

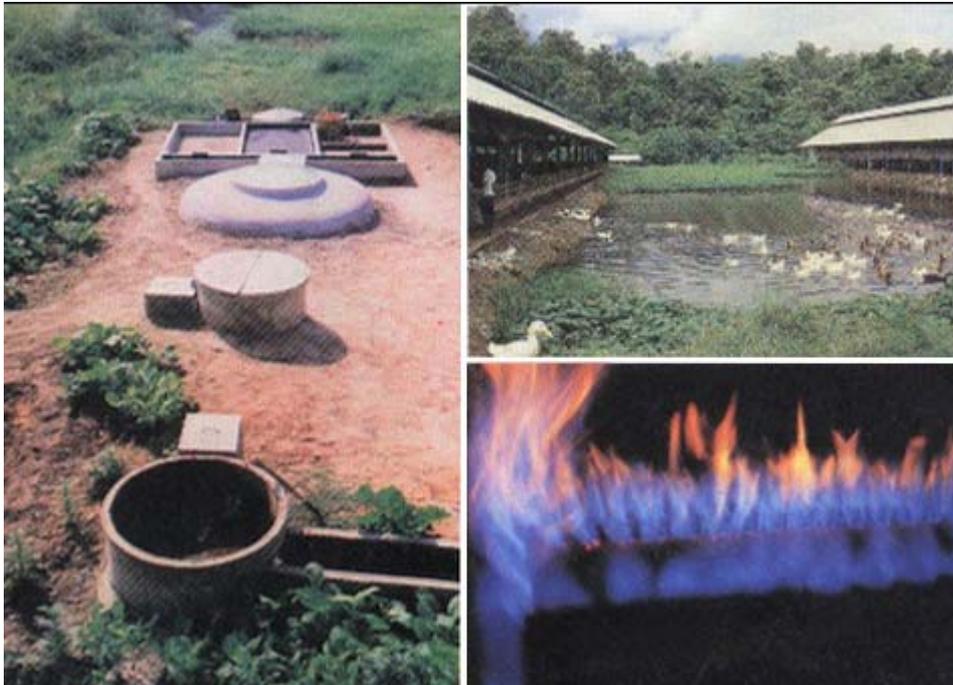
CHAPTER 7

Operation Manual of Bio-gas Reactor

7.1 The Significance of the Bio-gas

Bio-gas is a form of energy produced when organic materials such as animal excrement or products that are left over from agriculture are fermented easily and at low cost. The advantage of bio-gas is that it replaces other energy sources for example charcoal, firewood, electricity, liquid petroleum gas and oil. After animal excrement had been fermented in the gas plant it becomes a good quality and odorless substrate, which is better than fresh manure in improving the soil for the agriculture. As an energy source, it prevents deforestation and animal excrement from causing pollution, smell, flies and water pollution in the community.

Nowadays the use of bio-gas has spread from small farms to big animal farms. It is expected that bio-gas will be a significant source of energy in the future to preserve the environment, solve the pollution problem and to promote better health to agriculture and community.



7.2 Bio-gas Plant and Agriculture Cycle System

Three main cycle components as in full agriculture system are animal farming, bio-gas plant and animal products. Each provides direct economic benefit to agriculture.

Provide energy to household uses

Provide organic fertilizer to improve the soil or for merchandise.

7.3 Cycle System

1. Waste water and excrement from enclosure
2. Flow through the inlet pipe into mixing chamber
3. Then into digester chamber
4. Substrate overflow into expansion chamber
5. Into storage tank ready to be used in the agricultural fields or to be dried as fertilizer for merchandise.

7.4 Maintenance of Bio-gas System

Factors affecting bio-gas production

7.4.1 Animal excrement: daily quantity of excrement added must be sufficient, if too much or too little is added, very little or no gas will be produced as the bacteria dose not have sufficient time to break down the manure.

7.4.2 Time: suitable fermenting and breaking down time of manure is between 40-60 days.

7.4.3 Mixing: occasional stirring is required to help mixing the manure which will accumulate gas and prevent the forming of crust (cow dung) or scum (pig dung) in digester chamber.

7.4.4 Chemicals: such as antibiotic, pesticide, chemical fertilizer or other chemical products may damage bacteria that break down the organic materials in the chamber. The bacteria may stop working and gas will not be produced. Therefore chemical substances should not be released into bio-gas plants.

7.4.5 Temperature: the effective temperature for bacteria to grow is 37° C. If higher or lower than the suggested the bacteria will not develop, decreasing gas production. For example less gas will be produced in summer or winter.

7.4.6 pH Balance: A pH between 7-8.5 is optimal. If below the suggested pH, gas will not be produced.

7.5 Animal Excrement Adding

First adding (first 7 days) add cow or buffalo excrement daily.

- If cow or buffalo excrement is not available, pig excrement can be used at ratio of half the cow excrement suggested for a length of 2 weeks. After that add accordingly to the chart below.

Type of Materials	Sizes of Bio-gas plants						
	4.6M ³	8M ³	12M ³	16M ³	30M ³	50M ³	100 M ³
Cow/buffalo excrement (litres)	300	600	800	1,200	2,200	3,600	7,200
Water (litres)	300	600	800	1,200	2,200	3,600	7,200

- After the plant is built and tested by filling with water, the water should be left inside. Open the valve to release the air until the mono-meter is at 0 and animal excrement can then be filled.
- The first adding of excrement should not be filled up to the top to avoid the slow production of gas or materials becoming decomposed. It should be separately added in small amount until fully filled.

Next adding, after 7 days of the first addition, add the materials regularly on daily basis as shown below:

Type of Materials	Sizes of Bio-gas plant						
	4.6M ³	8M ³	12M ³	16M ³	30m ³	50m ³	100M ³
Cow/buffalo excrement (litres)	40	70	100	140	250	416	833
Water (litres)	40	70	100	140	250	416	833
Pig excrement (litres)	30	50	70	90	166	277	555
Water (litres)	60	100	140	180	332	555	1,110

- This addition will produce gas within 2-3 days.
- Release the gas from the tank 3 times before using it.
- Exceeded material will cease gas production.
- Use only fresh excrement, dry excrement is prohibited because it stops the process of producing gas and will block the pipes.

7.6 Animal Enclosure and Drainage Alley Maintenance



- ❑ Cleanliness of the enclosure is maintained daily by removing the excrement and putting it into the mixing chamber.



- ❑ Wash the enclosure with water and let it flow into drainage alley.
- * Water that mixed with chemicals, antibiotics or antiseptics is not allowed to flow into the digester chamber as bacteria that activate the gas in the chamber will die.

7.7 Mixing Chamber Maintenance

- ❑ All rice hay, rice husk, gravel, soil, sand or non-organic materials must be removed from animal excrement when mixed with water, before releasing it into the mixing chamber. Those materials will shallow the level of the digester chamber and cause blockage in pipes.



- ❑ Mix or stir the mixture in the inlet pit until it becomes liquid, then open the gate of the mixing chamber to let the mixture flow into the digester chamber.



- ❑ Clean mixing chamber and gate at every addition of the excrement in the digester chamber.



- ❑ Use wooden stick to stir the fermented liquid once a week to avoid the formation of crust or scum at the bottom of the chamber or blockage of the inlet pipe.
- * Before adding of excrement gas should be partly released for usage to let manure flow easily in to the digester chamber, as high pressure in the digester chamber would slow down the flow of the manure.

7.8 Digester Chamber and Outlet Pipe Maintenance

- ❑ Pour clean water into the inlet of the digester chamber to prevent the clay covering the pipe from drying and gas from leaking.

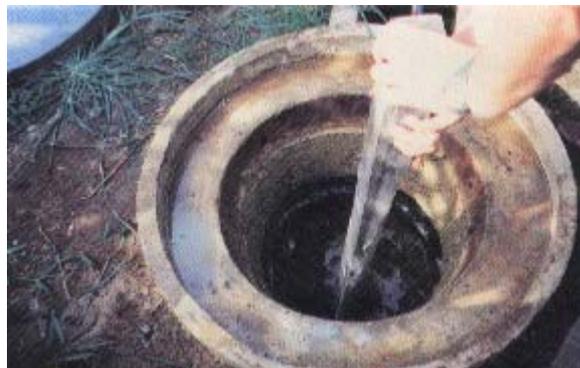


- ❑ Water level at the top of the inlet cover should not be over the steel clamp which tightens the gas pipe. It can become rusty.





- ❑ The inlet should be covered to prevent domestic animals from drinking this water and also prevent the water from evaporating quickly.



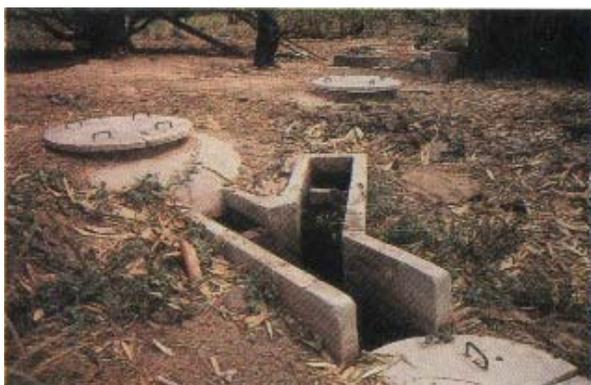
- ❑ The cover of the inlet pipe should be opened for maintenance once a year. The crust or scum formed by manure should be removed if possible.

**No excrement adding if gas is not produced for many days.*

7.9 Pig Excrement Chamber (Outlet Pipe Installed)

Pig excrement forms more residue than cow or buffalo excrement and the removal residue from the floor base is more difficult. To prevent the blockage or the build up of residue on the floor, these instructions should be followed.

- Pull gate at the outlet pipe while the pressure is at the highest level, gas will help push out residue at the bottom.



Leave gate opened for a while and after one smells the gas or the overflow slurry is very liquid then close the gate.

- * The substrate should be removed at least once a week. If the substrate does not flow out when the gate is pulled, use wooden stick to unclog the outlet pipe.
- * Gate must be closed tightly. If there is water leaking, the pressure in the digester chamber will decrease.
- * When the storage tank is full, the gas must be removed for usage.

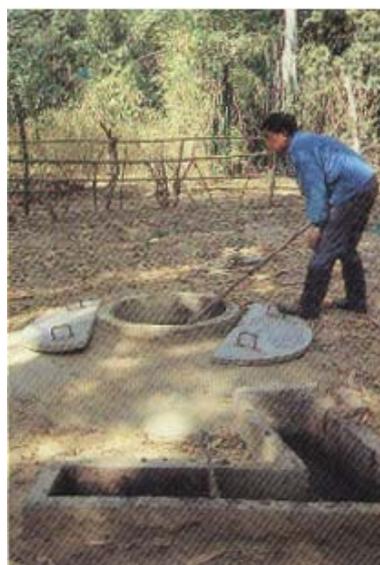
7.10 Expansion Chamber Maintenance

- ❑ Keep the outlet pipe free from blockage by clearing the dry manure or residue around the edge of the outlet pipe to let the manure flow freely.



- ❑ Close the lid of the expansion chamber to prevent animals or rainwater to fall in.

- ❑ At least once a week the inside of the chamber should be pushed and stirred with wooden stick to prevent crust or scum formed to block the pipe and the residue from forming at the bottom floor.



7.11 Storage Tank and Sand Bed Filter Maintenance



- ❑ Do not leave the substrate overflow from storage tank as it is unsightly and dirty.

- ❑ The substrate should be removed from storage tank and sand bed filter regularly to prevent the over filling and the flow of substrate back into the digester chamber. Use the substrate in the agricultural fields or store it for merchandise.



- ❑ Substrate in the storage tank can be used as liquid slurry form or mixed with cutting weeds as fermented fertilizer or dried for usage or as dried fertilizer for sale.

7.12 Water Trap Maintenance

- ❑ Water trap should be opened every two weeks without opening the valve at the inlet of the chamber to let the risen water flow out. Close the trap tightly to avoid the water from stopping the flow of gas.



- ❑ Water trap pit should be covered to avoid trash, leaves and rain which will cause problem or rust at the valve.

- ❑ Valve has to be changed or repaired immediately if there is any damage.

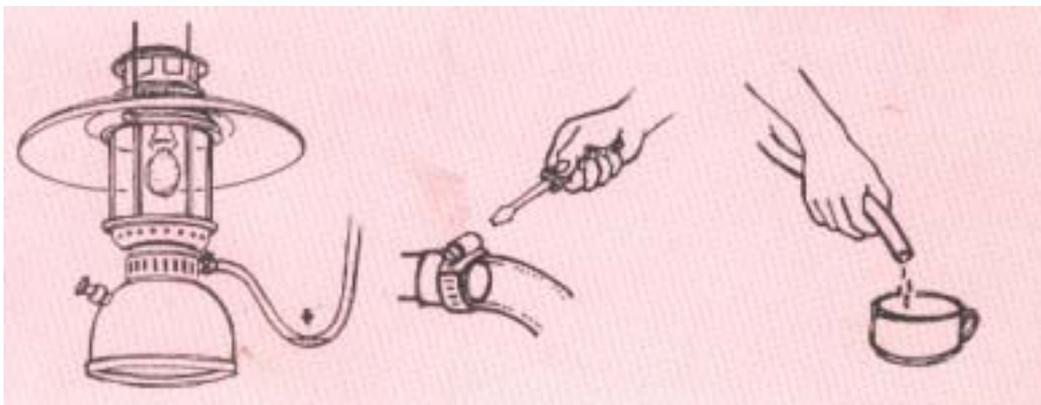


7.13 Gas Pipe Maintenance



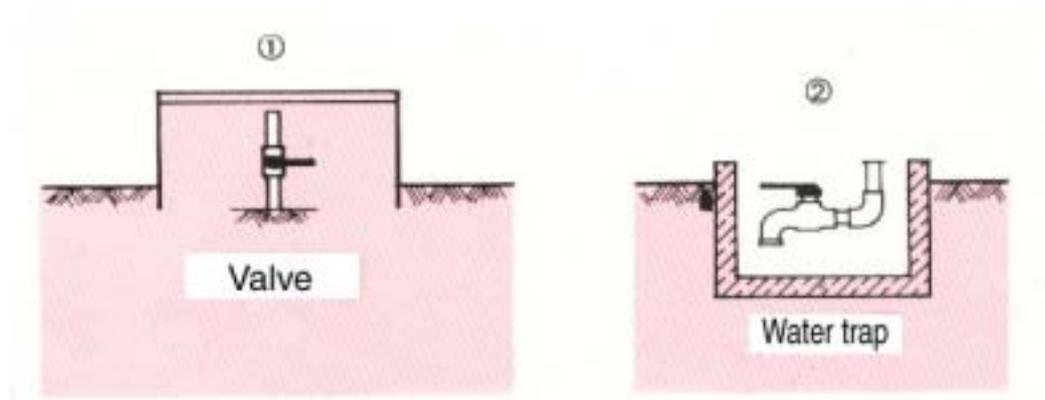
- ❑ Gas pipe should be installed against the wall or post and secure tightly. The pipe will be broken easily if installed independently or loosely.

- ❑ Underground gas pipe should be covered safely to prevent the damage caused by animals, humans or vehicles.

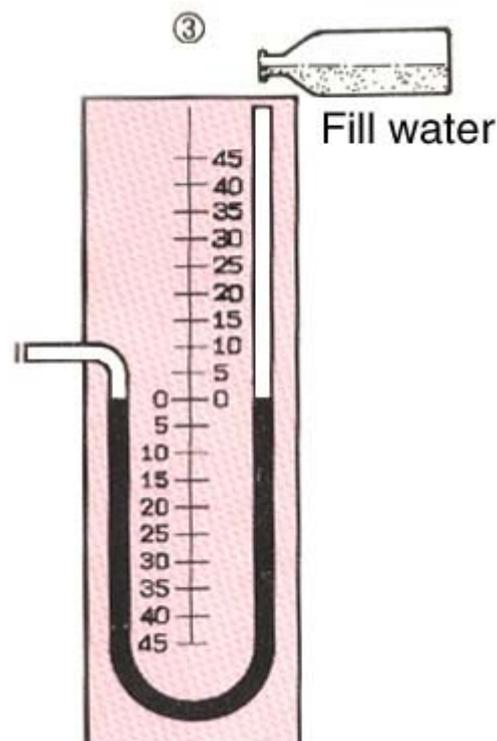


- ❑ Rubber hose should be checked every month for any water. Valve should be closed and hose emptied if there is water trapped inside. Hose clamp must be tightened after replacing the hose.

7.14 Manometer



- Manometer is an important instrument in bio-gas system. It indicates any malfunction in bio-gas system.



- Both water levels in mono-meter should be the same (when gas is emptied). To calculate the exact quantity of gas stored, adjust the level as follows :
1. Close the valve at the inlet of digester chamber.
 2. Open valve at water trap
 3. Fill water at the end of the pipe until both levels are at 0.

7.15 Bio-gas Equipment Maintenance

- ❑ Valve must be closed for safety before cleaning any gas equipment.

7.15.1 Burner



- ❑ Always clean the burner by removing the head burner and pushing through the holes with a sharp wooden stick, wire or nail so that gas will flow out easily. Use a wire brush to get rid of sediment. Later scrub the rust or dirtiness out.

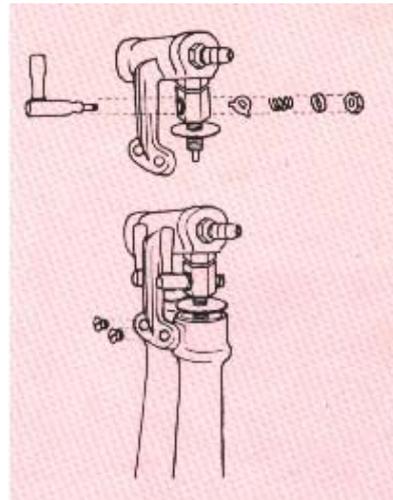


- ❑ For a stove with built-in cooking vessel built into the stove, remove the tray under the stove to clean.



- ❑ When stove is being used, open valve in the kitchen first and set fire prepared at burner then turn on the switch of stove last.

- ❑ Flame should come out from each hole of the burner head evenly, pale blue flame indicates clean burner but red flame indicates presence of sediment.
- ❑ After using stove, valve must be closed and switch on the stove must be turned off. If only valve is closed it may cause rust on the switch. Grease the switch occasionally, and do not let it dry. Change a new switch when damaged as stove has been long used.



7.15.2 Lamp



- ❑ To clean or change gauze mantle, detach gas hose, remove the shade and head of the lamp first. After cleaning put them back together and screw tightly. Attach the hose back to the joint and secure with clamp.



To get rid of sediment, dismantle the lamp and wash parts with sediment in water. When it will come out then dry it quickly.

- ❑ To clean lamp shade and glass cover, wash with water and dry with clean cloth. At the same time, remove dirt and dead insects from the head of the lamp. Change new gauze mantle if broken and secure tightly.



- ❑ Lamp should be lit by candle because match is too short and may cause damage.



- ❑ When the brightness is low and the gauze mantle is flaming, adjust the nozzle to the left with tongs or up and down until the light is bright again.



7.15.3 Piglet Heater



- ❑ To light piglet heater, open valve and press auto switch and hold it. Set fire at the heater plate and wait until the plate is heated thoroughly and become red then release the switch.



- ❑ To clean, leave the head of the heater in water for 2-3 minutes then dry with cloth or leave in the sun.

- ❑ Air filter should be looked after and cleaned with soft brush to avoid dust or insects.



7.15.4 Engine

Stationary engines such as water pump, milling machinery, generator, animal feed mixer and milking machine can use bio-gas by installing gas pipes to the intake pipe of the engines.

For using bio-gas in engine, one main valve must be installed to PVC gas pipe and one small valve to rubber hose before connecting to the engine.

7.15.5 Gasoline Engine

- ❑ Start the engine with gasoline as normal then adjust the accelerator at moderate speed. Turn gasoline valve to fully close position then turn main valve to fully open position. Slightly open small valve, adjust and listen. Proper position is when the engine runs smoothly without misfiring.



** Let gasoline flow to replace gas (close gas valve) and leave engine run for another 3 minutes then turn the engine off.*

7.15.6 Diesel Engine

- ❑ Start the engine and adjust accelerator at moderate position. Slightly open diesel fuel valve and at the same time turn main valve to fully open position then open the small valve to the position which the engine runs smoothly.

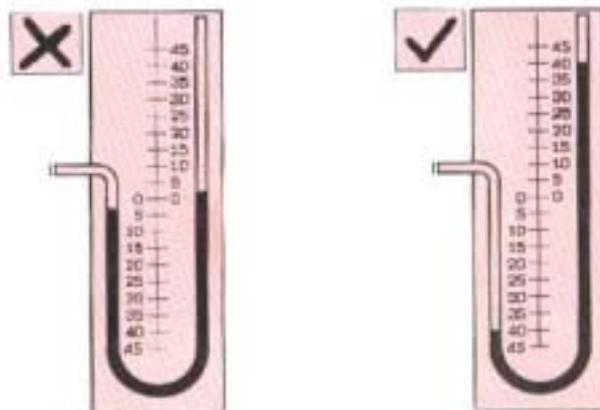


** Turn the engine and main valve off when not in use.*

- ❑ If higher RPM (accelerating) is required, small valve must be adjusted to let more gas enter. Engine will be accelerated without adjusting the accelerator.
- ❑ At the first installation after accelerator is properly adjusted, remove handle from the small valve for safety reason.
- ❑ The next starting
Benzene engine is started by gasoline. When engine is started, gasoline valve must be closed and open the main valve to fully open position.
Diesel engine will run normally after starting the engine and opening the main valve.

7.16 Practice Rules and Caution in Bio-gas Uses

- ❑ In a new chamber, gas produced after animal excrement has been first added must be vented as it cannot be used. It should be vented 2-3 times or until gas becomes flammable.



- ❑ Use manometer to check magnitude before using gas. Pressure should be at 10-80 cm.
- ❑ Do not leave valve opened when not in use. If pipe or hose is damaged, gas may leak and cause a fire.
- ❑ Light should be lit closely at the head of burner before opening the valve. If the valve is opened first, gas may come out exceedingly and is dangerous.
- ❑ Do not use igniter to lighten the stove because bio-gas is a slowly flammable passive gas.



- ❑ When valve is left open, excess gas will result in a bad smell. Close valve immediately and open windows and doors for ventilation. Do not fire until there is no more gas leaking.

7.16.1 Gas Saving

7.16.1 Gas Saving

- ❑ Food ingredients and condiments must be prepared before starting stove.



- ❑ Cooking container should be placed 1 inch above the head of the stove to save gas and avoid loss of heat energy while cooking.

Lid should be used regularly to cover cooking container when boiling, steaming or decocting to save energy and time for cooking.



- * Stove should not be placed in windy area as the wind will blow the heat away.
- * Stir frying should be in high heat while boiling or deep frying should be in medium heat.

daily will be changed and the component in this substrate can be used in agriculture as a better fertilizer than unfermented manure (unfermented fertilizer).

7.18 Methods of Using Substrate from Expansion Chamber

7.18.1 Liquid slurry

1. Draining through drainage alley

Substrate from expansion chamber will flow easily through the alley or drainage pipe with the aid of gravity if the ground is on slope area and bio-gas plant is located at higher elevation than agriculture areas. The loss of nutrients will be lower.



2. Using pump

Pump could be used in flat or remote area to pump substrate out directly from storage tank (which is filtered through sand bed) and sent along the alley or pipe to agriculture areas. (Density of substrate from expansion chamber is one of the limitation of using pump in remote area.)



3. Using container

Special implement is required to shift substrate from expansion chamber to remote area. Wheel barrows or carts are suitable for short distance. While animals or engines powered vehicles are very helpful for long distances.



7.19 Dry Manure

1. *Fermented fertilizer*

Substrate from expansion chamber can be kept in form of fertilizer when fermented together with cut weeds or grass. It is one of the easy ways of shifting. Scoop manure from expansion chamber and pour alternately over layers of cut grass. Stack of fermented grass should be turned over several times to speed up the process. Pile of fertilizer should be near the storage tank for easy access.



2. *Filtered in sand bed*

Filter component is gravel, coarse sand and fine sand. Water that has been filtered will flow into a pit to settle down, substrate will be left on top of sand bed surface. It will dry and be ready for removed within 3-4 days.



3. *Drying technique*

This technique is recommended when moving substrate from expansion chamber to remote area. Location for drying should be near the bio-gas plant. The ground should be a water proof concrete slab to avoid the liquid from seeping into ground water.

Farmers who do not use the substrate from expansion chamber in their field or there is a lack of implementation to help in shifting should use dry technique. Shifting dry manure is more practical than using slurry. Besides, dry manure can be packed and sold in small bags, sacks, bamboo baskets or loaded on to trucks.



7.20 Problems and Solutions

	Problems	Solutions
1. Pressure is low or decreasing even gas is not used	<ul style="list-style-type: none"> ★ Too little excrement adding when there is no consumption ★ Lid of digester chamber is leaking ★ Gas pipe or valve is leaking ★ Blockage at the end of gas pipe of digester chamber inlet ★ Fixed dome is cracked 	<ul style="list-style-type: none"> ➤ Add more excrement as related to size of chamber ➤ Check for any bubbles on the surface of trap water. If there is any leak, open the lid and have clay changed then close the lid. ➤ Use bubbles from soap liquid to check for leakage of valves and joints including all instruments involved with gas, pipes and hoses also check that water trap and/or gate of outlet pipe (pig chamber) is tightly closed. ➤ Disconnect hose between joint of digester chamber inlet and gas pipe. Have them checked by using thin stick or soft wire to unclog any manure that may cause blockage. ➤ Dig soil around the outside dome and check for leakage by using soap water. ➤ Bubbles will indicate the leak. Pump or take out all manure until the chamber is empty. Clean the chamber and check for any crack inside fixed dome. Chip cement around the crack and fill it up with new cement, added with waterproofer.
2. Pressure is normal but gas supply runs out quickly.	<ul style="list-style-type: none"> ★ Scum on surface of digester chamber ★ Residue sinks to bottom / shallow level ★ Scum on surface of expansion chamber ★ Outlet pipe is blocked 	<ul style="list-style-type: none"> ➤ Open lid and add water. Use wooden stick to stir until scum is dissolved then close the lid. ➤ Pull gate of the outlet pipe (pig chamber) up to release residue out. ➤ Use stick to break scum then scoop out. ➤ Use stick to unclog the pipe
3. Pressure is too high	<ul style="list-style-type: none"> ★ Gas pipe is blocked ★ The inlet of expansion chamber is on high level 	<ul style="list-style-type: none"> ➤ Use stick to unclog the pipe
4. Bubbles at the entrance of the expansion chamber	<ul style="list-style-type: none"> ★ Add too much excrement 	<ul style="list-style-type: none"> ➤ Stop adding excrement for 7 days or add lime 5 bags a day for 4 days.

5. Gas pressure is not consistent	<ul style="list-style-type: none"> ✦ Water is trapped in gas pipe 	<ul style="list-style-type: none"> ➤ Open water trap valve to empty water in the pipe then close valve tightly. <p>Solutions</p>
6. Enough pressure but gas have bad smell and is nonflammable	<ul style="list-style-type: none"> ✦ pH factor is too low indicates too much acid ✦ Add too much excrement ✦ Antiseptic or other toxin is mixing in animal excrement ✦ First filling with pig excrement 	<ul style="list-style-type: none"> ➤ Add lime into gas plant to decrease acid. ➤ Stop adding excrement temporary (follow No 4) ➤ Stop adding excrement 2-3 days, if the gas is still non flammable, remove old excrement and start new filling again ➤ Leave the gas valve on until gas is flammable or remove old manure and replace with cow or animal manure from operating gas plant
7. Enough pressure but gas is odorless and non flammable	<ul style="list-style-type: none"> ✦ Too much air 	<ul style="list-style-type: none"> ➤ Adjust air adjustment ring
8. Uneven flame	<ul style="list-style-type: none"> ✦ water is trapped in gas pipes or hoses 	<ul style="list-style-type: none"> ➤ Open water trap valve to empty the water and close tightly
9. Low flame	<ul style="list-style-type: none"> ✦ Low gas pressure ✦ Nozzle hole is too small or head burner is blocked 	<ul style="list-style-type: none"> ➤ Check gas plant and gas pipe for leakage. ➤ Enlarge nozzle hole to diameter as follows ➤ <i>Cooking burner</i> ➤ Size of inner ring nozzle 1.2mm (3/64") ➤ Outer ring 1.6mm (1/16") ➤ <i>Double ringed burner</i> ➤ Size of inner ring nozzle 1.6mm (1/16") ➤ Outer ring 2.3mm (3/32")
10. High flame	<ul style="list-style-type: none"> ✦ Nozzle hole is too big 	<ul style="list-style-type: none"> ➤ Change nozzle to diameter as No.9 ➤ Control quantity of gas by adjusting the valve
11. Yellow flame instead of pale blue flame.	<ul style="list-style-type: none"> ✦ Nozzle hole is too wide 	<ul style="list-style-type: none"> ➤ Open air regulator until flame is pale blue
12. Flame return to switch instead of going up through burning holes	<ul style="list-style-type: none"> ✦ Gas return because head burner is blocked. Air inlet is not completely closed 	<ul style="list-style-type: none"> ➤ Clean burner using wire or nail unclog burning holes or use wire brush to scrub and remove sediment and dirt from burner. ➤ As for cooking stove adjust ring of air regulator at fully close position