Construction Manual

by

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Construction Manual for SKG Sangha biogas plant

A. Pre-project aspects

1. Identifying project feasibility:

The feasibility of installation of biogas plants in a particular areas can be assessed by considering the following guidelines:

1. Check whether water is available on a daily basis.
2. The availability of water and other construction materials is the first requisite to consider before checking the the details of the number of animals. If water is scarce in the area then the number of animals a household can look after is limited.
3. Check for the availability of the required building material in the vicinity of the area. If certain building materials are not available in the area, they need to be transported from elsewhere, so the cost of these materials and their transport must also be calculated.
4. People need to be willing to bear the cost of obtaining building materials and transporting them to where they are needed. If people are not willing to bear these costs, then the plants cannot be built.
5. The next step is to collect data on the number of animals in the area, which can often be supplied by a government department.
6. If the available data is provided in terms of the number of animals in each household then it saves extra work.
7. If this information is not easily available, it is worth asking for it from other sources, as it saves the need to do a survey.
8. If the information is not available, it is necessary to select one or more typical villages and do door to door surveys. It is assumed the results can be applied to the total area. This gives an approximate overall view of the number of animals of the area
9. If there are at least 15 households in a typical village with 4 or more animals then the project can be considered feasible.

2. Awareness creation:

1. Awareness is difficult to define and measure. People may be aware that a biogas project is happening and its positive factors have been published in news papers and in the electronic media. But people may not have considered the details of how they could gain the benefits of biogas for themselves so are not listening to the details and precise information they need.
2. In order to make people aware of the project, the local leaders, such as the members of the local council need to be involved. They should be asked to arrange a meeting for their village so the details of the project can be presented.
3. The work of awareness raising cannot be done in one day. The meeting must be followed up by more meetings. There will be some young people who are enthusiastic and idealistic about development and new technologies. The most open minded of these people can be given pamphlets about the project to give to other people. If they feel they have responsibility for persuading people to come to meetings, they may want to become more involved. The best of these people can become supervisors and promoters of the programme as it develops.
4. The information provided at the first meeting should be simple. They need to know that they have to dig a small pit and procure building materials, such as bricks, sand and cement in order to have a unit. They need to understand that if they put dung into the unit, they will get gas for free.
5. Deep discussions about particular points should be avoided in the meetings. If people want more information about anything, they can discuss it after the meeting.

6. If people want to apply to have a plant, they should be able to do it at the meeting. If some people want to think about getting a plant, they should be told how they can apply later on.
7. If there are a group of people who want to learn more, a tour can be organised to an existing project area, where they can visit plants that are already working.

3. Finalizing applications:

1. Each person who makes an application should have enough space for the plant and have enough animals and water to feed the plant.
2. It is better to concentrate on middle and lower income farmers, with the right access to animal dung, water and the space to build the plant. The richer farmers have less of a need for the biogas and slurry.
3. People who have other jobs and rely on labourers to do their farm work, are often less interested in running the plant. They do not feed the plant and then complain about not getting gas. These people should have low priority.

B. Unit installation

1. Basic design considerations

A biogas plant is built as a spherical structure. This means that it is very strong, but only if it kept under compression. The gas inside the plant generates a pressure that is pushing outwards, causing tensile forces in the structure. This must be resisted by applying greater forces from the outside, which is done by covering the dome with soil. This is only possible, if the dome is placed inside a hole in the ground, that is deep enough for the top of the dome to be underground.

A spherical dome that is built above the ground will be under tension and will crack, unless sufficient steel reinforcement is used to prevent such cracking. It is therefore important to dig the hole for the biogas plant to the depth that is defined in the drawing.

Cement concrete and cement mortar only become strong if they are compacted. A loose mix of concrete or mortar will contain air holes, which weaken the structure. When concrete is laid, it should be compacted with a rammer while it is still wet, to press out any air that might be trapped in the mix. It is better to use a series of layers of concrete, each layer of less than 5 cm so that each layer can be compacted properly before the next is laid.

When cement mortar is placed between the bricks in the dome, it must be pushed tightly into every gap or hole. When cement plaster is used to coat the bricks after they are laid, it must also be properly compacted. The plaster is often spread with a metal trowel and then compacted with a wooden one. A cement wash is usually applied over the brick before a cement plaster is used.

A Deenbandhu plant is built as a half sphere consisting of a sequence of circles. The circles are progressively smaller, as they move upwards towards the top. The bricks should be laid so that the ends of bricks in successive circles do not line up with each other. Half bricks should be added in the circle being made to prevent this happening.

Each circle becomes a strong structure, once it is complete. The spaces between the bricks must be fully filled with mortar to conserve that strength. Each brick must be offset from the one below, so that the ends never line up.

The whole plant is covered with a layer of plaster, which fills in any small holes in the structure. Plastering must be completed at one time, so it is a complete structure. If the plaster work is stopped and restarted, the later part will not adhere to the earlier part and cracks can form. Also a layer of cement paste is applied to the plaster layer, to provide a better seal, as cement plaster can be porous, containing up to 30% of pores. Again, the cement paste must be applied at one time, so ensure there are no gaps and no areas are missed.

The correct amounts of material should be used and no excess material added. Thick layers of cement plaster are more likely to crack than thin layers. Excessive use of material adds unnecessary cost and can reduce performance. The quality of the material used must be of good standard (as defined below). Poor quality materials will reduce performance.

2. Regarding the use of reinforced concrete use

The way the plant is built depends on the soil conditions. If the soil does not compact easily, then steel reinforcing is not required for concrete floor. If the soil is of poor quality, then reinforcement may be required. The behavior of the soil affects other aspects of the construction process, as described below.

The first step, after the hole is dug, is to make a floor for the main digester. The drawings show the size of the hole and the shape for the floor.

1. If the soil is hard enough and the water does not percolate into it then normal mild cement concrete can be used as a base for the biogas plant.

2. If the soil is hard enough and water is percolating slowly into the pit then the water can be emptied out and the floor made from mild cement concrete with a reduced water content. The water will seep into the concrete and stablize it.

3. If water is percolating quickly into the pit, it can be trapped in a deeper pit of about 20 cm diameter at the centre of the floor, which must be emptied continuously. The floor is then made around this hole and allowed stabilize. The hole is then emptied completely of water and filled with a dry mix of concrete, which is rammed tightly into the hole. The water will mix with this concrete, which will then set. This concrete may be porous and allow water to seep into the pit. Once the biogas plant has been started with animal dung, the porosity will be sealed by dung.

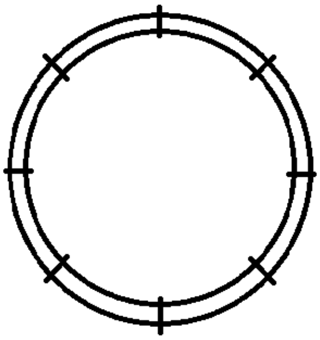
4. If the soil is loamy and soft, or if it is of the type called black cotton soil, then steel reinforcement may need to be used in the floor. It is difficult to use reinforced concrete, is the soil is very wet.

5. An alternative to the use of reinforcement is to use a larger diameter floor made of plain concrete. The bottom layer of bricks are then laid radially (ends pointing towards the centre of the floor) and on their sides to form a larger foundation for the dome.

3. Making a reinforced floor

1. A reinforced floor is required if the soil at 1 m and more below ground level is:

    a. Loose and difficult to compact
    b. Contain large amounts of clay
    c. Of the type called black cotton soil
    d. Is very silty



Steel rod rings on the shoulder of the excavated pit

2. The floor is made as a flat shoulder around a concave pit (see photograph). Two rings are required with different diameters for the shoulder, which are linked together with radial rods at 150 mm spacing (see diagram). The rods are wired together with flexible wire.

Concrete is poured into the curved pit and over the shoulder and smoothed to an even depth of 30 mm. The steel work is placed on the concrete and another 40 mm poured over it. The concrete needs to be well compacted to remove voids before it starts to set. The concrete should be cured, by keeping it wet with water for four days, before any further building work is started. This approach will prevent any problems caused by the soil shifting.

C. Supervising masons work:

The work of building a biogas plant is done by trained masons. They are human beings and subject to making errors and being affected by moods. People work to earn money, so the way they work depends on the way they are paid. A mason who is paid by the hour will work slowly. If he is paid by the number of completed plants, he will work quickly. The danger of that is concrete and cement mortar needs to be allowed to set before the next part of the work is started.

A set of guidelines can be used to ensure each plant is built to a good quality.

1. Individual masons are made responsible for each plant they build, so detailed records must be kept.
2. The fee for each plant will include a component that is only paid after the plant has been running for 6 months.
3. Plan the building work so that the best masons get more work and earn more money. Masons who produce poor quality work may be given less work to do.
4. Careful explanations and training are required to ensure masons understand the need to make and check measurements and the bad effects if the measurements are not accurate.
5. The measurements of each plant should be checked by a supervisor, who should go into the plant to check everything is correct.
6. Masons do need to be continuously supervised to ensure they are working properly.
7. A good team of supervisors and masons will learn to work well together and encourage each other to work well.
8. The masons must be given good quality tools, but they need to be used properly and looked after.
9. Cement plaster must be carefully smoothed, with the right amount of pressure, to prevent cracks. It is important to make sure sufficient pressure is applied.

D. Principles of pipe line laying

1. Water content in biogas

The inside of a biogas plant contains a high proportion of water, the the biogas in the gas storage volume will be at 100% humidity. If the air temperature around the pipe trough which the biogas passes is at a lower temperature, vapour will condense in the pipe to form liquid water. Water will always flow to the lowest point in the pipe. If the pipeline layout includes dips, the water will accumulate and block the pipe.

The simplest approach to placing the pipe is to lay it as an inverted "U". The pipe from the digester is placed so it rises to a high point. The pipe then slopes downwards to the point where the gas is to be used, which is usually the kitchen where a gas burner is placed. Most of the condensed water will flow back into the biogas plant. Any water that flows towards the gas burner can be removed just by detaching the rubber hose from the stove.

2. Proper fixing of Pipes:

1. The users of the gas stove may want to move the stove in the kitchen. When the pipeline is fixed in the kitchen, an extra length of pipe (about 2 m) can be provided that allows the gas burner to be moved. This extra pipe needs to be fixed to the walls of the kitchen.
2. The burner should be placed at least ½ meter from where the HDPE is fixed to the wall. If the heat from the burner is too close to the pipe, it will melt it.
3. Where the pipeline enters the kitchen, it should be fixed firmly to the wall with the use of metal brackets. .
4. The HDPE should be brought into the house by making making a hole in the wall. Existing holes, such as windows and chimneys are not suitable, as they are used for other purposes. If a fire is lit under a chimney, the heat will damage the pipe.
5. Extra pipe can also be left near the digester and tied to a pole, so give the upward slope. The the pipe is broken close to the digester, the extra pipe will help in making the reconnection.
6. The pipe coming out of the digester should be attached directly to a shut-off valve. The gas flow can be closed off, if there is a problem with the pipe.
7. When connecting screwed pipes together, the screw threads should be sealed, using PTFE (Teflon) tape. The tape fills in gaps and prevents leaks.
8. If HDPE pipe is used, it can be firmly fixed to steel pipe by heating the end of the HDPE to expand it, by dipping it in hot oil. The plastic pipe is pushed over the metal pipe and compressed onto it using a wet cloth. A metal clamp can be fixed over the plastic while it is still hot, to make a very tight fixing.

3. Connecting appliances

1. A typical domestic plant requires 2 lengths of galvanized iron pipe, each of about 100 mm long, a plastic shut-off valve, a brass nipple and a rubber hose, and a biogas burner.
2. The steel pipe fitted in the top of the digester is usually packed with plastic to prevent biogas escaping when the plant is fed with cattle dung slurry.
3. To connect the gas line, the temporary blocking material should be removed. The gas valve is screwed over the steel pipe, after PTFE (Teflon) tape has been wound around the thread on the pipe. The valve should be open until the valve has been tightened on the pipe, and then the valve can be closed. Gas may come out of the valve during this process, if cattle dung slurry has already been put in the digester pit.
4. One of the short lengths of steel pipes is screwed into the top of the valve, once the thread has been wrapped in PTFE (Teflon) tape. The threads can be tightened using wrenches, but must not be over-tightened, as it is possible to break the valve.
5. The brass nipple is screwed onto the second short length of steel pipe, again using PTFE tape to seal the threads. Wrenches are used to tighten this joint.
6. The roll of HDPE pipe is unrolled between the kitchen and the digester, until it stretches between them. An extra 2 to 3 metres is left, before the pipe is cut.
7. The end of the HDPE pipe needs to be stretched so it fits over the steel pipes. This is done by heating 60 to 70 mm of the pipe in hot engine oil, so it softens it. The pipe can be stretched with a wooden stick, until

the end fits over the steel pipe and can be pushed over the pipe for 40 to 50 mm. The hot plastic pipe can be molded to the steel pipe, using a wet cloth. A clamp can be placed over the pipe and tightened. (Note: the loose clamp should be placed over the HDPE pipe before the end is heated). One end is fixed over the steel pipe with the nipple, the other over the steel pipe coming from the main shut-off valve.

8. The end of the HDPE pipe entering the kitchen must be fixed firmly to the walls with metal pipe clamps.

9. All the joints should be tested with soapy water. A mixture of soap (usually liquid) and water is made, so that it easily forms bubbles. If there is gas in the plant providing good pressure, the soapy water can be dripped or brushed over each joint. If bubbles are formed from the joint, it is leaking and should be re-made. The joints should be repeatedly tested until no leaks can be seen.

10. Once the pipe is leak tight, the biogas burner can be assembled. It needs to be unpacked and the parts laid out and checked. As well as the main burner frame, the extra parts include knobs, rubber hose, brass nipple, pan supports and dip trays. The brass nipple is fitted to the galvanized iron pipe. The top cover plate is put over the burner frame and the knobs can be fitted to the control rods. The burner tops are placed over the burner manifolds. The burner can then be placed where the householder needs it and connected to the nipple fitted to the end of the HDPE pipe with the rubber hose.

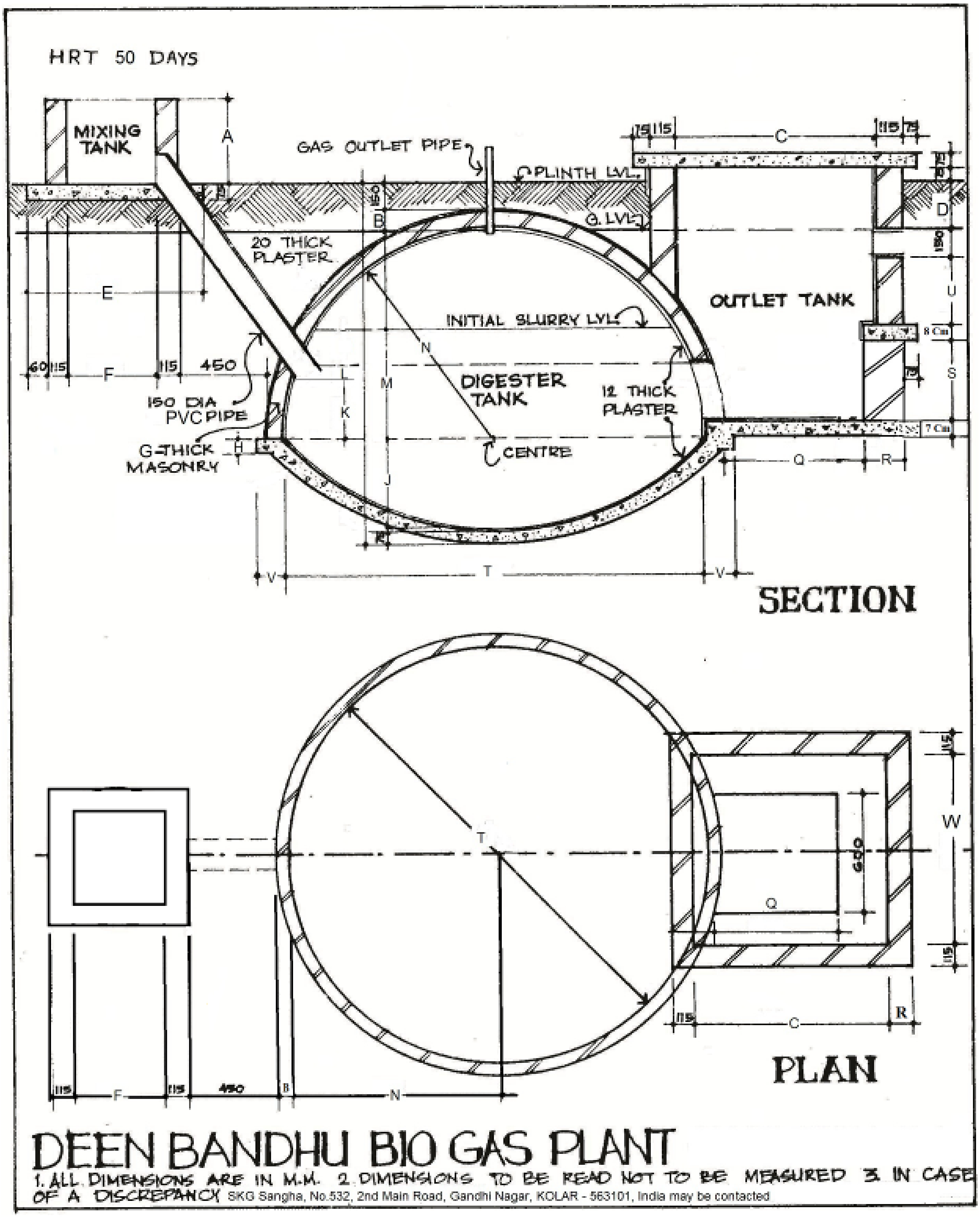
E. Dimensions of biogas plants

1. Dimensions of the biogas plant

The dimensions are in mm. The letters refer to those in the drawing of the biogas plant below.

Sl.No	Description	2 m^3	3 m^3	4 m^3	6 m^3
1	A – Height of the mixing tank	600	600	600	600
2	B – Thickness of digester at gas outlet pipe level	120	120	150	150
3	C – Width of the displacement tank	1000	1000	1200	1200
4	D – Displacement tank height above the hole	330	300	330	380
5	E – Width of the mixing tank concrete base	1000	1000	1100	1200
6	F – Width of mixing tank	600	600	700	800
7	G – Thickness of digester masonry work	70	70	100	100
8	H – Thickness of base concrete at digester base	70	80	100	150
9	J – Height of the on or height of the centre pillar	550	600	650	800
10	K – Height of the inlet pipe inner edge from the base concrete	300	400	500	600
11	L – Height of the outlet tank bridge from the bottom inner tip of the inlet pipe	250	250	250	250
11 A	Bridge height from the base concrete (K+L)	550	650	750	850
12	M – Initial slurry level height from the base concrete	730	870	980	1100
13	N – Radius of the digester dome	1300	1500	1650	1900
14	P – Bridge height from outlet tank concrete base	480	580	680	780
15	Q – Length of the outlet tank	700	700	900	900
16	R – Thickness of outlet tank wall under the displacement tank wall	220	220	220	220
17	S – Outket tank height until the bottom of the concrete base of the displacement tank	580	720	830	950
18	T – Horizontal diameter of the digester	2640	3000	3300	3800
19	U – Height of the slurry exit hole from the bottom of the displacement tank	350	400	450	550
20	V – Width of the concrete under the digester base	250	250	250	250
21	W – Length of the displacement tank	1900	2500	2500	3000

1. Section and plan of the biogas plant



Dimensions in the drawing are in mm, except where stated otherwise.

2. Material requirement for the biogas plant

Sl.No	Description	2 m³	3 m³	4 m³	6 m³
1	Well burnt solid mud bricks of 22 x 10 x 7 mm	1000	1200	1800	2600
2	Cement bags of 50 kg each, 42.5 grade OPC	17	19	25	35
3	Sand - course in cubic meters	1.5	2	2.5	4
4	Sand – fine in cubic meters	1.5	2	2.5	4
5	Stone aggregates – made from granite stone in Cubic meters	1	1.5	2.5	3.5
6	6 mm iron wire in kilograms	8	10	20	25
7	Binding iron wire in kilograms	0.1	0.1	0.2	0.25
8	PVC – 10kg pressure 6" diameter pipe in meters	1.35	1.5	1.7	2.1
9	Brackets welded 1/2" (20mm)diameter GI nipple of 30 centimeter long	1	1	1	1
10	Manual labour in man days – pit digging	6	10	15	25
11	Trained mason in man days	4	5	7	10
12	Manual labour in man days – for construction	15	20	25	35
13	Manual labour in man days – to compact the excavated soil on top of the plant and providing support to the structures	3	5	8	12
14	Manual labour in man days – water curing	4	4	4	5
15	Manual labour in man days – Initial feeding	4	6	8	15
16	PVC gate valve of 20 mm diameter	1	1	1	1
17	Biogas stove/Burner	1	1	1	1
18	100 mm long Galvanized iron 20 mm diameter nipples	2	2	2	2
19	Female threaded brass metal pipe nipple	1	1	1	1
20	Rubber hose in meters	1	1	1	1
21	High Density PolyEthylene (HDPE) pipe of 20 mm diameter in meters	50	50	50	50
22	Plumber in man days	½	½	½	½
23	Supervision of work in man days	15	15	15	15
24	Fresh animal dung for initial feeding in tons	2.5	3.75	5	7.5

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