Water for the World

Constructing a Biogas System

Technical Note No. SAN. 3.C.4

A biogas system is a means of digesting animal manure anaerobically to produce methane gas which is burned to provide heat or light. The system consists of one or more digesters, a gas holder, an arrangement of gas pipes, and one or more fixtures to burn the gas. Constructing a biogas system requires the services of a foreman experienced with these systems. Constructing involves assembling necessary labor, materials, and tools; making excavations; building the gas holder and digesters from reinforced concrete; installing the gas holder cover; installing gas pipes; and checking the pipes for leaks.

This technical note describes how to construct a biogas system. Read the entire technical note before beginning construction.

Useful Definition

METHANE - A gas produced when organic material such as manure decomposes in an airless environment; methane burns with a violet flame without smoke; it is explosive.

Materials Needed

Before construction can begin, the project designer must provide:

1) Location map similar to Figure 1,
2) Design drawings similar to Figures 2 and 3,
3) Layout of the gas pipe arrangement similar to Figure 4,
4) Materials list similar to Table 1.

You will also need:

5) All labor, materials and tools described in the materials list.

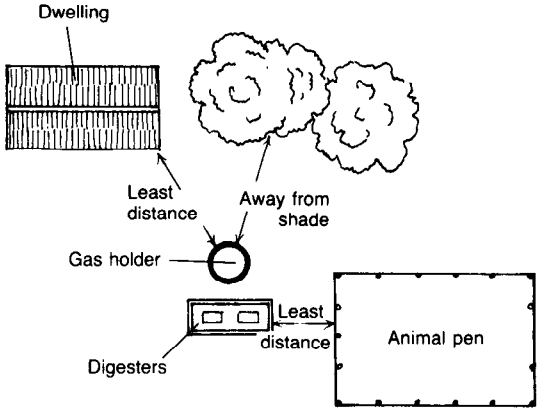

Figure 1. Location Map

General

Depending on local conditions, availability of materials, and skills of workers, some construction steps will require only a day, while others may require several days. Read the construction steps and make a rough estimate of the time needed for each step based on local conditions. You will then have an idea of when specific workers, materials, and tools must be available during construction. Draw up a work plan similar to Table 2 showing constuction steps.

Constructing Digesters

1. Assemble all laborers, materials, tools, and drawings needed to begin construction. Study all drawings carefully.

2. Using the location map and a measuring tape, locate the sites for the digesters and the gas holder and mark them with wooden stakes. See Figure 5.

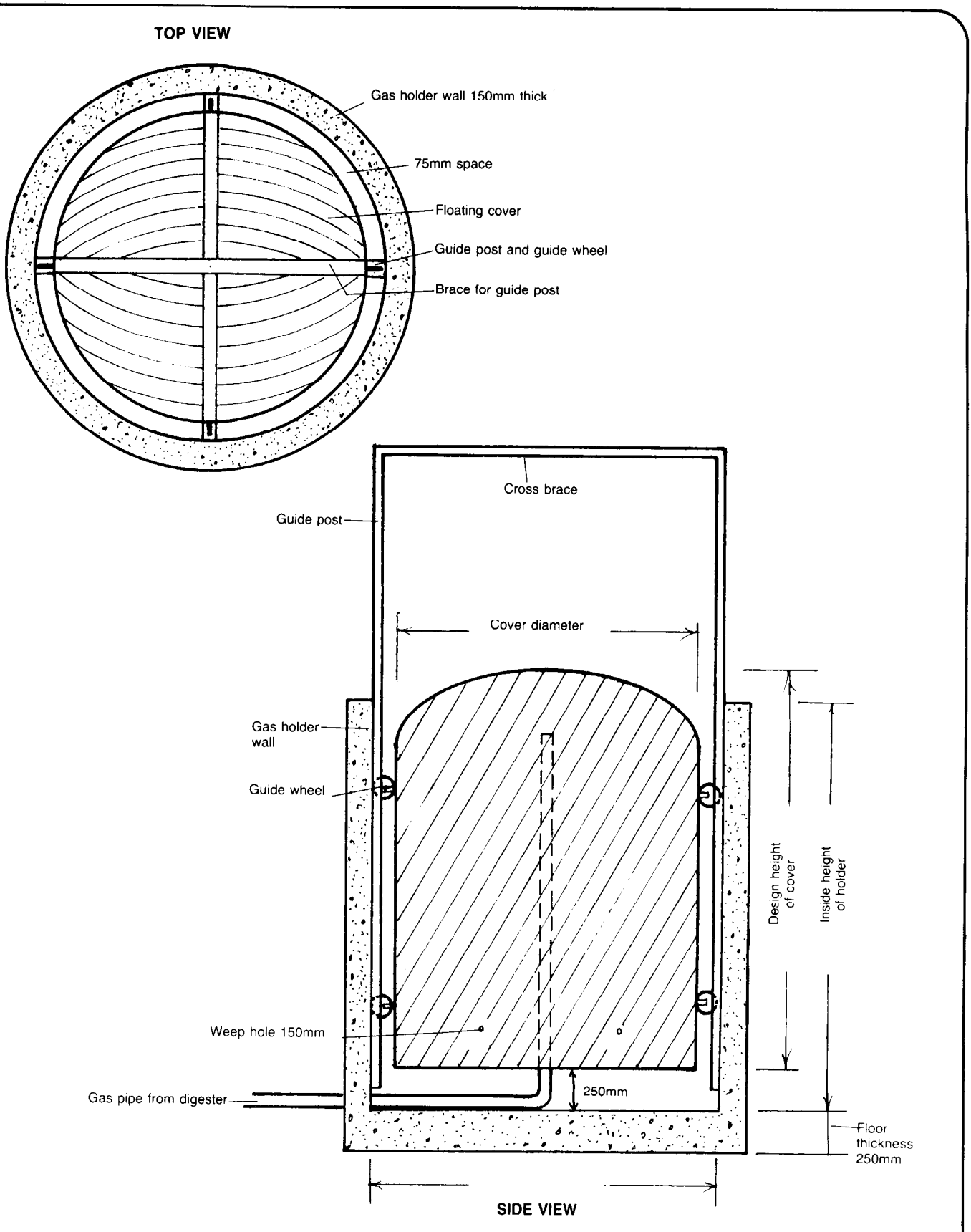

Figure 2. Design of Gas Holder

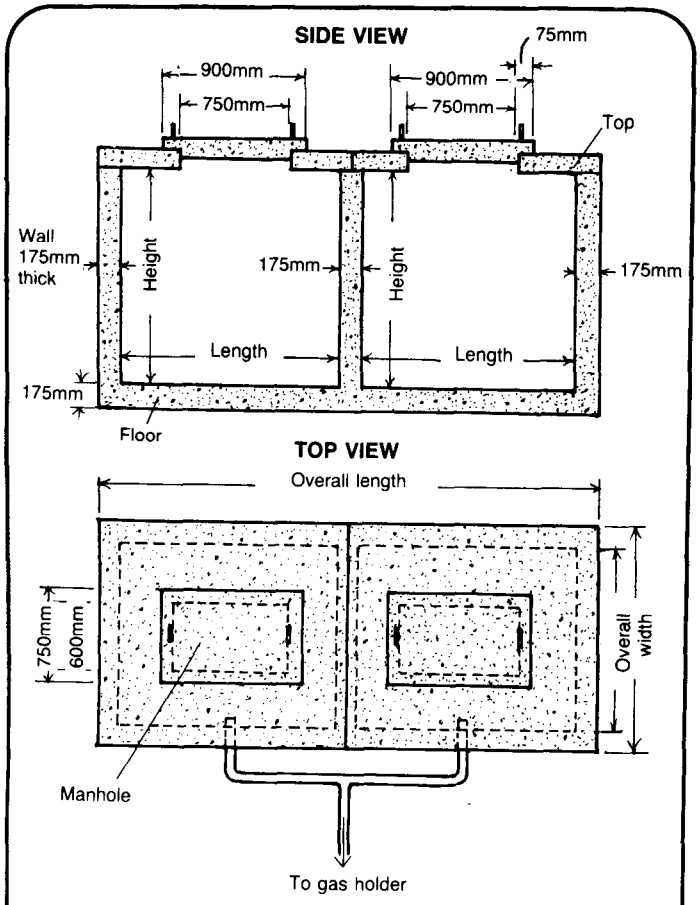

Figure 3. Design of Digesters

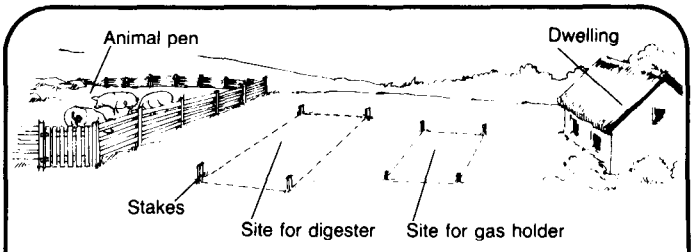

Figure 5. Marking the Site for a Biogas System

3. Dig the hole for the digesters 1.0-1.5m deep. Allow a working area of about 0.3m around all sides. Make the bottom of the hole level, tamp well, and spread a 50mm layer of gravel. See Figure 6.

4. Build the forms for the floor.

5. Mix concrete to the correct proportions. A common mix by volume is one part cement to two parts sand to three parts gravel and enough water to make a fairly stiff mix. Mix until sand and gravel are evenly coated with cement and water. For more details on concrete see "Constructing Septic Tanks," SAN.2.C.3.

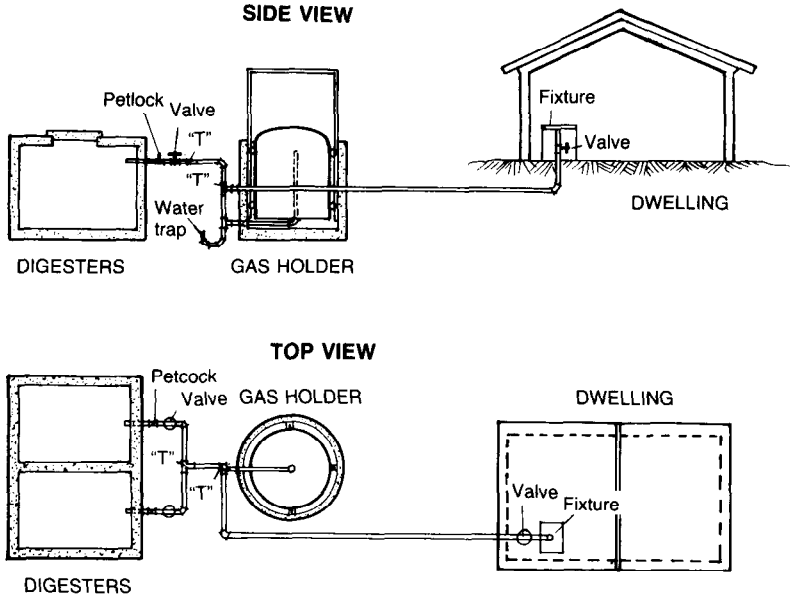

Figure 4. Typical Gas Pipe Arrangement

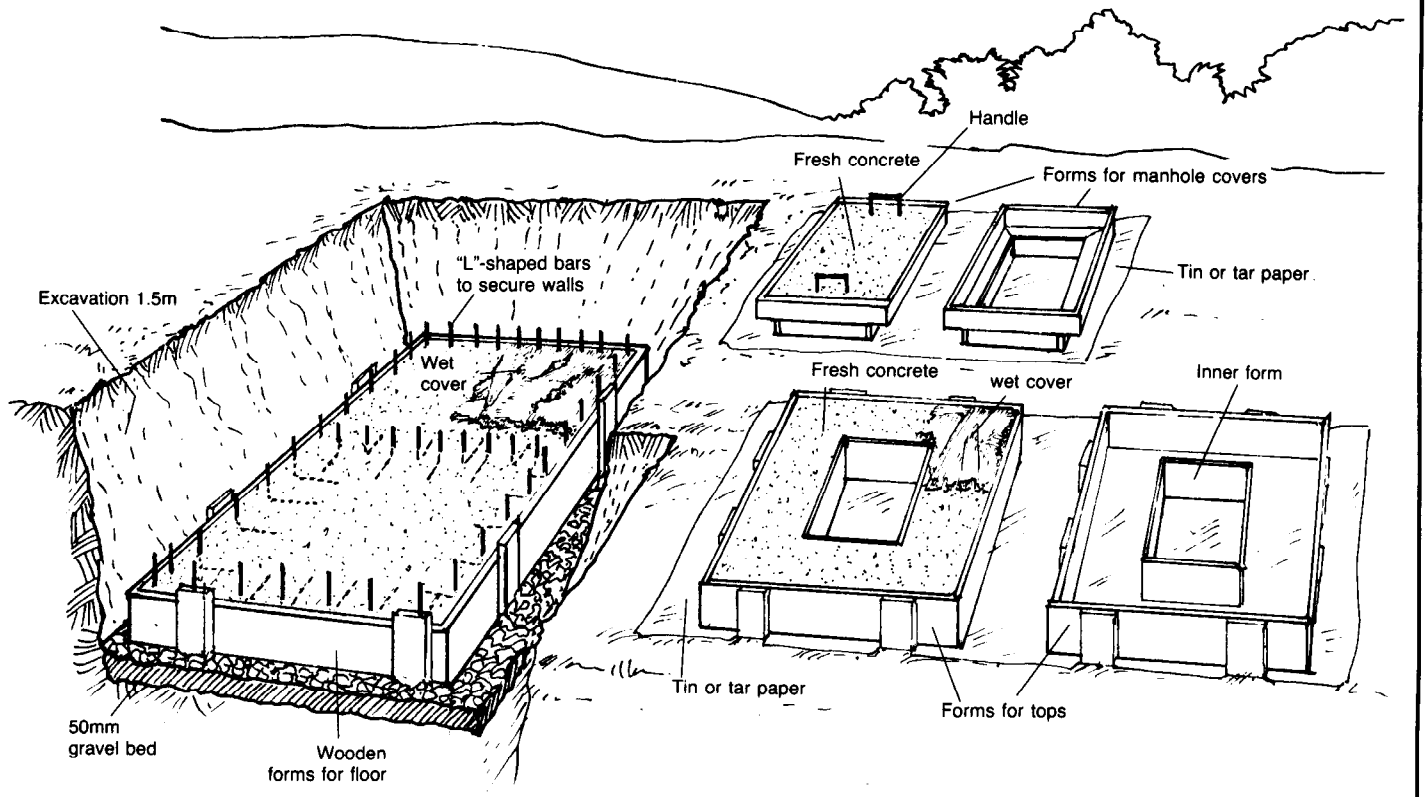

Figure 6. Constructing Digester Floor and Top

6. Pour in concrete to about 50mm from the top of the forms. Lay in reinforcing material such as steel rods, wire mesh, or bamboo strips. If L-shaped bars are available, position them in the concrete so that the vertical portion of the "L" will extend up into the center thickness of the walls. See Figure 6.

7. Fill the forms with concrete, trowel the surface smooth, and cover with wet straw or burlap bags. Keep moist for five to seven days.

8. While the concrete floor is setting up, build the forms for the top and manhole covers. Pour in concrete until the forms are about half full, lay in reinforcing material, then fill the forms with concrete. Set handholds made of horseshoes or bent steel rods into the concrete, trowel smooth, and cover with wet straw or burlap. Keep moist for five to seven days. See Figure 6.

9. When the concrete floor has set up, remove the cover material and the forms. Build the wall forms in place. Set a section of gas pipe near the top of one wall in each digester. Position reinforcing material in the wall forms. Brace the wall forms to prevent possible collapse when the concrete is poured. See Figure 7.

10. Mix and pour concrete into the wall forms. Be certain that concrete fills all voids in the forms. Use a steel rod or stout stick to work concrete between reinforcing material and the forms. Trowel the tops of the walls smooth and cover with wet straw or burlap. Keep moist for five to seven days. See Figure 7.

11. When the concrete walls have set up, remove cover material and forms from the walls, tops, and manhole covers. Mortar the tops in place with concrete mortar. Seal the bottom edges of the walls, inside and out, with

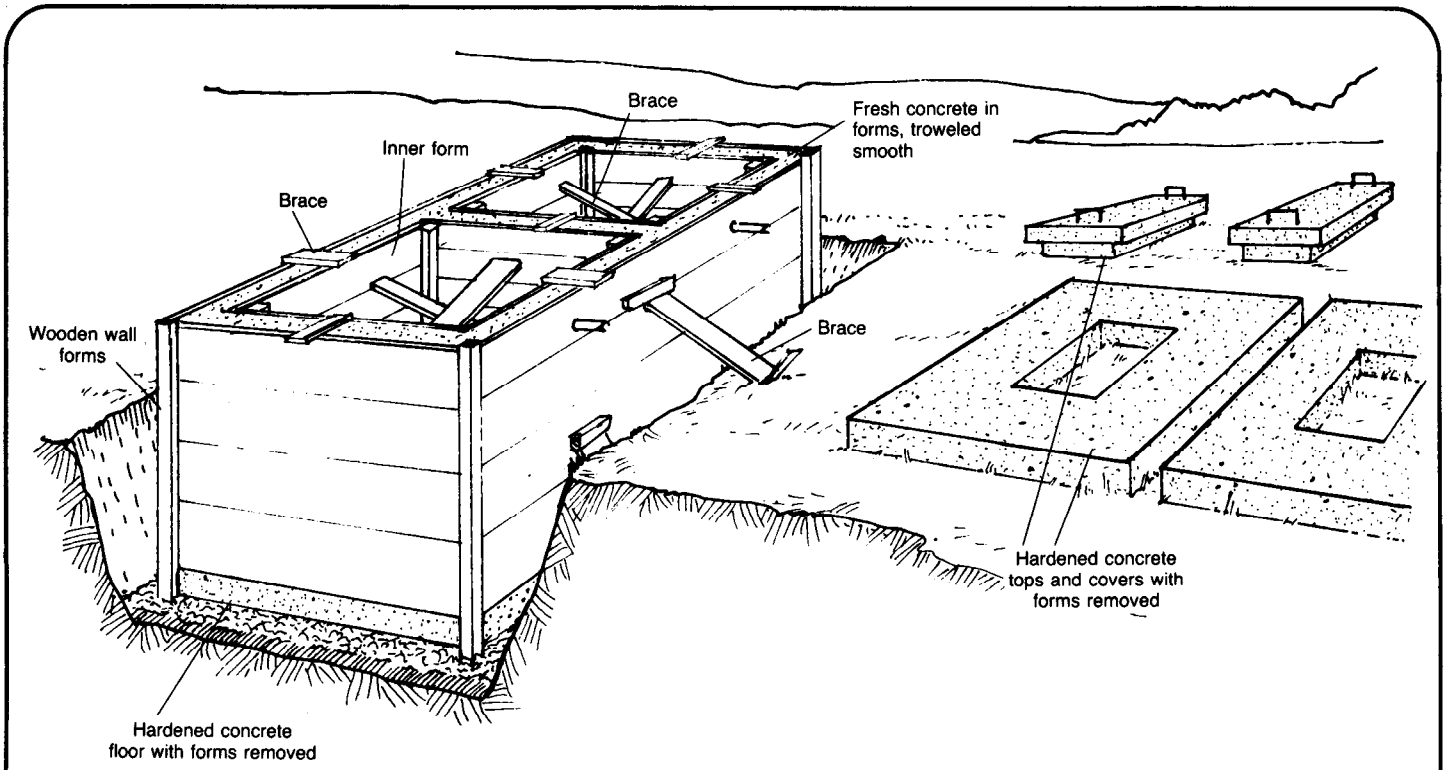

Figure 7. Constructing Digester Walls

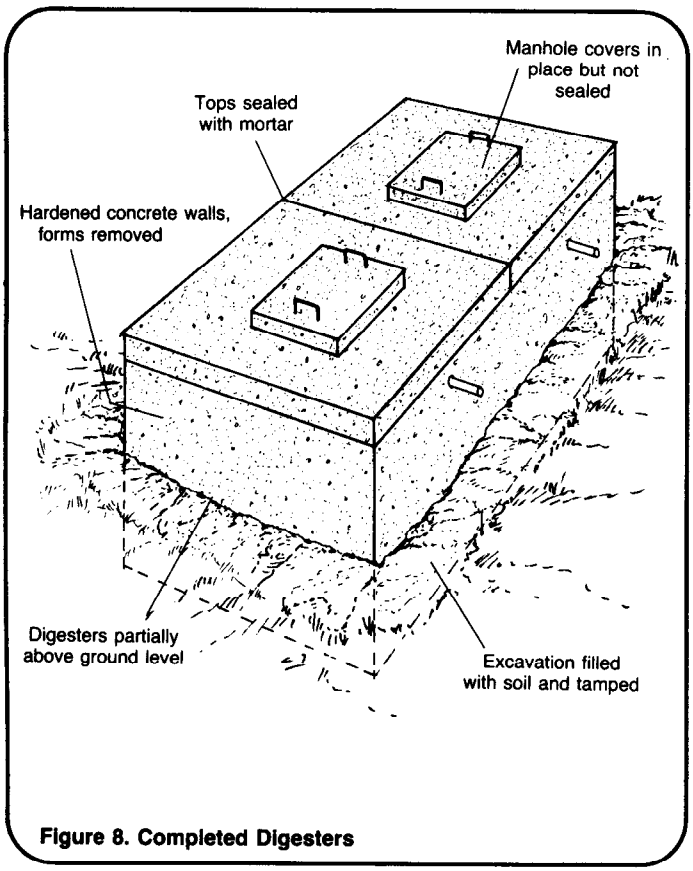

Figure 8. Completed Digesters

concrete mortar. Set the manhole covers in place, but do not seal until the system is ready for operation. See Figure 8.

12. Fill in the excavation around the digesters with soil and tamp firmly.

Constructing the Gas Holder

1. Dig the hole for the gas holder 1.0-1.5m deep. Allow a working area of about 0.3m around all sides and allow about 1.0m^2 for the water trap pit. Make the bottom of the hole level. Tamp the bottom of the hole, but not the bottom of the pit. Spread 50mm of gravel in the hole. See Figure 9.

2. Build the forms for the floor.

3. Mix and pour concrete to about 50mm from the top of the forms. Lay in reinforcing material. If L-shaped bars are available, position them in the concrete so that the vertical portion of the "L" will extend up into the center thickness of the walls.

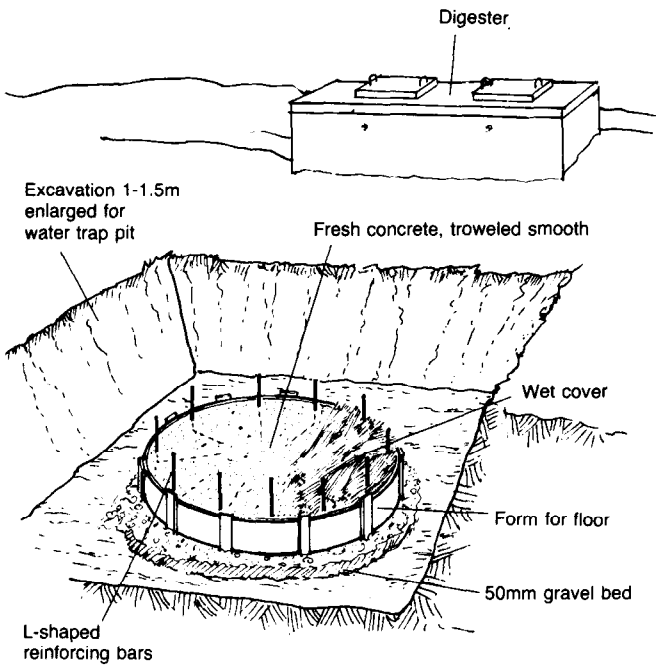

Figure 9. Constructing Gas Holder Floor

4. Fill the forms with concrete, trowel the surface smooth, and cover with wet straw or burlap bags. Keep moist for five to seven days. See Figure 9.

5. When the concrete floor has set up, remove cover material and forms. Build the wall forms in place. Set a section of gas pipe in the form near the bottom of the wall facing the digesters. Position reinforcing material in the wall forms. Brace the forms to prevent possible collapse when the concrete is poured. See Figure 10.

6. Mix and pour concrete into the wall forms. Be certain that concrete fills all voids in the forms. Use a steel rod or stout stick to work concrete between reinforcing material and the forms. Trowel the tops of the walls smooth and cover with wet straw or burlap. Keep moist for five to seven days.

7. When the concrete walls have set up, remove cover material and forms. Seal the bottom edges, inside and out, with concrete mortar.

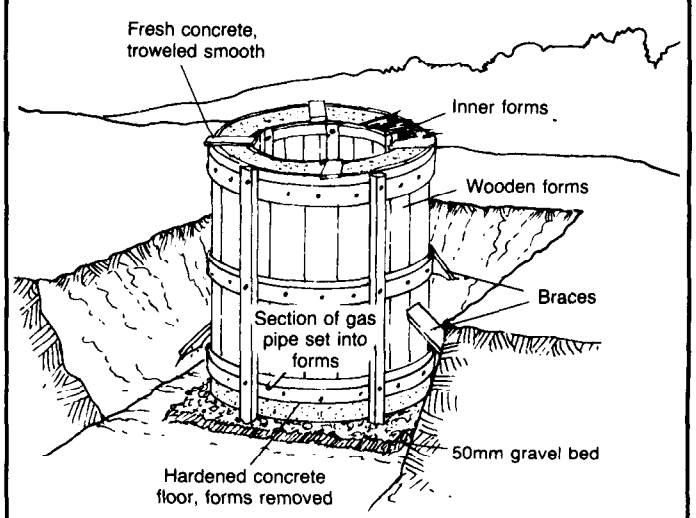

Figure 10. Constructing Gas Holder Walls

8. Excavate the bottom of the pit another 0.3-0.4m. Build walls for the pit from reinforced concrete or brick and mortar. The walls reach only as high as ground level. Rake the bottom of the pit and spread it with 0.3m of gravel. See Figure 11.

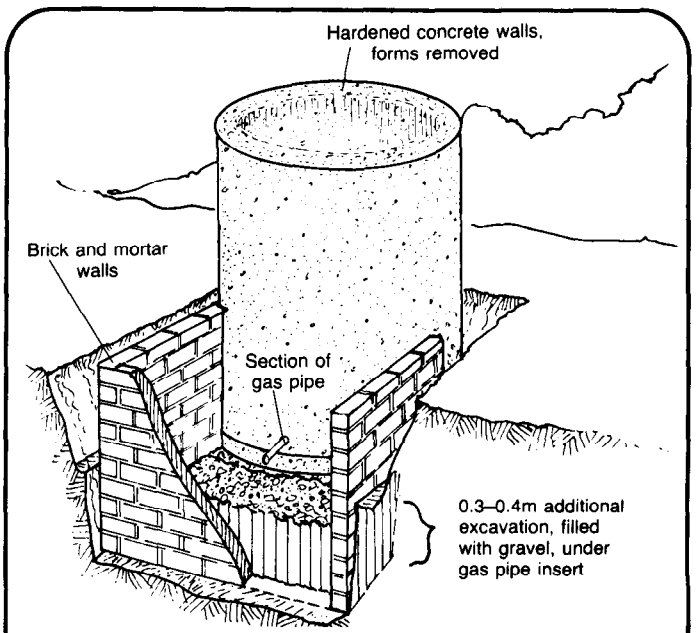

Figure 11. Constructing Water Trap Pit

9. When the walls for the pit have set up, fill in the excavation around the pit and gas holder with soil and tamp firmly.

Installing the Gas Cover

1. Drill holes and set bolts in the concrete wall for the guide posts. Depending on the design, there will be three or four posts. Attach the posts. They should have stops on the lower end. See Figure 12.

2. Extend the gas pipe to the center of the floor and then vertically upward until it is nearly level with the top of the gas holder walls. See Figure 12. All pipe installations must be performed by an experienced pipe fitter.

3. Lower the prefabricated gas cover in place. The guide wheels on the cover should fit into the guide posts. The stops on the guide posts will prevent the cover from sliding to the floor of the gas holder and damaging the gas pipe. See Figure 13.

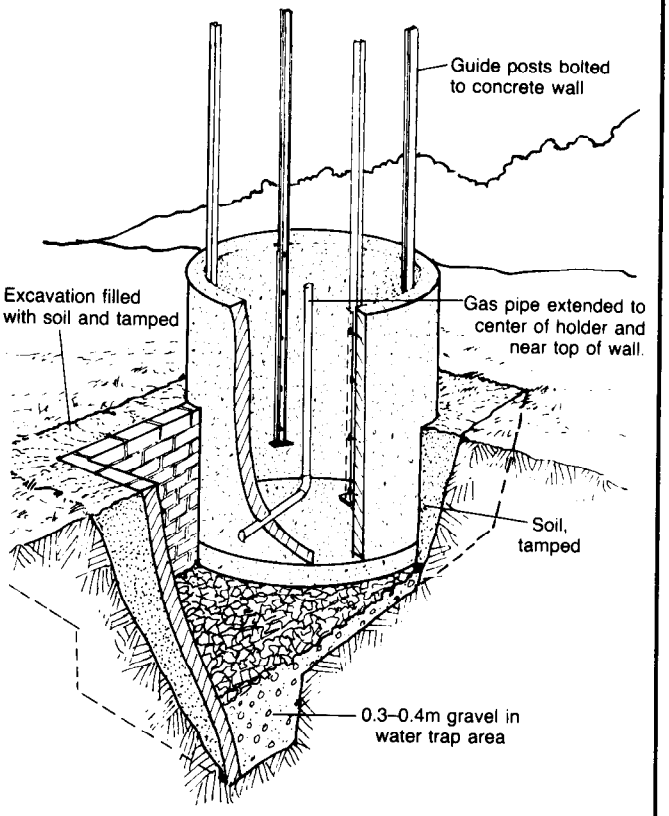

Figure 12. Completing Gas Holder Construction

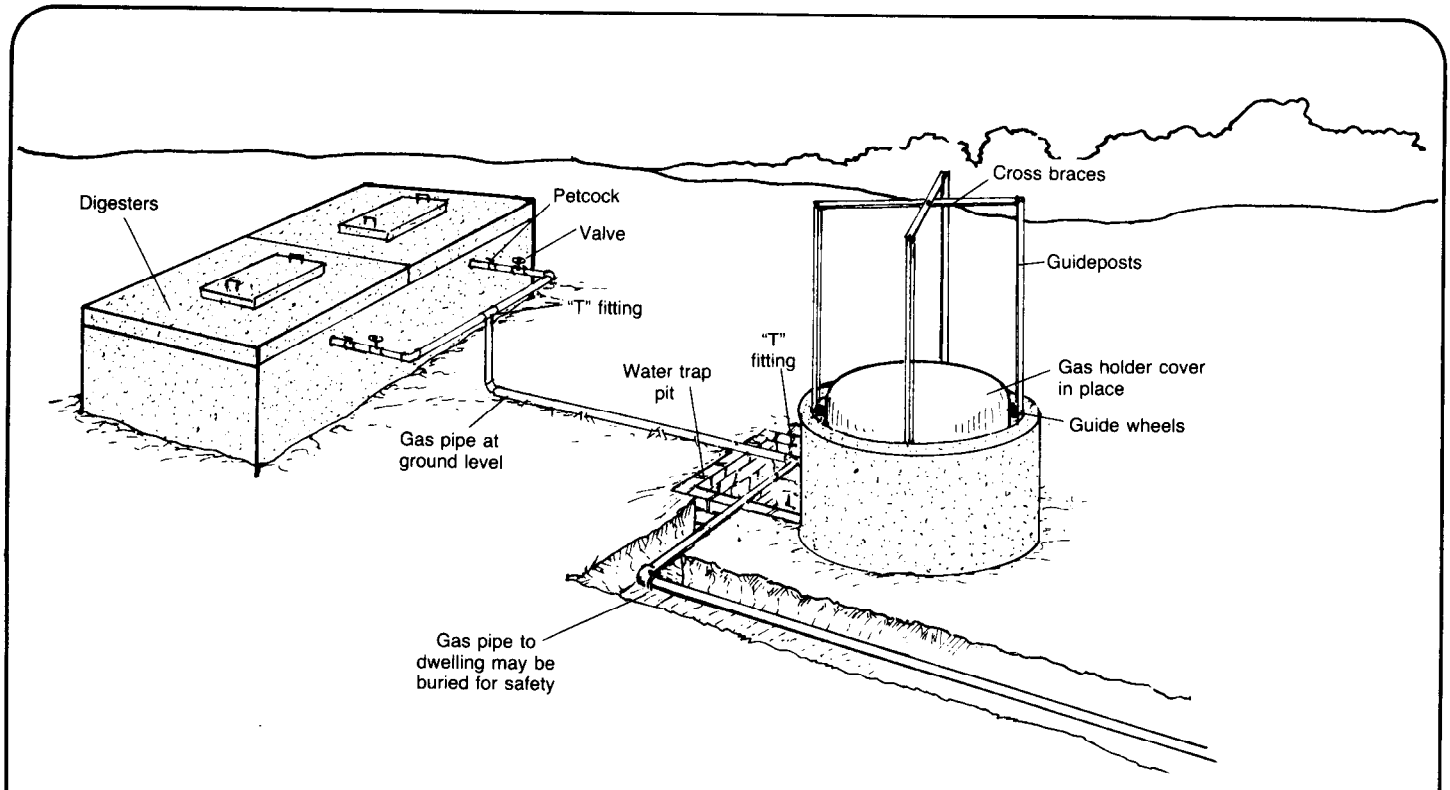

Figure 13. Completing Biogas System

Installing Gas Pipes

1. Extend gas pipes from the digesters and attach a petcock and valve in each line. Join the lines with a "T" fitting. See Figure 13. Extend the line to the water trap pit and attach a "T" fitting in or near the pit. This fitting will be used to extend the line to the dwelling.

2. Run the gas line across the top of the pit near one side, then down the outside wall of the gas holder to the section of the pipe in the wall. See Figure 14.

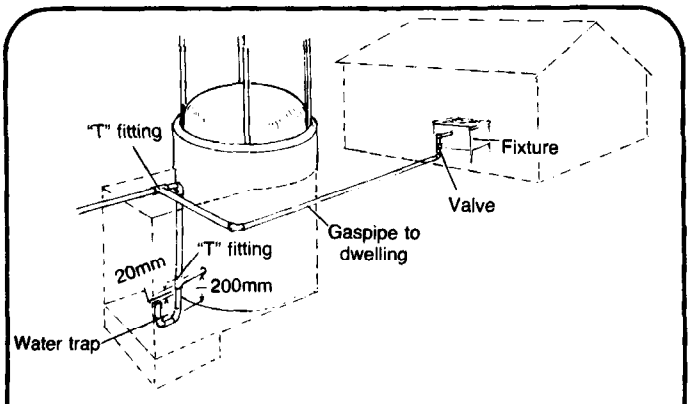

Figure 14. Gas Pipe Connections

3. Connect the gas line and the section of pipe with a "T" fitting. Attach a U-shaped arrangement of pipes to serve as a trap for condensation in the line. The inside leg of the "U" should extend 200mm below the section of pipe in the gas holder wall. The outside leg of the "U", the open end, should extend upward no higher than 20mm below the section of pipe in the wall.

4. Run a gas line from the "T" fitting in or near the pit to the dwelling. This line may be buried 100-150mm below ground to protect it from damage. Install a valve just inside the dwelling. See Figure 14. Extend the line and install the fixtures such as lamps, stoves, and water heaters.

5. After there is gas in the pipelines, check every connection point for leaks. Check the seal around the digester cover. Most leaks can be found by coating connections with a strong soap solution and watching for bubbles.

Table 1. Sample Materials List

Item	Description	Quantity	Estimated Cost
Labor	Construction foreman experienced with biogas	1	____
	Worker experienced with pipe fitting	1	____
	Worker experienced with reinforced concrete	1	____
	Unskilled workers	4	____
Supplies	Prefabricated floating cover: 3mm thick sheet iron; 1.60m diameter; 2.17m high	____	____
	Guide posts; galvanized iron	____	____
	Guide wheels	____	____
	Gas pipe: 18mm diameter	____	____
	Valves	____	____
	Petcocks	____	____
	"T" fittings	____	____
	"L" fittings	____	____
	Fixtures	____	____
	Concrete mix	____	____
	Reinforcing material	____	____
	Material for forms	____	____
	Sealer for digester manholes	____	____
	Other	____	____
Tools	Shovels	____	____
	Picks	____	____
	Hammers	____	____
	Saw	____	____
	Trowels	____	____
	Wheelbarrow	____	____
	Containers: for mixing concrete	____	____
	Pipe wrench	____	____
	Threader	____	____
	Pipecutter	____	____
	Hacksaw	____	____
	Other	____	____

Total Estimated Cost = ____

Table 2. Sample Work Plan for Constructing a Biogas System

Time Estimate	Day	Task	Personnel	Materials/Tools
2 hours	1	Layout system on ground	Foreman (always present); 1 worker	Map; drawings; measuring tape; stakes
1½ days	1-2	Excavate for digesters	4 workers	Picks; shovels
2 days	3-4	Build digester floor, tops, and manhole covers	4 workers; 1 worker experienced with concrete	Wood; hammer; saw; nails; cement; sand; gravel; water; trowels; steel bars; mixing containers; horseshoes
4 days	5-8	Keep moist for 4 days	1 worker	Wet straw
1 day	9	Build digester walls	4 workers; 1 worker experienced with concrete	Wood; hammer; saw; nails; cement; sand; gravel; water; trowels; steel bars; mixing containers
4 days	10-13	Keep moist for 4 days	1 worker	Wet straw
1 day	14	Mortar tops in place; set manhole covers in place; fill excavation with soil	4 workers; 1 worker experienced with concrete mortar	Concrete mortar mix; shovels
1 day	15	Excavate for gas holder	4 workers	Picks; shovels
1 day	16	Build gas holder floor	4 workers; 1 worker experienced with concrete	Material for forms; cement; sand; gravel; water; trowels; steel bars; mixing containers
4 days	17-20	Keep moist for 4 days	1 worker	Wet straw
1 day	21	Build wall forms	4 workers; 1 worker experienced with concrete	Material for forms; cement; sand; gravel; water; trowels; steel bars; mixing containers
4 days	22-25	Keep moist for 4 days	1 worker	Wet straw
1 day	26	Build water trap pit	2 workers; 1 worker experienced with masonry	Shovels; trowel; mortar mix; bricks; gravel
2 days	27-28	Let set for 2 days	----	----
½ day	29	Fill excavation with soil	4 workers	Shovels
1½ days	29-30	Install guide posts and extend gas pipe in holder	4 workers; 1 pipefitter	Drill; bolts; guide posts; gas pipe; fittings; wrench; threader
½ day	31	Install gas cover	4 workers	Pre-built gas cover
1½ days	31-32	Install gas pipes	2 workers; 1 pipefitter	Gas pipes; fittings; valves; petcocks; wrench; threader; fixture