As a result, the running cost of this generator will be approximately 18.7€/day or (with 260 working days per year): 4900€/year.

The running costs of the generator during its first year of usage may be higher than its initial price!

3.3 Project service life

Currently the average service life of Action Against Hunger's generator is 5 years. This lifespan could be much longer (7-10 years) with appropriate preventive maintenance.
Of course, the service life of a generator varies with its usage especially with daily running hours.

4 - Purchasing a generator

4.1 Generator manufacturers

A generator usually has 3 manufacturers:

- The manufacturer of the engine,
- The manufacturer of the alternator,
- The assembler.

Usually only the assembler's name appears on the generator. Some of the most commons brands and there ranges of power are:

- SDMO: small to high power
- Robin-Subaru (or Worms-Robin-Subaru): small to high power
- Perkins: medium to high power
- Lister Petter: medium to high power
- Honda : small power
- Caterpillar : high power
- Cummins : high power
- Yamaha : small to medium power
- Pramac : small to high power
- FG Wilson : medium to high power
- Kipor : small to high power

Be careful: generators can be counterfeit. Robin-Subaru, Honda, Yahama and Kipor are among counterfeiters' favorites. A list of authorized dealers can usually be found on manufacturer website.

All these manufacturers have their own distributors and contractors' networks and the availability of a brand can vary from one mission to the other. As a result there is no Action Against Hunger standard regarding the choice of a generator brand. Brands must be chosen according to local market, taking into account not only generator availability but also existing qualified maintainer and spare parts distributors.
In addition, to simplify maintenance, reduce spare parts stocks and negotiate purchase prices it is highly advisable to stick to one brand on each mission.

(Recommended) Choose a generator brand according to local market and to the availability of spare parts and competencies for maintenance. Stick to the chosen brand for any later purchase.

4.2 Power

4.2.1 What are we talking about?

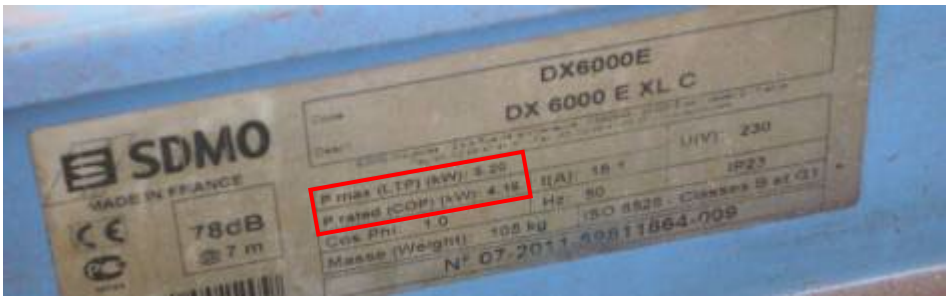
The main characteristic of a generator is the maximum power it can deliver. This power must be higher than the power that can be required by the electrical installation at any time even during very short periods.

Generators are like humans, the effort they can deliver depends how long and how often they have to produce it. For that reason, the maximum power of a generator cannot be considered without service duration.

Power rating is standardized, the most common standards are:

- "**Prime rated power**" PRP: this power is available during **unlimited** hours of usage with variable load factor. An overload of 10% is possible during maximum 1 hour every 12 hours but not exceeding 25 hours per year.
- "**Continuous operating power**" COP: this power is available during **unlimited** hours of usage with a fixed load factor. No overload allowed.
- "**Limited time power**" LTP: this power is available only during **500 hours per year** with a fixed load factor. No overload allowed.
- "**Emergency standby power**" ESP: this power is available only during **25 hours per year** with variable load factor. 80% of this power is available during 200 hours per year. No overload allowed.

Of course a generator rated in ESP or LTP will no break down after precisely 25 or 500 hours of service but once it reach this limit it service life will begin to decrease and its maintenance needs will start increasing.



Identification tag of a generator with both LTP (5.20kW) and COP (4.16kW) indicated

Most of the time, only PRP or COP is relevant when purchasing a generator. LTP may be relevant for back-up generator but only in countries with a very reliable public grid. ESP indications have to be ignored as the ESP rating is far below our requirements even for back-up.

Power can be rated either in watt (W), kilowatt (kW), volt-amps (VA) or kilovolt-amps (kVA).
1kW = 1000W and 1kVA = 1000VA
A rating in watts indicates a real power (P); a rating in volt-amperes indicates an apparent power (S). Only the real power has to be considered.
If only the apparent power is indicated, you can evaluate the real power with the following formula:

$$P_{(W)} = S_{(VA)} \times 0.8$$

Here, 0.8 is the power factor, it may vary from one machine to another but 0.8 is a reliable average value.

4.2.2 How much power does your installation need?

To calculate the power needed by your installation, the simplest and more accurate way is to fill the « energy diagnostic », refer to the "energy management" guideline for more details. Once you filed this file, the maximum power needed by your installation (in watts) will appear the cell AJ35 on the sheet "Conso".

If, for any reason, you cannot fill the energy diagnostic, you can estimate the power needed by a building with the following rules:

- For an office : 1.5kW + 0.3kW for each workstation
- For a guest-house : 2.5kW + 0.2kW for each bed

These estimations must not be used for buildings equipped with powerful electrical appliances (electric heater, air conditioning…).

If you need to calculate manually the maximum power of your installation, proceed as follows:

1. List all electric appliances fed by the installation
2. Find the maximum power of each electrical appliance. For appliance including an electrical motor the maximum power is approximately three times the nominal power (for example a 300W water pump will need around 1kW to start)
3. Add all power

Example:

1. List of appliances
   - Security lighting: 5 bulbs of 100W
   - 10 30 W bulbs
   - 1 electrical pump: U=220V I_{max}=3A
   - 1 fridge: P= 220W
   - 1 battery charger: U=220V I_{max}=4A
   - 1 electric heater: P=2 kW

2. Calculation of the power of each appliance
   - Security lighting: 5x100W = 500W
   - Other bulbs: 10 x 30W = 300w
   - Pump: 220V x 3A = 660W
   - Fridge: 220W
   - Charger: 220V x 4A = 880W
   - Heater: 2000 W

3. Total power
   - P = 500 +300 + 660 + 220 + 880 + 2000 = 4560W

4.2.3 Power of the generator

Once you calculated the maximum power needed by your installation, you still need some precaution to choose the power of your generator:

- **Don't mix kW and kVA**: most of the time the power of your installation will be calculated in kW and the power of your generator will be rated in kVA. In that case, divide by 0.8 (or add 25%) to convert the power of your installation from kW to kVA.

Example: with a 4560W installation, the power of the generator must be at least 4.6kW PRP or:

4.6/0.8=5.8kVA PRP

- **Take derates into account**: the power a generator can provide decreases with the altitude and temperature. The following chart give an evaluation of these derates:

Altitude	Derate
≤150m	No derate
300m	-1.8%
500m	-4.1%
1000m	-9.9%
2000m	-21.6%
3000m	-33.3%

Temperature	Derate
≤30°C	No derate
35°C	-1.8%
40°C	-3.6%
45°C	-5.4%
50°C	-7.3%
55°C	-9.1%

(Note that temperature inside the generator room can be far higher than ambient temperature)

Example: The actual power a 10kVA generator can deliver at 2000m is only:

10 x (1 - 0.216) = 7.8kVA

- **Only trust PRP or COP**, be very cautious if the power of the generator is indicated without reference to a standardized rating method.

4.3 Other characteristics

4.3.1 Security

(Mandatory) Generators must be equipped with residual current circuit breaker.

(Recommended) Generators with acoustic canopy should be equipped with an emergency stop push button outside the canopy.

4.3.2 RPM

Generators' engines usually have either:

- 1500 rotations per minute: intended for intensive usage (running more than 6 hours) capable to reach high power
- 3000 rotations per minute: intended for short term usage, better power/volume and power/weight ratios but higher hourly consumption

(Recommended) 1500 rpm generators should be preferred.

4.3.3 Noise level

Noise levels are relative:

- To the measuring instrument frequency response
- To the measurement methodology, especially to the distance between noise source and measuring instrument

Under European Union standards, noise levels are indicated in dB(A) L_{WA}.
(A) means that the frequency response used in sound measuring instruments corresponds approximately to the human ear response at low sound levels, L_{WA} indicate a methodology calculating noise level at the emission point (distance = 0). The maximum noise level authorized for a generator in the European Union is 97 dB(A) L_{WA}.

For comparison purpose here are some common sound and there rating in dB(A)

Threshold of pain	120 dB(A)
Discotheque	110 dB(A)
Jack hammer at 10 m distance	100 dB(A)
Petrol Lawnmower	90 dB(A)
High traffic on an expressway at 25 m distance	80 dB(A)
Main road at 5 m distance	70 dB(A)
Vacuum Cleaner at 5 m distance	60 dB(A)
Refrigerator at 1 m distance	50 dB(A)

An average office should around 70dB(A). Noise level in a bedroom at night should be lower than 50dB(A).
Note that a continuous noise even at very low level can become exhausting over long period of time.

When comparing noise levels at different distance, you can use the following estimations:

- dB(A) @ 4 meters ≈ dB(A) L_{WA} – 20
- Then noise level decreases by 6dB each time the distance double

Example: I want to use a 97 dB(A) L_{WA} generator in a generator room located at 15 meters from a building. How loud will I hear the generator in the building?

97dB(A) L_{WA} is equivalent to 77dB(A) @ 4 meters
77dB @ 4m = 71dB @ 8m
71dB @ 8m = 65dB @ 16m

The noise level in the building will be approximately 65 dB(A), maybe lower depending on the acoustic isolation of the generator room and the office.
This is an acceptable level for an office but not for a guest-house at night.

(Recommended) Generators should not produce a noise level higher than 97 dB(A) L_{WA}.

(Recommended) Generators intended for intensive usage or night usage should be equipped with acoustic canopies.

4.3.4 Tank capacity

For evident safety reasons, a generator cannot be refueled while it is running. Tank capacity is then the main factor determining autonomy.
A conservative estimation of a 1500rpm generator hourly consumption is 0.15 x rated power. Fuel tank must be chosen accordingly.

Example: I want to use a 10kVA PRP generator for an office without refueling it during working day.
The hourly fuel consumption of that generator can be evaluated to:

$$0.15 \times 10 = 1.5 L/hr$$

The autonomy needed is approximately 10 hours (8am to 12am, 14am to 18am + 2 hours security margin).
Then the fuel tank capacity must be at least: 1.5 x 10 = 15L

4.3.5 Single or three phases

A single phase system has 2 wires (+ earth): one neutral and one live conductor carrying AC. Appliances using single phase current are connected between live and neutral.

A three-phase system has 4 wires (+ earth): one neutral, 3 live conductors carrying waves that are 120° (⅓ of a cycle) offset in time. A three-phase system which max power is P can be regarded as 3 unsynchronized single-phases systems which individual power is P/3 with a shared neutral.
As a result, a 3-phases installation must be balanced: the load on each phase must be more or less the same. Otherwise a part of the power will be lost (as the power which is not consumed on one phase cannot be recuperated on the others) and there is a risk to damage the generator.

Generators (as well as grid connections) can provide either single phase or 3-phases current.
There is no simple way to transform a 3-phases generator in a single phase one.
Whenever possible 3-phases current as to be avoided as a 3-phases installation is more complex and has a lower usage ratio than a single phase installation (i.e. the ratio between the power you actually use and the rated power will be lower for a 3-phases generator than for a single phase one leading to overinvestment and shorter lifespan).
However there are 2 cases where you will be forced to choose a 3-phases generator:

- To power a 3-phases appliance, as 3-phases appliance can use only 3-phases current. Luckily 3-phases appliances are very rare on standard Action Against Hunger installations, the only exception being some water pump.
- To feed a very powerful installation, as most of the generator above 10kVA are 3-phases.

(Mandatory) Generators under 10kVA must be single-phase**.**

(Recommended) All generators should be single-phase.

4.3.6 Fuel

Generator can use either diesel or gasoline. Diesel generators are more expensive (but diesel is often cheaper than gasoline) and have better power/volume and power/weight ratios than gasoline generators.
Fuel choice must be determined according to local price and availability of both type of fuel. However as Action Against Hunger cars use diesel it may often be simpler on a logistic point of view to choose diesel for generators as well.

5 - Installing a generator

5.1 Safety first

(Mandatory) A generator must never be running in an occupied room.

(Mandatory) Generator room must be correctly ventilated.

(Mandatory) Fuel and oil must not be stored in the generator room.

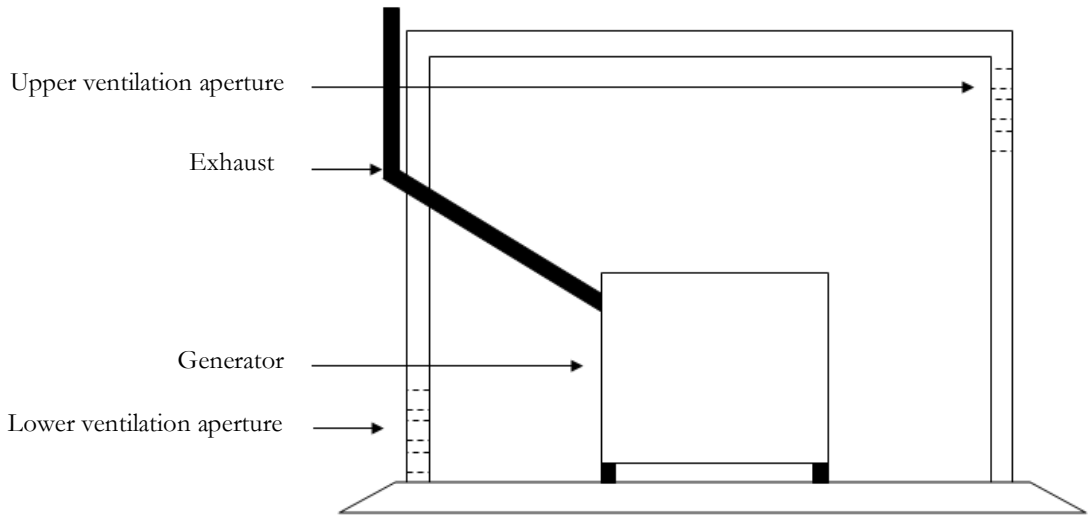
(Mandatory) A fire extinguisher rated for electric and fuel fires (i.e. a carbon or a dry chemical fire extinguisher) must be available outside the generator room. Fire sand bucket can be an option when extinguishers are not available.

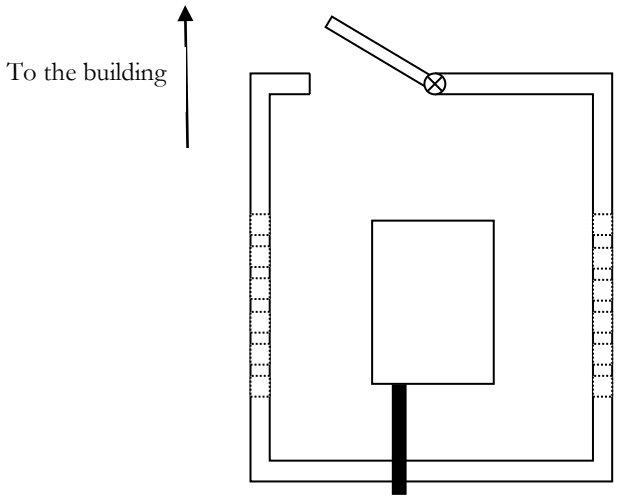
5.2 Generator room

A generator room has two (contradictory) purposes:

- Isolate the generator to decrease its impact on the rest of the base and on the neighborhood: noticeably generator room must help to decrease the noise level and must prevent non-authorized access (whether staffs, visitors, animals…) to the generator.
- Ensure good operating conditions for the generator: generator room must protect generator against bad weather and ensure correct ventilation of the generator (in addition to the risk of carbon monoxide intoxication, an excessive temperature would reduce power and service life of the generator).

A standard design for a generator room is the following:





To reduce noise disturbance, ventilation apertures must not be facing a building. The space available on the sides and behind the generator must be sufficient to perform maintenance (~1.5m)..

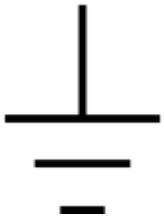
The choice of the building material is not critical to reduce noise level.

5.3 Grounding

Grounding is indispensable to ensure safety and correct operation of the generator.

(Mandatory) All generators must be grounded

In most of the case, you will find a bolt on the frame (or the door for soundproof generators) of the generator connected to other parts with a metal strap and marked with the ground symbol:



Connect your ground line to that bolt.

If you cannot find it, connect the ground line directly to the metallic frame of the generator.

It is possible to connect the generator's ground to the same ground line as the installation but the length of the ground line must not exceed 10m. If you have to create a ground socket see electricity safety guide for details.

6 - Using a generator

Only the manufacturer manual can provide full details on the usage and maintenance of a generator. **Read the user manual first!**
If the following instructions are in conflict with manufacturer instructions, only the latest have to be trusted.

6.1 Generator monitoring

To monitor correctly fuel consumption and maintenance, generator follow-up is essential. At least the following data have to be traced:

- Running hours
- Refueling
- Preventive maintenance

(Mandatory) Running hours, fuel consumption and maintenance have to be recorded for all generators

An example of generator follow-up is proposed in the annex.

6.2 Starting and stopping a generator

Generators must never be started or stopped while loaded (i.e. connected to the installation).

Standard starting procedure:

1. Make sure that the generator circuit breaker is open (if the generator does not have a circuit breaker : make sure that the installation main breaker is open)
2. Check the oil level
3. Check the fuel level
4. For water-cooled generators only : check the water level
5. Make sure that there is no leakage (no oil or fuel under the generator)
6. Start the generator
7. Wait 2 minutes and fill the generator follow-up
8. Close the circuit breaker

Standard stopping procedure:

1. Warn users that the power will be cut (save files, etc.)
2. Open the generator circuit breaker (if the generator does not have a circuit breaker : open the installation main breaker)
3. Wait 2 minutes and fill the generator follow-up
4. Stop the generator

(Mandatory) Starting and stopping procedures must be displayed in the generator room.

This display must be adapted to your generator. A frame is proposed in annex 3.

6.3 Preventive maintenance

Maintenance indicative timetable:

	Intensive usage	Occasional usage
Starting generator	As often as required	At least once a week
200 hours maintenance	Every month	Every 4 months
600 hours maintenance	Every 3 month	Every year

If a generator is rarely used, it is essential to start i tat least once a week to keep it in good condition.

6.3.1 200 running hours maintenance

The following controls are to be performed every 200 running hours:

- Check the ground connection
- For gasoline generators only : check that the spark plug are correctly screwed
- Check the air cleaner element

The following operations are to be performed every 200 running hours:

- Drain fuel tank
- Clean fuel filters
- Refill oil
- Check battery liquid level and refill with distillated water when necessary
- Check spart arestor clogging and clean it with filtered water when necessary

These operations may be performed without the help of a specialist technician.

6.3.2 600 running hours maintenance

The following operations are to be performed every 600 running hours:

- replace the fuel filter element
- check fuel injection bozzle condition
- check the fuel injection timing
- drain the oil when engine is still warm and replace it
- clean lube oil filter
- replace the air cleaner element
- adjusting the intake and exhaust valve clearance
- check commutator brush and slip ring

These operations have to be performed by a professional technician.

6.4 Corrective maintenance

Typical faults are listed below together with the action required to remedy the fault. The help of a qualified technician will be required most of the time to solve one of these issue.

6.4.1 Engine breakdown

There are four kinds of possible engine breakdowns:

- The engine does not start
- The engine starts, but it stalls or misses
- The engines works all right but starts overheating after a while
- The engine runs smoothly, but the electricity is not properly generated

Fault	**Possible cause**
Starter does not work	a) Battery discharged. Loose or incorrect cable connections. Electrical fault in starting circuit. b) Faulty starter motor. c) Starter pinion will not engage on flywheel starter ring.
Action	
a) Check voltage. - Check voltage at battery terminals with a multimeter. - If voltage < 10V change or charge battery. If possible try to start the generator manually. b) If voltage present: - Check all connections. - Replace starter motor if fault remains	

Fault	**Possible cause**
Starter works but engine does not start	a) No fuel reaching injectors. Fuel supply line blocked. b) Air lock in fuel line. c) Fuel filters choked. d) Water in fuel. e) Air cleaners choked. f) Fuel pump timing out. g) Lift pump faulty.
Action	
a) Check that fuel tap is 'on' and adequate amount/head of fuel is in tank. b) Operate excess fuel device. c) Bleed fuel system. d) Change filter elements on engine. Drain contaminated fuel. Empty fuel filter bowls and change elements. e) Clean air cleaners.	

f) Reset timing. g) Change lift pump.

Fault	Possible cause
Engine fires but fails to pick up speed	a) Fuel supply system faulty. b) Air cleaner choked. c) Faulty lift pump. d) Faulty air injectors.
Action	
a) Check all pipe joints. Bleed fuel system. b) Clean air cleaners. c) Change lift pump. d) Change injector(s).	

Fault	Possible cause
Engine misfires	a) Air lock in fuel line. b) Fractured injector feed pipe. Faulty injector. c) Faulty injection pump. d) Tappet clearances incorrect.
Action	
a) Bleed fuel system. Replace pipe. b) Loosen feed pipe to each injector in turn and note any change in engine response. c) Change injection pump. d) Check and readjust tappet clearance accordingly.	

Fault	Possible cause
Low power output	a) Inadequate fuel pressure. b) Air filters choked. c) Fuel injection pump timing incorrect. d) Faulty injection. e) Tappet clearance inadequate. f) Faulty turbocharger. g) Inlet manifold and/or cylinder head joints leaking
Action	
a) Check over complete fuel supply system as previously laid down. b) Clean air filters. c) Reset timing. d) Change injector(s). e) Adjust tappets. f) Replace turbocharger. g) Renew gasket or joint packings as necessary.	

Fault	Possible cause
Low oil pressure (Sudden pressure drop as opposed to progressive drop due to	a) Oil level too low. b) Oil pressure gauge faulty. c) Oil filters choked.

worn bearings)	d) Relief valve faulty.
Action	
a) Check for leaks and fill to level indicated on dipstick. b) Fit an identical replacement gauge. c) Change filter elements. d) Examine and clean pressure relief valve.	

Fault	**Possible cause**
Overheating	a) High oil temperature. b) No coolant in engine. c) Coolant system polluted. d) Blocked air passages in radiator matrix. e) Fan belt tension incorrect. f) Thermostat fault. g) Fuel injection pump timing out. h) Low oil level.
Action	
a) Check for leaks and refill (ensure correct percentage of anti-freeze is also added if necessary). b) Drain, flush out and refill. c) Carefully clean all air passages. d) Adjust tension. e) Fit an identical replacement thermostat. f) Reset timing. g) Check for oil leaks and fill to level indicated on dipstick.	

Fault	**Possible cause**
Inadequate fuel	a) Fuel supply system faulty. b) Faulty fuel lift pump. c) Fuel relief valve faulty. d) Choked fuel filters.
Action	
a) Check all pipe joints for leaks. b) Replace with identical unit. c) Examine and clean valve. d) Change filters elements.	

Fault	**Possible cause**
Exhaust emits black smoke	Excess fuel being used.
Action	
Change pump if maximum fuel stop seal has been broken.	

6.4.2 Alternator Breakdown

Engine is running well but alternator is not working properly or current delivered to your installation is not satisfying. In the latest situation it is recommended to measure voltage and

current at the output of the generator to make sure that the problem is not caused by the installation itself (short-circuit, open breaker, faulty appliance, etc.).

Anyway, it is recommended to refer to the user manual for specific fault finding instructions as designs vary from a manufacturer to the other. The details given below are for general guidance only.

Fault	**Possible cause**
Alternator is very hot	a) Cooling air inlet blocked or obstructed. b) Cooling air discharge blocked or obstructed. c) Rotor bearings running hot. d) Machine overloaded. e) Short circuit between windings and/or windings to frame.
Action	
a) Clean screen protection and remove any obstruction preventing air entering the air inlet. b) Proceed as for air inlet above. c) Too much or too little grease. Remove bearing from machine and check conditions. Repack with correct grade and quantity of grease before reassembling. d) Check that the electrical overload equipment and circuit breaker are working satisfactorily. e) Replace windings.	

Fault	**Possible cause**
No output voltage	a) Engine speed too low. b) Loose terminals. c) No excitation and/or loss of residual magnetism. d) Open circuit in windings. e) Faulty automatic voltage regulator (AVR). f) Faulty diode in main rectifier assembly on the rotor. g) Open circuit of the gain and/or range control on the AVR. h) Hand operated voltage trimmer open circuit (if fitted).
Action	
a) Check and set up correctly. b) Check over and tighten all terminals. c) Re-excite by flashing in accordance with manufacturers handbook. d) Check for continuity in accordance with manufacturers handbook: renew if required. e) Remove leads at voltage control unit terminal block, run set up to speed and flash excitor in accordance with the manufacturer's handbook. If the voltage appears then the AVR is faulty and should be tested out in accordance with the instructions given for testing A.V.R.'s. f) Remove and test with ohmmeter; the forward resistance should be less than 1000 ohms and the reverse resistance greater than 100K ohms. Replace if necessary. N.B. When this fault occurs it is likely that more than one and possibly all the diodes may need replacing. g) Check for continuity.	

Fault	**Possible cause**
Output voltage unstable	Incorrect setting of gain control.
Action	
Adjust slowly until a stable voltage is obtained.	

Fault	Possible cause
Output voltage incorrect	Voltage set up incorrectly on band trimmer or choke tappings.
Action	
Adjust accordingly.	

Fault	Possible cause
Output voltage too high and cannot be reduced on controls	Automatic voltage regulator faulty.
Action	
Remove AVR and make tests according by the manufacturer handbook. Replace if found necessary.	

6.4.1 Other breakdown

If both engine and alternator are working, fault may be caused by faulty controls, protections (fuse, RCCB…) or connections.
Faults liable to occur in these devices will depend upon the design of the control scheme supplied. It is only possible to give general recommendations regarding fault findings on this equipment.

Fault	Possible cause
Circuit fuses or breakers are opening	a) Incorrect rating of fuse used. b) Short circuit between panel wires and/or between wires and frame.
Action	
a) Check circuit rating and fit new fuse of the recommended rating. b) From circuit diagram check wiring of components. Rewire or replace components found faulty.	

Fault	Possible cause
Circuit operating satisfactorily only intermittently	Faulty or out of adjustment relay or auxiliary contacts.
Action	
Replace and/or readjust auxiliary and clean where necessary.	

Fault	Possible cause
Excessive 50 Hz buzz or hum	Dirty, rusty or badly aligned pole faces
Action	
Clean, de-rust with fine emery paper and readjust. Leave a minute film of oil on the parts concerned to retard formation of rust.	

Fault	Possible cause

Overheating cable ends and terminations	Loose connections.
Action	
Tighten all connections, making sure all dangerous voltages have first been switched off and cannot be switched on again whilst work is in progress. Ensure all terminations subject to heat/load cycling i.e. the main cabling terminations are suitably lock nutted.	

Annexes

Annex 1: Standards overview

Annex 2: Generator follow-up

Annex 3: Starting and stopping procedures (frame)

Standards overview

(Recommended) Choose a generator brand according to local market and to the availability of spare parts and competencies for maintenance. Stick to the chosen brand for any later purchase.

(Mandatory) Generators must be equipped with residual current circuit breaker.

(Recommended) Generators with acoustic canopy should be equipped with an emergency stop push button outside the canopy.

(Recommended) 1500 rpm generators should be preferred.

(Recommended) Generators should not produce a noise level higher than 97 dB(A) L_{WA}.

(Recommended) Generators intended for intensive usage or night usage should be equipped with an acoustic canopy.

(Mandatory) Generators under 10kVA must be single-phase**.**

(Recommended) All generators should be single-phase.

(Mandatory) A generator must never be running in an occupied room.

(Mandatory) Generator room must be correctly ventilated.

(Mandatory) Fuel and oil must not be stored in the generator room.

(Mandatory) A fire extinguisher rated for electric and fuel fires (i.e. a carbon or a dry chemical fire extinguisher) must be available outside the generator room. Fire sand bucket can be a temporary alternative when no extinguisher is available.

(Mandatory) All generators must be grounded

(Mandatory) Running hours, fuel consumption and maintenance have to be recorded for all generators

(Mandatory) Starting and stopping procedures must be displayed in the generator room.

MONTHLY GENERATOR FOLLOW-UP

GENERATOR:
MONTH: **YEAR:**

Date	Check		Refuel (L)	Meter (hrs)	Start at	Stop at	Start at	Stop at	Meter (hrs)	Remarks and signature
	Fuel	Oil								
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										

Date	Check		Refuel (L)	Meter (hrs)	Start at	Stop at	Start at	Stop at	Meter (hrs)	Remarks and signature
	Fuel	Oil								
21										
22										
23										
24										
25										
26										
27										
28										
29										
30										
31										

MONTHLY RUNNING HOURS AND FUEL CONSUMPTION			
A	Monthly fuel consumption		Remarks:
B	Monthly running hours		
C	Average hourly fuel consumption (A/B)		

MONTHLY MAINTENANCE							
Check ground	Check sparkplug	Check air cleaner	Drain fuel tank	Clean fuel filters	Refill oil	Check battery	Check spart arrestor

(Once completed keep this document carefully)

STARTING AND STOPPING GENERATOR

RUNNING HOURS OF THE GENERATOR

On working day generator has to be started at xxxx and stopped at xxxx
During weekends and holiday, generator has to be started at xxxx and stopped at xxxx.

STARTING GENERATOR

1. Check that the generator breaker is open

Paste here a photo of the generator breaker when open

2. Check fuel level

Paste here a photo of the fuel tank with apparent fuel level and minimum/maximum levels

3. Check oil level

Paste here a photo of the dipstick with apparent oil level and minimum/maximum levels

4. Start generator

Paste here a photo of the generator starter

4. Fill the generator follow-up form and wait 2 minutes
5. Close the generator breaker

STOPPING GENERATOR

1. Warn users that the power will be cut
2. Open the generator breaker
3. Fill the generator follow-up form and wait 2 minutes
2. Stop generator

Don't forget monthly maintenance!